

Ce volume présente sous la forme d'articles synthétiques toutes les communications scientifiques présentées par voie orale ou par affiche lors du 38ème Congrès de la CIESM. Les articles, qui sont illustrés en grande majorité, incluent chacun un résumé et des références bibliographiques. Comme ce sont plus de 800 chercheurs qui se sont rassemblés en avril 2007 à Istanbul, l'ensemble offre un vaste panorama, bien représentatif des recherches menées actuellement en Méditerranée et en mer Noire dans la plupart des disciplines marines.

Les articles et synthèses correspondant aux Panels matinaux sont publiés sous mon contrôle éditorial direct, tandis que les articles présentés dans le cadre des six comités scientifiques le sont sous la seule responsabilité du Président de comité correspondant. Il est à noter que seules les communications physiquement présentées par leur auteur lors du Congrès ont été retenues pour l'impression.

Frédéric Briand Directeur Général, CIESM

Editeurs scientifiques

Pour les Panels: Frédéric Briand Pour le reste du Volume: les Présidents des comités scientifiques de la CIESM, 2004-2007 Dimitris Sakellariou (Géosciences marines), Jordi Font (Physique et climat de l'océan), Nicholas Fisher (Biogéochimie marine), Gerhard Herndl (Microbiologie marine), Bella Galil et Kostas Stergiou (Ressources vivantes et écosystèmes marins), Maria Snoussi (Ecosystèmes côtiers).

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PANEL 1

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# Mediterranean biodiversity on-line

Modérateur : Ferdinando Boero

# PANEL REPORT BY THE MODERATOR

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#### Keywords : Biodiversity, Gis, Eastern Mediterranean, Western Mediterranean.

Information systems are the new powerful tool to collect, integrate and analyse data from different sources and to make them readily accessible to the scientific community worldwide. This panel focused on issues concerning the management of biodiversity databases on the internet (data integration, accessibility, quality control) and their scientific and educational applications.

The session started on time, all speakers where sharp in their presentations, leaving an hour for discussion with the audience. The first two contributions focused on patterns and trends in the introduction and distribution of alien species based on the analysis of datasets from the CIESM Atlases of Exotic Species. Daniel Golani showed the abrupt increase in exotic fish in the Mediterranean Sea in recent years, with 18 newly introduced species since 2002, mainly through the Suez Canal. Many established species extended considerably their range of distribution and for some species real population explosions occurred in just few years time. As the rate of invasion is likely to increase in the future, D. Golani discussed the need for more research on the impact of exotic fish on native assemblages. In particular, he stressed the importance of long-term monitoring of fish invasions and the need for comparative studies between exotic fish and ecologically similar native species for more reliable assessment of impacts on local diversity.

The rate of invasions in the Mediterranean Sea is steadily increasing also for other taxa, as was clearly shown in the communication by Bella Galil. To date, 66 exotic crustacean decapod and stomatopod species have been recorded in the Mediterranean Sea and the number of introductions increased in the last decade. The Eastern basin is the most affected by species introductions, which have been five times higher than in the Western basin. Marked differences between the two basins in the origin and way of introduction were also outlined. B. Galil finally examined potential determinants of the establishment success of tropical species in the Mediterranean Sea, with special reference to climatic changes.

Marc Verlaque introduced the forthcoming CIESM Atlas on Exotic Macrophytes, which is the first inventory of macroalgal species introduced in the Mediterranean Sea. The Atlas provides comprehensive, referenced information on the morphological features, ecology and biogeography of 110 exotic macroalgal species. The Atlas, soon accessible online, will be regularly updated, dynamically integrating records on new introduced species. Since the Mediterranean Sea harbours the greatest number of exotic macrophytes in the world, and since new species introductions are increasing exponentially mainly due to shellfish farming, this Atlas represents a unique benchmark to assess past and future changes on macroalgal diversity.

Giuseppe Notarbartolo di Sciara presented the joint project between CIESM and ACCOBAMS to develop, in cooperation with the Pelagos Sanctuary, a database on cetacean sightings covering the Mediterranean and Black Seas. The database will integrate historic datasets collected and archived by the CIESM Marine Mammals Task Force with current and future records on the presence, distribution, abundance and habitat of cetaceans. The importance of building a scientifically rigorous cetacean sightings database was underlined by the author, who stressed the need for basin scale observations to further scientific understanding of marine mammals and improve conservation measures.

Key issues concerning data integration, accessibility and ownership in web-based information systems were presented by Christos Arvanitidis on behalf of the panellist Edward Van Berghe (excused). As he pointed out, one of the main problems related to integration of several datasets is the lack of a common taxonomic nomenclature. He then described the European Register of Marine Species, an initiative of the EU Network of Excellence MARBEF to provide a standard taxonomic list of European marine species. This list is available online and should serve as a reference guide when integrating datasets using different terminology. A brief presentation of the MedOBIS database on Mediterranean and Black Sea species was given by her colleague Sarah Faulwetter.

Data integration, however, does not only imply the use of a common terminology. The need to adopt an ecosystem-based approach to study biodiversity has prompted the development of information systems which host datasets of numerous biological and environmental variables.

The new CIESM GIS-based application developed at CIESM Headquarters was presented in a joint paper authored by Paula Moschella and Kaveh Rassoulzadegan. It will integrate CIESM datasets on biodiversity, environmental variables and bibliographic resources into one single information system. The multilayer architecture of the application and the partitioning of the Mediterranean into subregional zones allows an at glance visualization of several datasets in a particular area of interest. P. Moschella also explained that the system was specially conceived to make it accessible and easy to use on both shores of the Mediterranean, and to provide scientific information that would equally serve scientists and non-specialist end users.

The last presentation was given by Stéphane Pesant, who highlighted the importance of integrating datasets that provide information on the different levels of biological diversity (e.g. taxonomy, genetics, ecology) to better understand the functioning of marine ecosystems and the biogeochemical fluxes. The problems of data aggregation, quality control, and metadata standardization were also addressed using examples from EurOcean, SESAME and MARBEF initiatives.

The following is a summary of the main questions, answers and comments raised during the general Panel debate.

*Comment*: Databases are too difficult to use, and not exactly user-friendly, with the exception of that of CIESM.

*Answer*: Databases are available through the internet, and so are accessible to all those who can take advantage of a connection with the world wide web. Most databases, however, are just for the scientific community and are often not even available without permission.

*Question*: Are there biological parameters that can be used to show long term changes, as it happens with oceanography?

Answer: It is possible with the fossil record over the long term. Then there are middle term information, like with alien species, where we can reconstruct the recent history of the Mediterranean in terms of arrival of new species from both Gibraltar and Suez. EurOceans and SESAME are working with this aim in mind, collecting past information and assembling it into a single temporal framework. Long term series have been set up at several places (Naples, Villefranche-Sur-Mer, Plymouth, Helgoland) but are being abandoned because they are costly and not scientifically rewarding over the short term (the term that determines scientific careers and funding availability). They should be fostered because they reconstruct the history of biota and are conducive to the understanding of present-day situations.

*Question*: There is not enough knowledge of the biodiversity of the south shore. No more taxonomists. What about the species living in the southern shore and that have never been recorded due to lack of observation? If they will widen their distribution range, they will be considered as aliens, and they are not. We have to convince the decision makers that taxonomy is important.

*Answer*: this is correct. We have information from the northern shore, and sometimes we produce floras and faunas, but they do not cover the situation of the southern shore. The exploration of the Mediterranean is far from having been accomplished. The problem does not reside with

decision makers, though. The problem rests with the scientific community. The perception of taxonomy as an obsolete discipline comes from within the scientific community. Even Nature publishes articles stating that taxonomy is extremely important, but then the money allocated to taxonomy mostly goes to information and technology for the building of databases that provide information. This is necessary but it is not sufficient. Taxonomists cannot find jobs because they do not attract proper funding. Taxonomists produce the knowledge that makes information available. Information without knowledge is not very useful, even if it gives the impression of great achievements. We have to convince the rest of the scientific community that taxonomy is important, so to give proper inputs to decision makers.

*Question*: Why is the Sicily Channel not a biogeographic region on its own on the map of CIESM?

Answer: good question, it will be taken into consideration.

*Comment*: The southern shore is going through the most spectacular change throughout the Mediterranean and it is not appreciated enough because there are no trained people to witness it.

*Answer*: Even fish are not covered very well because there are many mistakes. If there are no specialists, it is almost impossible to have reliable records. The issue is extremely important and calls for proper effort in building new taxonomists.

*Comment*: Virtual libraries with pdf papers will help people to identify organisms.

*Answer*: taxonomy is not identification. If people think to be able to identify specimens just from a key or an atlas, there will be a great risk of misidentification, as it is happening even for fish. Floras and faunas have to be developed, but they are important tools for identification only if novel cases (e.g. of records new for the basin) are inspected by specialists.

## ALIEN DECAPODS IN THE MEDITERRANEAN SEA - WHICH, WHEN, WHERE, WHY?

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## Abstract

The presence and the spatio-temporal spread of 66 alien decapod and stomatopod species in the Mediterranean Sea were studied. The majority of aliens in the eastern Mediterranean entered through the Suez Canal, whereas mariculture and shipping are powerful means of introduction in the northwestern Mediterranean and in the Adriatic Sea. Most aliens are thermophilic species. The possible causes for the epic scale of invasion in the Mediterranean Sea are discussed in relation to a complex of stressors and climatic factors. *Keywords : Species Introduction, Crustacea.* 

#### Introduction

Growing awareness worldwide that bioinvasions constitute one of the most significant components of global change, with often harmful effects on biodiversity, economy and human health, coupled with the opportune misfortune of a handful of invasive aliens noted for their conspicuous impacts on the native Mediterranean biota, have drawn the attention of scientists, management and media. It was widely perceived that the littoral and infralittoral biota of the sea had been undergoing a rapid and profound change. A series of CIESM Atlases summarize the extant knowledge of the scale and impact of 'Exotic species in the Mediterranean' (www.ciesm.org/atlas/).

#### Discussion

WHICH? A geographic classification of the alien decapods and stomatopods shows that their native range is most commonly the Indo-Pacific Ocean, the Indian Ocean, and the Red Sea (80%). Caution should be exercised: the true origin of Mediterranean populations of a species widely distributed in the Indo-Pacific Ocean may be its population in the Red Sea, or much further afield, or secondarily from established southern Levantine populations. However, it is quite clear that most of the alien crustaceans are thermophilic, originating in tropical seas. This flies against the widely held assumption that successful bioinvasions originate in similar latitudes [1]. A classification according to the means of introduction shows that the majority of alien crustaceans entered through the Suez Canal (73%), followed by vessels (15%). Here too, caution should be exercised when using this data: only rarely the means and route of introduction are known from direct evidence.

WHEN? The number of alien crustaceans has been increasing steadily. A surge in the records in the 1920s reflects the publication of the results of 'The Cambridge Expedition to the Suez Canal'. There seem to be more introductions recorded in the first years of the  $21^{st}$  C than in the 1980s and 1990s. Since the 1950s major political, economical and societal changes have occurred in the peri-Mediterranean countries. Their impact on the rate and means of introduction is apparent: though the Suez Canal remained the main access route for alien species, the rate of introductions by vessels and mariculture has been higher. The increase in vessel-transported aliens may be attributed to the increase in shipping volume throughout the region, the changing trade patterns that result in new shipping routes, improved water quality in port environments, augmented opportunities for overlap with other introduction vectors, and rising research effort. Similarly, the increase in intentional and unintentional mariculture introductions.

WHERE? The bulk of the alien species recorded in the Mediterranean are littoral and sublittoral benthic or demersal species. Since the shallow coastal zone has been extensively studied, the chances that new arrivals will be encountered and identified are higher. Also, the species most likely to be introduced by the predominant means of introduction (Suez Canal, vessels, mariculture) are shallow water species. A comparison of alien decapods and stomatopod species between the Mediterranean coasts of Spain and France, and an equivalent coastline from Egypt to Turkey, shows marked differences in their numbers, origin and means of introduction. There are five times as many alien species along the Levantine coast (49) as in the westernmost Mediterranean (9). The majority of aliens in the Levant entered through the Suez Canal (92%), whereas mariculture (78%) is the main means of introduction in the western Mediterranean. Consequently, the native ranges of the western Mediterranean aliens are spread over 'the seven seas', while the Levantine aliens mostly originate in the tropical Indo-Pacific or parts thereof (IP 61%, IO 14%, RS 5%).

WHY? The extraordinary physiography and climatic history of the Mediterranean left it with vast vacant "climatic" niches. Modern shipping, the Suez Canal, and mariculture breached the biotic isolation of the sea and provided the major pathways for alien marine organisms to enter and occupy those niches. Most alien species in the Mediterranean had not originated in similar latitudes like marine bioinvasions elsewhere, but are thermophilic, mostly tropical, species [2, 3]. Rising seawater temperature may change the pool of species which could establish themselves in the Mediterranean, enable the warm stenothermal species (native and alien) to expand beyond their present distributions, and may impact on a suite of population characteristics (reproduction, survival) that determines interspecific interactions, and, therefore, the dominance and prevalence patterns of both native and alien species, and provide the thermophilic aliens with a distinct advantage over the native biota. However, concurrent alien invasion and rise in the sea surface temperature do not themselves imply causation: the complexity of the ecosystem and the difficulty in assessing and understanding the biological response to climate forcing caution against simplistic unidimensional interpretations. The epic scale of invasion in the Mediterranean Sea may be explained as the consequence of a synergetic complex of stressors - pollution, eutrophication, destruction and fragmentation of habitats, fisheries overexploitation, and climate change - a catastrophic anthropogenic ecosystem shift - superimposed on a unique physiographical and climatic history.



Fig. 1. Number of alien crustaceans in the Mediterranean, presented by means of introduction, before and after 1950.

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# FISH INVASION OF THE MEDITERRANEAN - RETROSPECTIVE AND PROSPECTIVE

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## Abstract

The rate of fish invasion into the Mediterranean has continued without showing any sign of deceleration. Since the publication of the CIESM Exotic Fish Atlas in 2002, 18 new exotic fish species have been recorded and many species have extended their distribution range. Two distinct periods (1977-1982 and 2000-2005) of population explosion were documented for nine cases of invasive fish species just following initiation of invasion. In light of the supposition that the rate of invasion will continue steadily, it is suggested that future research should concentrate on comparative studies of the ecology and life history strategies of the invasive species and their closely related Mediterranean indigenous species as well as application of population dynamics and genetics. *Keywords : Fishes, Species Introduction, Western Mediterranean, Eastern Mediterranean.* 

Bio-invasion is considered to be one of the main factors influencing alteration of species diversity and faunistic structure. The Mediterranean Sea, as an enclosed sea heavily affected by anthropogenic actions such as intense fishing activity, pollution and tourism, is pervious to the invasion of alien species. The bio-invasion of the Mediterranean encompasses nearly all the major marine taxonomic groups. Three of these, namely, Fish, Crustaceans and Molluscs, have been the subject of recent publications of CIESM (www.ciesm.org/atlas/). The scientific study of fishes has an advantage over the other groups, since commercial fishery exploitation provides extensive quantitative and qualitative data in "samples from the local marine environment, in addition, the taxonomy of fishes is relatively clear.

Fish invade the Mediterranean via three pathways: 1) via the Straights of Gibraltar; 2) via the Suez Canal and 3) via direct human activity (e.g., ship-mediated transport, mariculture, etc). Unlike other groups, the third way of direct human activity is of lesser importance regarding fishes.

Since the publication of the CIESM Fish Atlas in 2002 [1], 18 new exotic fish species have been recorded, reaching a total of 108 representing 61 families, of which 37 were new to the Mediterranean ichthyofauna. This represents an increase of 20% within only four years (Fig 1). In addition, many established species extended their distribution range. The most substantial range extensions were observed for *Etrumeus teres*, *Sphyraena flavicauda*, *Petroscirtes ancylodon*, *Callionymus filamentosus* and *Lagocephalus suzensis* from Rhodes [2], *Upeneus pori* and *Scomberomorus commerson* from Tunis [3], *Fistularia commersonii* [4] and *Siganus luridus* from the Tyrrhenian Sea; *Pseudupeneus prayensis* progressed to the northwestern Mediterranean while *Seriola fasciata* reached the eastern Mediterranean.



Fig. 1. Cumulative number of alien species in the Mediterranean by origin.

Invasive fish species succeeded in colonizing almost every available niche, including sandy and muddy bottom, pelagic and rocky, the first two of which were considered to be the most vulnerable to colonization [5]. The deepwater environment has been invaded to date only by Atlantic species; deepwater Red Sea species have been unable to reach the Mediterranean due to the shallow Bay of Suez. The general pattern of population growth of invasive fish species in the Mediterranean is characterized by a small founder group that gradually expands its population. However, there have been some instances of invasive fish species experiencing a population explosion shortly after invasion initiated. Two distinct periods of population explosion were observed. Between 1977-1982 four species, *Pempheris vanicolensis, Sillago sihama, Oxyurichtys petersi and Sphoeroides pachygaster* expanded their populations rapidly. Another wave of population explosion occurred between 2000-2005 regarding the species *Fistularia commersonii, Plotosus lineatus, Hippocampus fuscus, Lago-cephalus sceleratus* and *Decapterus russelli*.

The impact of invasive fish on the Mediterranean indigenous species has been addressed by several authors who have noted cases where alien fish displaced, replaced or out-competed native species. However, except for the individual cases of Mullidae and Synodontidae, no other direct comparative studies of invasive fish species and their closely related indigenous species sharing a similar niche have been reported; thus, such sweeping conclusions regarding the vast majority of invasive fish species are of a speculative nature only. Future directions in research will need to deepen our knowledge of the impact of invasive species in the Mediterranean. One of the main challenges to future research on invasive species is to conduct comparative studies on the ecology and life history strategies of invasive versus that of their closely related indigenous species with similar ecological life traits. Another important research topic is to monitor the rate of invasion, since there is no sign that this rate will lessen in the foreseeable future. Other subjects for future studies may include the causal relation between population dynamics and species invasion, including genetic studies at the molecular level.

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# A JOINT CETACEAN SIGHTING DATABASE: A COOPERATIVE EFFORT AMONG CIESM, ACCOBAMS AND THE PELAGOS SANCTUARY

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## Abstract

Atlantic waters.

The organization of a cetacean sighting database has been started by CIESM in cooperation with ACCOBAMS and the Pelagos Sanctuary. Aims of the database are to support the conservation and scientific goals of the participating organisations by providing a readily accessible body of knowledge, collected across time (past, present and future), concerning the occurrence, distribution, abundance and habitat use of cetaceans in the Mediterranean Sea, the Black Sea and contiguous Atlantic Ocean. *Keywords : Cetacea, Black Sea, Eastern Mediterranean, Western Mediterranean.* 

For several decades CIESM has been concerned with the progress of ecological knowledge of Mediterranean cetaceans, and such efforts and interest have resulted, among other things, in recent years in the publication of a preliminary Atlas on cetacean distribution [1], and of a Workshop Monograph [2] on the roles of cetaceans in marine ecosystems. Furthermore CIESM actively supports the functioning of ACCOBAMS - an intergovernmental organisation for the conservation of the region's cetaceans - by nominating five independent members in its Scientific Committee. Collecting and organising cetacean sighting data from the Mediterranean and the Black Seas has been a CIESM activity for a long time [1, 3]. Now ACCOBAMS and the Pelagos Sanctuary - another intergovernmental entity established in 2002 by France, Italy and Monaco to protect cetaceans in a large area of the NW Mediterranean basin - have decided to join efforts with CIESM to create a cetacean sighting sdatabase. A joint *ad hoc* 

meeting was organised in Monaco in September 2006 for this purpose. Aim of the database will be to support the conservation and scientific goals of the participating organisations by providing a readily accessible body of knowledge, collected across time (past, present and future), concerning the occurrence, distribution, abundance and habitat use of cetaceans in the

area of interest, i.e., the Mediterranean Sea, the Black Sea and contiguous

A better understanding of the distribution and occurrence of cetaceans in the area of interest is important for many reasons. First, although cetacean ecology is beginning to be reasonably well known in parts of the Mediterranean and Black Seas, knowledge is completely lacking from major portions of the area, and even where such knowledge exists, it is mostly limited to summer observations. Second, even if we were to succeed in securing state-of-the-art information (i.e., completion of a measure of effort and of the concurrent environmental co-variates) on future sightings over the whole area of interest, and across seasons, past details on the abundance and distribution of cetaceans in the region, not to speak of time series, are very scarce and difficult to find, making the detection of trends in an epoch of rapid change an arduous challenge. Third, creating a centralised database will facilitate the application to the data of increasingly sophisticated analytical techniques which will ensure that management and conservation decisions will rest on robust science and become more effective. Finally, a shared database will facilitate the creation of a network of like-minded scientists cooperating on a regional scale so as to better understand the ecology of cetaceans, and improve the conservation status of their populations.

In order to proceed with the establishment of the common database, the following priority objectives were identified:

1.Organising a single, accessible, scientifically credible and robust database, integrating relevant and validated existing datasets forfuture information. Such dataset will contain information collected within the area of interest.

2.Gathering data that can be analysed to obtain effective and predictive distribution and abundance maps for all cetacean species within the area of interest.

3.Implementing new spatial analysis tools, in order to define ad hoc models for the region that will allow the correct use of new baseline and monitoring data.

The database will be hosted in Monaco. A "Data Availability Group" shall

be created soon, including representatives from the three organisations and scientists holding the datasets. In recognition of the fact that data represent a significant temporal and financial investment by scientists and research institutes, the use of their data by third parties shallbe accompanied by appropriate safeguards. The following general principles will constitute the base of the working approach: (1) data owners maintain ownership; (2) data owners are offered co-authorship in any relevant technical report of the involved Organisations; (3) publication rights remain strictly with the data owner.

The following basic Terms of Reference were indicated for the "Data Availability Group":

To clearly identify all procedures for:

A.1 database accessibility policy, by establishing rules on:

a.data transmission to potential users(deciding on the applicants' eligibility);

b.submission of data access proposals;

c.evaluation of data access proposals.

A.2 data quality control, by defining rules on data validation methods (for example, on the eligibility of datasets and data providers, methods and protocols for data collection, data verification system).

In practice, the main work of the Data Availability Group will include:

1.Definition of data to be collected, and what fields are obligatory (e.g., latitude, longitude, time, date, group size, distance, angle, speed and height of the observation platform, sea and wind state, linear km covered or tracks, sampling design, etc.);

2.Criteria to define acceptable data, and definition of basic research methods considered reliable (for example, one dedicated/ experienced observer, GPS position, picture, etc.); this would include a procedure for data quality control;

3.Establish different levels of accessibility (data providers, "third parties", public/website);

4.Data use (validity of aims of the proposed use of data by third parties), including the format and "temporal validity" for the distribution of documents;

5.Data providers must be selected and data should be made available based on clear rules;

The term "data owners" shall be clarified (e.g., data collector, data holder, data owner, opportunistic vs. systematic, experienced vs. opportunistic).

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# DEVELOPING DATABASE ARCHITECTURES SUITABLE TO ASSESS THE IMPACTS OF CLIMATIC AND ANTHROPOGENIC PERTURBATIONS ON MARINE ECOSYSTEMS

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## Abstract

Biodiversity is helpful to assess the impacts of climatic and anthropogenic perturbations on marine life; it can be assessed at various levels and requires data from various fields of research, including genetics, taxonomy and ecology. Our challenges are (i) to quality check, authenticate and aggregate data from the different fields; and (ii) to agree on networking solutions and metadata standards. *Keywords : Global Change, Biodiversity, Food Webs, Geochemistry.* 

The Mediterranean Sea is subject to several perturbations, some of which are linked to short-term events or long-term trends in the regional and global climate and in human activity. Biodiversity is helpful to assess the impacts of these perturbations on marine life. For that reason, several European initiatives [1-4] are gathering biodiversity data, with the aim to model and predict changes in marine systems.

Traditionally, biodiversity is assessed at the taxonomic level of species and leads to the study of biogeography and species diversity, which is of significance for the conservation of our natural heritage. Besides that interest, biodiversity also plays an important role in the functioning of marine ecosystems and their associated biogeochemical fluxes. Notably, biodiversity at one easies at several levels of organisation including genomic diversity at one end of the spectrum and ecosystem diversity at the other end (Figure 1). Intermediate levels of organisation include the diversity of functional groups and food webs, which are being progressively incorporated into ecosystem and biogeochemical models. These various levels are complementary to species diversity and require additional data from the fields of genetics and molecular biology, and from other biological and environmental sciences.



Fig. 1. Levels at which biological diversity is of interest and their respective data requirements.

Historically, the fields of genetics, taxonomy and ecology are segregated, such that each field has developed its own European Network of Excellence [4, 3 and 1, respectively] and its own databases. These have yet to be merged to successfully address the functioning of marine ecosystems and biogeochemical fluxes, but fortunately they all share, at minimum, common geo-references that allow us to assemble the puzzle. The challenges are thus (i) to quality check, authenticate and aggregate data from the different databases; and (ii) to agree on networking solutions and metadata standards.

To address the first challenge, International and European initiatives are developing authoritative taxonomic lists of marine species [5, 6] that are augmented by the scientific community and reviewed by experts. Besides nomenclature issues, traditional and emerging methodologies must be rigorously validated and corrected when necessary, e.g. systematic vs. targeted counts, expert-to-expert validation; and manual vs. imaging identification. Similar attention must be given to other biological data such as the abundance of plankton functional groups estimated from light and epifluorescence microscopy, HPLC and remote sensing. This is particularly relevant for time series analyses involving indicator species. Finally, the conversion of abundances into biomass is particularly relevant to modellers.

To address the second challenge, at least partially, European networks of marine databases were created by the different fields of research [4, 7, 8]. Besides establishing common metadata standards and exchange protocols, the proper integration and use of marine data will require that database architectures refine their granularity. Coarse granularity implies that metadata are attached to pre-assembled datasets (e.g. per project, per taxon or per geographic area), whereas fine granularity implies that metadata are attached to each datum. The latter must be achieved in order to aggregate data into customised, cross-fields data products [9].

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3 - MarBEF: Marine Biodiversity and Ecosystem Functioning EU Network of Excellence (www.marbef.org).

4 - Marine Genomics Europe (www.marine-genomics-europe.org).

5 - ITIS: International Taxonomic Information System (www.itis.gov).

6 - APHIA combines several Registers of Marine Species (www.vliz.be/Vmdcdata/aphia/).

7 - EUROBIS: European Ocean Biogeographic Information System (www.marbef.org/data or www.iobis.org).

8 - SeaDataNet: Pan-European infrastructure for Ocean & Marine Data Management (www.seadatanet.org).

9 - WDC-MARE/PANGAEA: World Data Centre for MARine Environmental sciences (www.wdc-mare.org).

## INTEGRATING ENVIRONMENTAL DATA FROM HETEROGENEOUS SOURCES:LESSONS LEARNED IN MARBEF

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## Abstract

One of the objectives of the EU Network of Excellence 'Marine Biodiversity and Ecosystem Functioning' was to bring together existing datasets in large databases, to facilitate analysis on long term, and on the European scale. Data integration proved to be a non-trivial and labour-intensive task. Good standard lists (vocabularies/ontologies) for both taxonomy and geography are essential tools. Vastly different sampling equipment and design often precludes quantitative analysis on the level of the integrated database. Sampling bias, resulting from the objectives of the projects that generated the individual data sets, needs special attention. *Keywords : Analytical Methods, Biogeography, Ocean History.* 

Scientific data are often collected in the framework of relatively small projects; the resulting datasets are usually relatively small-scale, and fail to inform on the scale of global environmental problems with which humankind is confronted. This has prompted a multitude of data integration activities, to try and assemble several of these smaller datasets in larger, interpretable databases. One of the objectives of the EU Network of Excellence 'Marine Biodiversity and Ecosystem Functioning' was to bring together existing datasets in large databases, to facilitate analysis on long term, and on the European scale.

Older datasets are transcribed from paper to electronic forms in data archaeology and rescue projects. The digitisation of historical data from paper files can cost  $\leq 0.5\%$  of that of the original field surveys [1]. While these integrating and rescue activities are extremely useful, they are often labour-intensive, they often cause a certain degree of loss of detail in the information, and they introduce an inherent danger of data duplication. Very often, essential metadata (such as sample size) are not immediately available with the dataset, and have to be traced in literature based on the data. Lack of standard protocols results in variations in sampling equipment, and makes quantitative comparisons difficult. Often sample size is missing, and abundances are only given as densities per unit area or volume - but this precludes the use of rarefaction, which is an essential technique when dealing with samples from different sizes.

To facilitate integration, reference should be made as much as possible to standard vocabularies of terminology: standard taxonomic names, geographical names and parameter names. For parameter descriptions, a dictionary developed at the British Oceanographic Data Centre is used [2]. The reference for taxonomic names used within MarBEF is the European Register of Marine Species (ERMS) [3, 4, 5], a synonymised list of names of organisms that have been reported from European marine waters. ERMS contains not only valid names, but also invalid synonyms and documented misspellings; this way, ERMS forms a guide to the correct application of taxonomic names. ERMS provides an online tool for data integration. A gazetteer of marine place names was compiled, based on several existing lists of place names (e.g. from IHO and FAO), and on the basis of literature on an ad-hoc basis [4]. The purpose of the gazetteer is to improve access and clarity of the different geographic, mainly marine names such as seas, sandbanks, ridges, bays or even standard sampling stations used in marine research. Maritime boundaries and Exclusive Economic Zones in particular are important concepts for a lot of biogeographical applications. As no global public-domain cover of such information was available, the Flanders Marine Institute (VLIZ) decided to develop it: treaties between countries were gathered and the coordinates that were published herein were imported in a GIS. Where no treaties were available, maritime boundaries were calculated in ArcGis as 200 nautical mile buffer lines or as median lines, according to the regulations of the United Nations Convention on the Law of the Sea.

Where standard protocols were used in generating the observations or where there is an opportunity to make a priori agreements with the scientists about minimal required metadata, the integration process can be simplified and the loss of detail can be minimized. In all cases, extensive documentation is essential. Some controlled vocabularies exist, such as those provided by the Global Change Metadata Standard (GCMD), ISO 19115 and the Federal Geographic Data Committee (FGDC), but urgently need to be expanded for management of marine biology and ecology data. Most data are collected using public funding of some kind; it is only reasonable to assume that these data would ultimately be available in the public domain. Unfortunately, that is not always the case; for example, NODCs contain less than half of the oceanographic data collected in their countries [6]. Few of the marine papers in top journals publish raw data. The concerns of data owners, and reasons why not to make data publicly available, were reviewed by Froese [7]. Incentives are needed for data custodians to share their data. One possible mechanism would be to make datasets citeable; contributing data to on-line datasets, and having the data cited by others, should be treated in the same way as publishing research papers and being cited. To facilitate this, authors of scientific papers could be requested to deposit their raw data in a public, well-managed archive. It is the expected practice in taxonomy to lodge type specimens in museums and, in genetics, to deposit sequences in GenBank, prior to publication. There should be a similar requirement by journals that ecological data be made publicly available prior to printed publication [8]. Apart from making data more widely available, this has the advantage of increasing the level of possible peer-review.

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# CIESM ATLAS OF EXOTIC MACROPHYTES IN THE MEDITERRANEAN SEA

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## Abstract

The CIESM Atlas of Exotic Species covers the marine macrophytes. A total of 110 species (22 Chromobionta, 71 Rhodobionta, 16 Chlorobionta and 1 Magnoliophyta) are listed. Several other exotic species only known on the NE Atlantic coast are listed in the Annex. The kinetics of species introduction into the Mediterranean Sea is exponential since the late  $19^{th}$  century. As far as the number of introduced macrophytes is concerned, the main donor area is the Indo-Pacific region, and the main vectors of introduction are the shellfish aquaculture, followed by the ship traffic and the Suez Canal. Diagnostic features, biological information, references and a distribution map are given for each species.

Keywords : Algae, Species Introduction, Suez Canal, Aquaculture.

The CIESM Atlas of Exotic Species is the first attempt to provide a comprehensive, group by group, survey of recent marine "immigrants" in the Mediterranean Sea, which is witnessing drastic and rapid changes in its biota. The present volume, which follows the publication of the first three Atlases (Fish, Crustaceans decapods/stomatopods and Molluscs), covers the marine macrophytes. As far as Macrophytes are concerned, the Mediterranean is the sea harbouring the greatest number of exotic species worldwide. In this volume, we drew a list as broad as possible of the exotic macroflora on the basis of recent checklists and unpublished data [1-6], considering as "exotic" a species being a relative newcomer to the Mediterranean Sea (e.g.: not having appeared before 1869, date of the opening of the Suez Canal, for species originating from the Red Sea). Several species reported before this date and assumed to be native by some authors [2] (e.g.: Asparagopsis taxiformis) have nevertheless been included because recent and fast changes in their Mediterranean distribution give evidence to a recent introduction of either a cryptic species similar to the Mediterranean one or an exotic genotype from remote population. A total of 110 species (22 Chromobionta, 71 Rhodobionta, 16 Chlorobionta and 1 Magnoliophyta) constitute the main core of this CIESM Atlas. Considering the high risk of secondary introduction into the Mediterranean Sea of exotic species present on the NE Atlantic coast, 12 other exotic species until now unknown in the Mediterranean are briefly listed in the Annex. Each species is classified within the following categories according to the likeliness of being introduced: very high (introduction with no doubts); high (introduction likely); medium (introduction debatable). Presumed not-established and established species in the basin are distinguished as having either only one record in the scientific literature, or self-maintaining populations (minimum of two published records from either different localities or in different periods).



Fig. 1. Arrivals of exotic macrophytes species in the Mediterranean through the late  $19^{th}$  and the  $20^{th}$  century according to the first year of collection (by default, year of publication).

In the Mediterranean Sea, the introduction of macrophytes may result from a variety of causes (vectors): transportation of species on the hulls of ships and offshore structures (fouling) (e.g.: *Antithamnionella* spp.), deballasting of waters and solid matters transported by ships, opening of the Suez Canal (e.g.: *Stypopodium schimperi*), importations of aquaculture species from native regions, then transfers between basins (e.g. the exotic flora introduced along with the importation of *Crassostrea gigas*  from Japan in the 1970s), accidental escapes from public and private aquaria (e.g. Caulerpa taxifolia), and releases of species used as packing material of fishing baits (e.g. Fucus spiralis). Lastly, some epiphytic species have certainly arrived on their exotic host (e.g.: Acrochaetium spp.). Once introduced, an exotic species can spread by one or several of the previous vectors but also via other human activities as fishery and ship traffic, entangled with the anchorages and fishing engines (e.g. Caulerpa spp.). Transportation of fixed organisms on ship hulls is certainly the most ancient vector of species introduction in the marine realm. The relative importance of this vector has actually decreased with time and, nowadays, one might suppose that most of the macrophytes that were potential candidates for introduction via fouling have been already introduced. Ballast waters seem to play a minor role as a vector for introduction of macrophytes but not as a secondary dispersal vector (e.g. Caulerpa spp.). The main vector of introduction is shellfish aquaculture, followed by ship traffic and the Suez Canal. Multiple introductions via different vectors (e.g. fouling, ballast waters and aquaculture) are probable for several species (e.g.: Codium fragile).

The kinetics of species introduction into the Mediterranean Sea is exponential since the beginning of the late  $19^{th}$  century, and the main donor area is the Indo-Pacific region (Fig. 1). The marked upsurge in the introductions in the 1970s results from accidental introductions along with massive importations of Japanese Oysters from Asia. This exponential trend was probably also accented by the intensification of research efforts in marine invasions since the *Caulerpa taxifolia* event. In the future new records will need to be added to those presented in this volume. These changes will be documented in the electronic version of this Atlas, to be found on the CIESM website at <w.w.w.ciesm.org/atlas/macrophytes.html>.

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# **Recent advances in Black Sea sciences** *Modérateur* : Temel Oguz

## PANEL REPORT BY THE MODERATOR

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#### Keywords : Black Sea, Fisheries, Food Webs, Pollution.

Panel 2, which was held on Tuesday 10 April, discussed recent advances in Black Sea research. The forum placed particular emphasis on the following subjects:

- 1. ecosystem functioning and food web structure;
- 2. biogeochemical cycles;
- 3. pollution and biodiversity;
- 4. climate-induced changes;
- 5. prediction and future scenarios of the Black Sea ecosystem functioning.

Particular attention was given to the current status of the ecosystem, its possible state within the next few decades, and missing critical research information.

The panel started with presentations by five Black Sea experts.

Nicolae Panin presented an overview of the current state of Black Sea coastal areas and of the threats arising from global change and regional variability. Antje Boetius described the latest findings on the biogeochemistry and microbiology of the anoxic Black Sea environment, which is recognized worldwide as a natural laboratory for such research activities that were made thanks to the recent German cruises in the region. The major motivations behind this research project were to understand the characteristics and driving forces of the geological structures that harbour anoxic microbial ecosystems, to define the unique key microorganims, diversity of fauna and biogeochemical pathways present in anoxic habitats, to discover how these ecosystems interact with geological structures that host them, and how they are affected by environmental change, and to carry out long term observations of gas vents, mud volcanoes and hydrate systems in the Black Sea. Iolanda Osvath touched another interesting issue, i.e. the existence of links between radiotracer observations and fate of contaminants within the basin. The major focus of her presentation was the capacity building in the region to measure, monitor and assess marine radioactivity and apply tracer techniques. An overview on the status of radioactive contamination as identified by various radiotracers was also given.

Andrei Zatsepin presented an overview of high-resolution, interdisciplinary field surveys carried out along the eastern coast of the Black Sea during the last five years, in relation to the basin mesoscale dynamics and its impact on plankton, fish eggs and larvae communities. An important finding of these studies is that intense Rim Current can restrict cross-slope exchange and cause the uneven plankton distribution identified for different species on both sides of the shelf-break front, whereas the weakening of the Rim Current gives rise to more even plankton distribution and intense cross-slope transport. Finally, Ahmet Kideys summarized existing knowledge regarding the role of models for ecosystem-based fishery management. His presentation was centered on the description of different factors that, at different degrees, have the potential of affecting ecosystems and fisheries and are subject to both spatial and temporal variability.

Approximately, 50 scientists from the region and beyond actively participated in the panel discussion after the individual presentations. The debate was on a) the major factors controlling the re-organization of the ecosystem during the past several decades, b) whether or not the present status of the Black Sea shows signs of recovery, and c) what could be the fate of gelatinous carnivores and anchovy populations within the next ten years. It was agreed by the audience that anthropogenic perturbations are decaying and the ecosystem is now more strongly regulated by natural climatic variations. Some robust features of the Black Sea ecosystem were identified:

- decrease of nutrient content in the water column and shift of the system towards oligotrophy;

- apparent reduction in the biological production as compared to the 1980s due to the persistence of warming since the mid-1990s;

- comparable level of present day anchovy catch with that of the mid-1970s;

- domination of gelatinous carnivore population by *Beroe ovata*, which suppressed the *Mnemiopsis* population and helped sustain greater anchovy stocks.

It was however agreed by the audience that it is still too soon to talk about ecosystem recovery, as the system continues to be in transient post-eutrophication state. The Black Sea ecosystem fate is expected to critically depend on future environmental conditions, most importantly the degree of exploitation of fishery stocks. In this respect, a careful fishery management may help shifting of the system to a healthy state, which otherwise would regress to the conditions that prevailed in the 1980s and early 1990s.

Two additional issues discussed in the panel were related to the current efforts devoted to operational oceanography and end-to-end, holistic modelling approaches, to enhance the understanding of ecosystem functioning and sustainable management of resources.

# THE BLACK SEA AS NATURAL LABORATORY FOR BIOGEOCHEMISTRY AND MICROBIOLOGY OF ANOXIC HABITATS

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## Abstract

The Black Sea is the largest anoxic basin on earth and provides unique conditions for the study of microbial habitats and controls on key anaerobic microbial processes in the element cycles. Recent studies of European research programs carried out *in situ* measurements of fluxes and turnover of methane and sulfur at seep systems of the Black Sea, and investigated the microbial diversity in permanently anoxic settings, especially those associated with fluid flow and gas seepage. This presentation will summarize recent work on shallow and deep continental margin settings northwest of Crimea and in the Sorokin Trough and present first results of the expedition MICROHAB with RV METEOR (HERMES project).

Keywords : Bacteria, Biodiversity, Black Sea, Mud Volcanoes.

Currently, the global inventory of fluid seeps at passive continental margins is growing rapidly, but geological, chemical and biological processes operating at those fluid seeps remain poorly understood. In the Northern Black Sea, a variety of active methane seeps have been identified at depths from 100-3000 m, including actively gas emitting mud volcanoes, and unique microbial reefs. The total area influenced by gas seepage and hydrate deposition is currently not known, but it is likely that a significant part of the methane released into the Black Sea hydrosphere comes from methane release from subsurface sediments [1]. The main objectives of the recent expedition METEOR M72/2 "MICROHAB" was to map specific methane-driven microbial habitats at high resolution, to quantify the composition, distribution and development of microbial communities in the anoxic Black Sea, and to obtain insight in element cycling and export at different types of fluid seeps in the Black Sea. This expedition carried out in Feb. and Mar. 2007 contributes to the GEOTECHNOLOGIEN program MUMM II studying the microbiology and biogeochemistry of methane and sulfur turnover by in situ technologies, as well as to the EU FP6 Integrated Project HERMES which deals with the biodiversity of hot spot ecosystems at Europe's continental margins.

Methane is produced in ocean margin sediments as a consequence of the microbiological degradation of organic matter buried below the zone of sulfate penetration. As methane builds up, it migrates upwards and may reach the sediment surface, where it leads to the formation of complex geostructures such as pockmarks or carbonate chimneys and platforms, caused by methane ebullition and oxidation, or of large scale topographies on the deep sea floor such as mud volcanoes and carbonate mounds. The microbiological key process of sub-surface methane oxidation accounts for perhaps 90% of the entire methane flux in the sea floor and, therefore, plays a critical role as a barrier against methane emission to the sea and atmosphere [1].



Fig. 1. Methanotrophic reefs of the NW Crimea margin. Left: Sampling of escaping gas. Right: Measurement of microbial methane turnover in the microbial mat. Source: MARUM, Exp. MICROHAB M72/2.

The formation of carbonate nodules, chimneys and crusts can be related to methane oxidation at fluid seeps, and the responsible methanotrophic communities can be traced via analysis of biomarker isotope signatures even in fossil carbonates. Key players in this process are some enigmatic archaeal/bacterial communities, which use sulfate for the anaerobic oxidation of methane (AOM) or for the oxidation of higher hydrocarbons. In the Black Sea, unique microbial habitats of previously unknown biomass accumulations form above gas seeps, because oxygen is absent and thus any higher life [2]. This affects the biogeochemistry of methane and sulfur turnover considerably, making the Black Sea an interesting natural laboratory to study anoxic microbial processes and their signatures in the geosystem.

For the research during the expedition with RV METEOR M72/2 "MI-CROHAB" with the remotely operating vehicle QUEST (MARUM) the following target areas have been selected (Fig. 1): 1) In the northwestern Black Sea, hundreds of active gas seeps occur along the shelf edge west of the Crimea peninsula at water depths between 35 and 800 m. At some of the shallow Crimean seeps, microbial mats were found associated with isotopically light carbonates. Aspects of the microbiology, sedimentology, mineralogy, and selected biomarker properties of these deposits were recently described [2,3]. 2) Abundant mud volcanoes and near surface gas hydrate occurrences were found in the Sorokin Trough (Fig. 2; [1]). The mud volcanoes have diameters of up to 2.5 km and heights of up to 120 m above the surrounding sea floor. We have focussed on the Dvurechenskii mud volcano, a flat-topped and very active mud volcano in the Sorokin Trough with a highly interesting geochemistry



Fig. 2. Mud volcanoes of the Sorokin Trough. Source: after [4]

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# KNOWLEDGE FROM THE BLACK SEA: A ROLE MODEL FOR ECOSYSTEM MANAGEMENT

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### Abstract

There has been substantial accumulation, particularly during the last two decades, of accessible information about the Black Sea ecosystem. Major natural and anthropogenic factors (i.e. pollution, eutrophication, overfishing, invasive species, climatic changes) have all been shown to have impact on the overall ecosystem dynamics of the Black Sea, often collectively. Successful models encompassing all these factors simultaneously are needed as an indispensable tool in overall ecosystem based management in the Black Sea. The information gathered on the abrupt ecosystem changes seen in the Black Sea could be invaluable in solving the similar problems of other ecosystems. *Keywords : Black Sea, Global Change, Species Introduction, Fisheries, Models.* 

With its specific limited characteristics such as (a) biodiversity and relatively short food chains, (b) exchange of water with world oceans, and (c) benthic pelagic coupling, the Black Sea ecosystem could serve as a large laboratory, with strong reactions to tested parameters due to its high productivity. The major threats for pelagic marine ecosystems are (1) pollution and eutrophication, (2) overfishing, (3) human-accelerated climate change, and (4) invasive species. Almost all these threats have been shown to have had impacts on all main components of the Black Sea ecosystem. This is not surprising as can often these factors closely affect each other and any affected component would cause a domino effect through top-down or bottom-up control mechanisms. The role of these factors or components mainly affected may change spatially or temporally.

Trends in the catch of small pelagics reveal much about how these factors and mechanisms affect the Black Sea. The catch of small pelagics in the entire basin, and of anchovy from the southern Black Sea in particular, rose from the 1960s till 1988. The steady increase observed regarding the anchovy catch of the Turkish fishery (that is confined to the southern Black Sea) is not solely due to the use of modern fishing gear, but also to increased fertility (i.e. mesotrophic) of this region and a decrease in predation pressure [1]. Increases in small pelagics for most of the other regions of the Black Sea were only evident until the 1980s when the eutrophication and pollution levels along with accelerated habitat destruction were reported to be strongest for the shallow northwestern shelf regions. The impact from climate change in this period seems low when the system was warm (causing decreased fertility due to limited vertical transport of nutrients) and relatively stable. During the period between 1988 and 1992 the sudden collapse of small pelagics along with zooplankton for all regions of the Black Sea occurred, undoubtedly caused by the invasive ctenophore Mnemiopsis leidyi, a voracious mesozooplankton and ichthyoplankton predator. However, the sudden explosion of this ctenophore, which reproduces at higher temperatures, must be closely correlated with the temperature increase in the late 1980s, following one of the coldest periods in the early 1980s in the Black Sea. It should be noted that an overall high productivity level of the basin is the main prerequisite for the success of this ctenophore, which poses no threat to oligotrophic regions. The sharp decrease in temperature during the early 1990s was beneficial for the small pelagics, through (a) increasing the overall productivity due to vertical mixing and (b) decreasing levels of the competing Mnemiopsis. During the warming period of the mid 1990s, Mnemiopsis peaked again, causing sharp decreases in zooplankton and fish but high chlorophyll levels (due to decreased grazing). Field observations and modeling studies unquestionably underline the key importance of this ctenophore in the ecosystem dynamics [2,3,4]. The appearance of another invasive ctenophore Beroe which feeds exclusively on Mnemiopsis has resulted in a much lowered preassure on fisheries (and ecosystem) from the latter during the last decade, emphasising the importance of top-down control in the food web of the Black Sea [3]. Based on observations from the Black Sea, timely warnings and mitigations have already been put forward for similar ecosystems (i.e. Caspian Sea, Baltic Sea etc) which are also suffering from the invasion of Mnemiopsis.

Trophic models encompassing the major components of the Black Sea ecosystem have been refined during the last decade [4,5]. Future models would benefit from integrating the rates of changes in all major threats to the ecosystem, the main ecosystem components, along with detailed fisheries parameters. The accumulated knowledge gathered from the Black Sea may facilitate the application of such a holistic ecosystem approach towards better management of its resources.

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# WHAT CAN RADIOTRACERS TELL US ABOUT THE FATE OF BLACK SEA CONTAMINANTS?

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## Abstract

It is commonplace that radiotracers are time clocks for environmental processes: they can be used to trace water masses, to quantify mixing, to assess sedimentation rates, to fingerprint sources, to study transfer of contaminants in the food chains. The application and applicability of radiotracers, combined with other markers, to the study of sources and pathways of contaminants in the Black Sea are critically reviewed.

Keywords : Radionuclides, Models, Pollution.

Due to its particular oceanographic features, scientists often term the Black Sea "a natural laboratory". As a side-effect of human activities, this over-sized experimental tank received two major inputs of anthropogenic radioactive tracers: (1) the global fallout, peaking in the early 1960s, following the atmospheric nuclear tests, and (2) atmospheric fallout and riverine input following the 1986 Chernobyl nuclear power plant accident. The latter event created public concern for the potential radiological effects on humans, which were finally estimated as negligible for marine exposure pathways [e.g. 1], and was at the origin of much scientific work carried out and published over the last 2 decades [e.g. 2-5, to quote only a few publications]. In addition natural radionuclides and stable isotopes have also been applied in a variety of studies [e.g. 6, 7]. The published results increased considerably the knowledge on Black Sea oceanography and on the fate of contaminants (see example in Fig.1), being of particular value due to the environmental and ecological problems facing this marine basin.





Fig. 1. The radiotracer-based reconstruction of the geochronology of PCB input to bottom sediments of Sevastopol bay, in a core collected at Pavlovskiy Cape - Southern Bay, 44°37.06 N; 33°32.13 E indicates a nonuniform input rate [8], attributable to various levels of economic activity in the area. Post-depositional migration of PCBs is equally observed.

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# THE BLACK SEA COASTAL ZONE: PRESENT-DAY STATE AND THREATS ARISING FROM GLOBAL CHANGE AND FROM REGIONAL VARIABILITY

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## Abstract

The total length of the Black Sea coastline is over 4 400 km and it belongs to 6 states: Bulgaria, Turkey, Georgia, Russian Federation, Ukraine and Romania. The proposed zoning of the Black Sea coastal zone evidences 17 main zones characterised by different geology and morphology, as well as specific littoral water circulation, sediment drift systems and sedimentary budget. These zones belong to three main morphodynamic categories: (1) low, accumulative coasts mostly related to the rivers mouth zones (mainly sandy complex barrier beaches with strong longshore sediment drift systems); (2) Erosive coasts within lowstanding plateaux and plains, with active cliffs with very narrow beaches in front of the cliffs; (3) Mountainous coasts, with cliffs, marine terraces, land slides, sometimes with sandy or gravely beaches. An overview of the coastal erosion in the Black Sea and of factors controlling these erosional processes is given. The threats to the coastal zone generated by global changes and anthropogenic pressure are analysed. The most vulnerable sections of the Black Sea coastal zone exposed to environmental risks are presented and analysed. *Keywords : Coastal Processes, Erosion, Black Sea, Global Change.* 

The Black Sea coastline

The total length of the Black Sea coastline is over 4 400 km and it belongs to 6 states: Bulgaria, Turkey, Georgia, Russian Federation, Ukraine and Romania. The Black Sea coastal zone can be divided in 17 main zones characterised by different geology and morphology, as well as specific littoral water circulation, sediment drift systems and sedimentary budget [1].

In a more general approach, the Black Sea coast zone could be subdivided into three main morphodynamic categories, with very specific characteristics and behaviour:

1. Low, accumulative coasts mostly related to the main rivers mouth zones. This type of littoral zone consists of sandy complex barrier beaches with strong longshore sediment drift systems; these zones are generally characterised by isostatic adjustments of overloading by rapid accumulation of sediments (subsidence). To this type belongs the Danube Delta front with a very exposed to erosion littoral of about 240 Km; two sections of the River Dnieper liman - Karkinit Bay unit: the Kinburn spit - Dolgyi Island section ( $\sim$  20 Km) and the Tendra spit - Dzharylgatch Island section ( $\sim$  137 Km); the Taman - Anapa unit (about 200 Km long); the Kolkhida (Rioni) Lowland where the rivers Chobi, Rioni, Inguri and Supsa have built up their deltas; on the Turkish coast there are the deltas of Kizilirmak, Yesilirmak and Sakaraya rivers, and finally, in Bulgaria, sandy accumulative beaches related mainly to the rivers Diavolska, Kamchya, Provadyiska and Batova, summing about 100 Km.

2. Erosive coasts in front of lowstanding plateaux and plains, with active cliffs in lœss and lœss-like deposits, sometimes underlyed by older deposits as Pontian limestones, Meotian clays and Sarmatian lumachelles, with very narrow beaches in front of the cliffs. To this type of coasts could be distributed the north-western unit of the Ukrainian coastal zone (from the northern limit of the Danube Delta to the town of Ochakov or the western limit of the Dnieper liman, summing 232 Km), the southern unit of the Romanian coastal zone (Cape Midia - Vama Veche at the Bulgarian border - about 75 Km long), and the northern part of the Bulgarian coast, from the Romanian border to Caliacra Cape (about 50 Km long) [2].

3. Mountainous coasts, with cliffs, marine terraces, land slides, sometimes with sandy or gravely beaches. This type of coasts is generally subject of isostatic and orogenic uplift. To this type are belonging the coasts of Crimea, Caucasus, Pontides, Strandza and Staro Planina Mountains, as well as of Frangensko and Avrensko plateaux [1,2].

*Coastal erosion in the Black Sea: factors controlling the erosional process* The coastal erosion in the Black Sea represents one of the main environmental concerns of the riparian countries. The erosion is controlled by: a) Global and natural factors. The Black Sea coastlines erosion is strengthened as everywhere in the World Ocean by the global changes and the general sea level rise. The coast erosion will depend on synergetic effect of factors controlling the littoral processes (meteorological regime, wave energy regime, water circulation, sediment supply and drift etc.), global changes and the consequent modification of the energetic level of the coastal sea, general sea level rise and regional characteristics as shoreline morphology, elevation and geologic constitution, subsidence or/and neotectonic regime.



Fig. 1. Erosion of the Danube delta.

b) Anthropogenic factors. The coast zone erosion and the state of the coastal sea ecosystems are strongly affected by anthropic activities, the effect of which is added to the impact of natural factors. The anthropogenic changes of large rivers hydrologic characteristics (water and, especially sediment supply, regularisation of floods etc.), men-made littoral structures as breakwaters, dykes, groins, harbours etc., which are modifying the littoral circulation cells, the uncontrolled use of beach sand, dredging of sand too close to the beaches or within the river mouth bars and many other activities are causing an enhancement of coastal erosion and endangering of the coastal ecosystems.

The low, accumulative coasts (first category of coasts described above) are the most influenced by global change, specifically by the sea level changes and by the changes in the river sediment inputs [1, 3-5]. The decreasing sediment supply and changes in littoral sediment drift due to anthropic activities (river damming, hydrotechnical regularisation, littoral structures etc.), especially when the sandy beaches are low, added to the rising of the sea level and the increasing of littoral sea energy could determine in certain conditions a very active and almost continuous recession of the beach line (up to 20 m/y, as it happens in some sections within the Danube Delta littoral - Fig.1) [1,5,7].

The coasts in front of lowstanding plateaux and plains (2-nd category of coasts) could be also affected by erosional processes but the rates of coastline regression do not reach the same values as within the first category (only 1-2 m/y). In this case the erosion affects mostly the narrow beaches in front of the cliffs or the stability of cliffs [2,7].

The mountainous coasts (third type of coasts) are the least affected and transformed by the erosional processes. Generally, the littoral of this type is constituted of consolidated rocks, resistant to the eroding process. In front of such rocky littoral there are no beaches or they are very narrow and coarse grained (coarse-grained sand and pebbles).

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# BLACK SEA DYNAMICS AND ITS IMPACT ON PLANKTON COMMUNITIES

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## Abstract

The peculiarities of interactions between the Black Sea basin- and mesoscale dynamics and their dependences on wind forcing and continental slope topography are considered on the base of the ship-borne, drifter, satellite data analysis and laboratory modeling results. It is shown that the dynamical regime of currents considerably affects the cross-basin exchange and the spatial distribution of plankton biomass.

### Keywords : Black Sea, Plankton, Deep Sea Processes.

The Black Sea is a semi-enclosed basin with complicated ecological conditions, which are a result of its limited water exchange with the adjacent seas and enhanced contamination/eutrophication caused by river discharges, city and tourist resort wastes, oil and other pollution from intensive shipping and oil terminals. Most of the contamination/eutrophication comes from the shore and near-shore regions, and hence the horizontal exchange, which strongly depends on the Black Sea dynamics, should be important for the shelf zone self-purification and nutrient supply into the open basin.

The classical scheme of the Black Sea basin scale circulation includes the Rim current (RC) cyclonically flowing along the continental slope. Broad oceanographic application of satellite remote sensing revealed energetic mesoscale eddy-like structures that produce an effective cross-basin exchange (Fig 1) [1]. Although the satellite images give an idea on the mechanism of the horizontal mixing it is hardly possible to obtain its regular features by using the satellite data only.



Fig. 1. The Black Sea mesoscale dynamic activity: AVHRR sea surface image (combination of channels 1 and 2) from NOAA-11 (23 June 1993 at 13:10 GMT). Light (dark) shades correspond to high (low) backscattering, consequently.

New quantitative information on basin- and mesoscale circulation and horizontal exchange processes in the Black Sea upper layer was obtained from the international drifter experiment. During 5 years (1999-2003), more than 50 SVP and SVPB Lagrangian satellite tracked drifters were deployed in different parts of the sea. Drifter trajectories indicated the general cyclonic circulation, the presence of RC and the existence of intensive mesoscale eddies (mostly anticyclonic) both over the continental slope and in the deep part of the sea. Using the drifter data an estimate of the horizontal eddy diffusivity was obtained and the timescale of the exchange between the central part and coastal zone of the sea was determined. The latter turned out to be 3-6 months that is nearly the same as a timescale of drifter round-trip in the RC. So it is reasonable to propose that the RC basin-scale advection and cross-basin exchange induced by mesoscale eddies are interrelated [2, 3].

cross-basin exchange and their dependences on wind forcing and bottom topography were studied with the help of field observations and laboratory modelling [4]. It was shown that in the northern-eastern Black Sea where continental slope is very narrow, the topographic control of RC is not strong. Position and stability of RC are governed by wind forcing (Ekman pumping). Under high positive Ekman pumping, RC is a coherent and strong jet located over the continental slope. In that case "shelf-deep sea" exchange is rather weak: coastal and deep waters are separated by the dynamical front. In the opposite case, RC becomes unstable, meandering and breaks up into eddies. Some of the eddies penetrate into the central basin producing strong lateral exchange. It should be pointed out that, due to variability of Ekman pumping, transition from jet-dominating regime of RC to the eddy-dominating regime occurs several times a year. In the north-western Black Sea with wide continental slope, both the RC and the mesoscale eddies should be topographically controlled.

In case of narrow shelf, the RC regime strongly affects the distribution of plankton species. Intense RC restricts cross-slope exchange and causes the uneven plankton distribution. The weakening RC is accompanied by intense cross-slope transport and causes more even plankton distribution [5]. Eddy-induced cross-slope transport affects the abundance and composition of benthos species (by removing the larva from shelf to deep sea).

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Physical interrelations between the basin -and mesoscale water dynamics,

PANEL 3

# **Ecosystem Changes: past, present, and future** *Modérateur* : Evangelos Papathanassiou

# HYDROCHANGES: FIRST RESULTS AND PERSPECTIVES

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#### Abstract

Five years after its launching, the CIESM HydroChanges hydrological monitoring program (see www.ciesm.org/marine/programs/hydroch anges.htm for full partnership and details) has become routinely operational in most selected sites. An overview of the first scientific results is presented here.

Keywords : Hydrology, Time Series, Monitoring.

HydroChanges was initiated in 2002, following a dedicated workshop organised by CIESM. At each site,  $\theta$  and S time series such as the ones shown on Fig. 1 and Fig.2 (S not shown for clarity) are collected, most often completed by current measurements. Even though the program is in its early stage, several papers partly or entirely based on HydroChanges data are presently under review or published by individual partners. At Gibraltar, Millot *et al* [1] first compared the Jan 2003-Apr 2004  $\theta$  and S time series sampled at 270 m in the deepest part of the Camarinal sill (Fig.1b) with all the historical data collected there since the '60s.They concluded that the deepest outflowing waters have been continuously changing from the mid-1990s,  $\theta$  and S now being much warmer and saltier (+0.3°C and +0.06) than 20 years ago. They ascribed these changes to modifications of the outflow composition from [LIW-TDW-WMDW] to [LIW-TDW] only (TDW being a varying mixture of eastern EOW and western WMDW) and invoked the EMT as a possible cause for this dramatic evolution.



Fig. 1.  $\theta$  time series collected in the western basin.

Analysis of the remaining Apr 2004-Oct 2005 data showed that the densest part of the outflow markedly changed near mid-Apr 2005 becoming again "more western than eastern" (Fig. 1b) [2]. Millot [2] also notes a significant increase of the inflow's salinity (at 80 m) of  $\sim 0.05$ /year over the 2003-05 period and points out that salinification of AW was rarely considered for explaining the long-term historical trends observed in the whole sea. Another mooring maintained by UM at Gibraltar's Espartel sill, the "last gate" of outflowing waters to the Atlantic, has been operating since Oct 2004. It supports a SBE37 at 355 m, coupled with an upwardlooking ADCP. According to García-Lafuente et al [3], the Oct 2004-Oct 2006  $\theta$  and  $\sigma_{\theta}$  time series show a seasonal cycle with relatively warm and light waters outflowing in winter (with maximum volume transport in April). These features are linked by the authors to WMDW formation, supposed to replenish the deep western basin by the end of winter and thus to rise the interface between WMDW and the above waters. The saw-tooth pattern observed on the records (rapid cooling in winter and subsequent slow warming) is found consistent with this interpretation.

In the NW Med, the SBE37 and currentmeter deployed at 1875 m by ICM-CSIC recorded effects of WMDW formation and shelf-cascading

during winter 2005. From Oct 2003,  $\theta$  and S were found almost constant without any seasonal signal. They suddenly increased at the end of Jan 2005, dropped again in early Mar 2005 and displayed rapid fluctuations during ~1 month before reaching new stable characteristics in Apr 2005. According to Font *et al* [4], the resulting water is a mixture of newly-formed anomalously warm and saline WMDW ("B" on fig. 1a) and of water resulting from an intense and persistent shelf cascading process ("C"). Font *et al* also note that the sudden variations in late January and early March preceded the dramatic changes in the structure of deep CTD profiles observed in the NW Med in spring 2005 by Schröder *et al* [5] who found a clear correspondence between this evolution and the propagation of the EMT signal from Sicily to the NW Med (Fig.2).



Fig. 2.  $\theta$  time series collected at 450m in the western sill of the channel of Sicily by ISMAR-CNR. The highest  $\theta$  and corresponding S (not shown) evidence a remarkable input of heat and salt in the western Med [5].

We trust that links between time series collected in the western basin can be established. We will present a preliminary analysis during the congress, as a starting point for further discussion among HydroChanges partners.

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# HISTORICAL OCEANOGRAPHIC MULTIDISCIPLINARY DATASETS IN THE MEDITERRANEAN BASIN FOR MODELLING PAST AND FUTURE ECOSYSTEM CHANGES

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## Abstract

Collection of historical multidisciplinary time series and spatial datasets is actually undertaken in the SESAME (Southern European Seas: Assessing and Modelling Ecosystem changes) EU program. Data are collected from existing national and international sampling sites and from different cruises in the Mediterranean and Black seas. The aim is to analyse the changes in the ecosystems and forcing variables. Emphasis is given on the data collection on pelagic biodiversity and biomass of bacterio-, phyto- and zooplankton and nekton. Geochemical data related to sequestration of carbon and to the temporal evolution of the Mediterranean basin's river systems will be collected as well. Typical marine habitats will be defined and mapped. The data will be used for trend analyses and for model validation. *Keywords : Hydrology, Food Webs, Time Series, Geochemistry, Models.* 

#### Introduction

The scientific objectives of SESAME are to assess and predict changes in the Mediterranean and Black Sea ecosystems (SES) and in their ability to provide goods and services. Both seas will be approached as a coupled climatic/ecosystem entity, with links and feedbacks to the world ocean. The assessment of ecosystem changes will be based on the identification of the major regime shifts that occurred during the last 50 years. Mathematical models validated and upgraded using existing and new observations will be used to predict ecosystem responses to changes in climate and anthropogenic forcings during the next five decades. SESAME will provide an integrated, ecosystem based approach, with a coupled climatic/ecosystem modelling.

#### Scientific objectives

 Identify the major changes and/or regime shifts and the natural and anthropogenic forcings responsible for these changes for the last 50 years.
 Assess the current ecosystem status that represents an important landmark from which future evolution of the SES ecosystems can be estimated.
 Collect historical and current multidisciplinary datasets, including new observations, in order to analyse the signals of environmental changes in the past and validate the models.

4- Collect new information through multidisciplinary, multiship oceanographic cruises in the SES.

#### Assessment of past changes in the Mediterranean and Black seas

The resilience of ecosystems depends on the levels of functional diversity. For a given ecosystem, functionally diverse communities are more likely to adapt to climate change and climate variability than impoverished ones. The conservation of biodiversity and functional types, along with the reduction of habitat loss, fragmentation and degradation, may promote the long-term persistence of ecosystems. Therefore, in order to assess impact of the climate change and anthropogenic activities we will collect historical multidisciplinary and time-series data from: published databases, grey literature, reports and observations, cruise data, unpublished existing datasets as well as from re-treatment of historical samples, where necessary. Comprehensive datasets will be organised and introduced into SESAME databases. Data on phytoplankton biomass and biodiversity will be collected from various areas reflecting the diversity in the photosynthetic production. Zooplankton species associations will be used as indicators to evaluate long-term changes in the marine environment. related to the climate change and to increased anthropogenic pressure. An effort will be devoted to construct a zooplankton research and monitoring network (i.e. MedZoo built in the framework of the CIESM Zooplankton Indicators program) that will include the Black Sea and Mediterranean countries. Existing long time zooplankton and environmental data series (figure 1) collected at several sites of the SES, will provide a unique database for assessing trends and shifts in pelagic ecosystems [1,2,3]. MedZoo is a CIESM initiative that will act within the project and may become a legacy of SESAME to the SES community.

Data concerning fish stock biomass parameters, species diversity and composition will be collected and occurrence and abundance of invasive species will be investigated. Information on the habitat types will be ranked according to features regarding resistance, resilience and vulnerability. Quantitative and qualitative information on water column characteristics related to the carbon cycling including remotely determined sea temperature, colour and sea level fluctuations will be provided. Seafloor biogeochemical processes related to the marine carbon fixation will be monitored and changes in the quantity of organic matter and analysis of time dependent changes in macrofauna composition will be carried out. Information will be given on the effects of the variability of river discharges on the evolution of plankton communities in the estuaries impacted by anthropogenic activities. The controlling factors influencing variability in river discharge at decadal and centennial scales will be assessed.





Fig. 1. Coastal zooplankton long term series. The gap in the data from southern Mediterranean is to be completed through the activities of the MedZoo CIESM group (axes: longitude and latitude).

Data collected in the different fields will be used first for the simulation of major changes in ecosystems functioning in the last 50 years in response to natural and anthropogenic forcings. In the second phase, future scenarios as outcomes of predictive models will be validated against the past observations.

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# RIVER INPUTS TO SOUTHERN EUROPEAN SEAS: MAJOR DRIVERS FOR ECOSYSTEM CHANGES DURING PAST AND FUTURE DECADES?

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## Abstract

The purpose of this paper is to highlight the changes that characterize the river discharges of water and nutrients of Mediterranean and Black Sea rivers during recent decades, giving them an important role in the control of the productivity and distribution of the marine ecosystems that depend upon these inputs. In particular the fluxes of inorganic nitrogen and phosphorous species evolved very differently, and the nutrient availability in the coastal zones may have been altered significantly, not only quantitatively, but also qualitatively. *Keywords : Eastern Mediterranean, Western Mediterranean, Black Sea, River Input.* 

The influence of river basins on the coastal zone and even on the open part of enclosed seas as the Mediterranean has been recognized since the early 1970s as a key driver in sediment, water, nutrients and pollutants budgets when UNEP launched a series of Regional Seas Programmes on the Caribbean, Gulf of Guinea and Mediterranean, among others. These first studies pointed out the great heterogeneity of Mediterranean and Black Sea rivers in terms of water runoff, sediment discharge, and associated nitrogen and phosphorus fluxes, mainly due to the great climatic variability in this region and the related differences of land use and socio-economic practices in the corresponding drainage basins.

Also at temporal scales, the evolution of the river inputs is characterized by great differences. Several reasons can be cited for this. First of all, the river inputs directly translate the effect of climate change on the Mediterranean and Black Sea regions. A first state of the art evaluation [1] indicates that freshwater inputs by rivers might have considerably changed during the last century, at least for the Mediterranean Sea. Precipitation rather increased in the high latitudes, whereas it tended to decrease in the lower latitudes. This should have strengthened the contrast between the water inputs from the north and from the south.



Fig. 1. Evolution of the annual fluxes of nitrate (A) and phosphate (B) in three major Mediterranean rivers [1]

Moreover, the river inputs directly reflect the intensification of human activities in the corresponding drainage basins. Certain nutrient fluxes, such as the fluxes of dissolved inorganic nitrogen (DIN), are closely linked to anthropogenic controlling factors like population densities and/ or fertilizer spreads. As a consequence, DIN fluxes in the great Mediterranean rivers, such as the Po and Rhone rivers, increased since the '70s at least by a factor of two or three, mainly because agricultural practices changed (Fig. 1A). But nutrient levels in rivers are also sensitive to policy changes and other changes that affect societal behaviour, and not all human released nutrients followed this increase. An illustrative example for this is the riverine flux of dissolved inorganic phosphorous (DIP), which, as DIN, also strongly increased from the '70s on, but then decreased drastically during the eighties or nineties because of the banning of phosphate detergents and the improvement of wastewater purification in the drainage basins (Fig. 1B).

Finally, the river inputs are strongly affected by dam constructions. Since the second half of the last century, dam constructions rapidly increased in the Mediterranean and Black Sea countries, which had a considerable impact on the rivers. On the one hand, water extraction for irrigation and drinking water could be intensified, which also contributed to the decrease of the freshwater inputs especially by the southern rivers. On the other hand, dams strongly reduced the riverine transfer of particulate and dissolved nutrients (e.g. silica) to the sea.

Up to now, the forcing of the marine ecosystems through rivers has not been evaluated on the scale of the Mediterranean and Black Sea on the whole. This issue was the focus of a recent CIESM Workshop [2] and it is one of the objectives of the EU project SESAME (Southern European Seas: Assessing and Modelling Ecosystem changes). Reconstructions and modelling data for the riverine nutrient fluxes will be combined with a variety of biological models in order to test whether the river discharges can explain the major changes in productivity and compositions of marine biota that were observed during the last decades, and, together with climate and anthropogenic change scenarios for the future, whether they may affect the ability of the marine ecosystems to provide goods and services in the near future.

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# IMPACT OF HUMAN ACTIVITIES ON PRESENT-DAY MEDITERRANEAN RIVERS

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## Abstract

Human activities on rivers discharging into the Mediterranean Sea have affected annual as well as seasonal discharge, annual sediment loads, and the quantity and character of dissolved constituents. As population pressures increase, these trends undoubtedly will accelerate. Present and future environmental changes and their impacts require a more concerted monitoring effort as well as an efficient dissemination of data and observations.

Keywords : River Input, Coastal Systems, Monitoring.

Rivers discharging into the Mediterranean and Black seas have long been influenced by human interference to the landscape and to the rivers themselves through such activities as mining, deforestation, agriculture and urbanization. As a result, erosion in Mediterranean watersheds tends to be higher than in other global watersheds (Fig. 1A), and historically sediment delivery to the coastal zone has been elevated.

Over the past century, however, dams and irrigation have reduced discharge from many rivers, including the southern, northeastern and northwestern Mediterranean [1], far more than what one might predict from reduced precipitation (Fig. 1B). In fact, other than French and many Italian rivers, in fact, fluvial discharge to much of the Mediterranean has declined by >50%. The present-day Nile, for example, discharges only a fraction of its pre-Aswan levels, and during this same period Ebro discharge has declined by  $\sim$ 50%.

Dams also have affected the seasonality of river discharge, not only in those rivers in which annual discharge has decreased but also those rivers in which annual discharge appears to have changed little. It is not surprising, for instance, that the winter and spring peaks in Ebro discharge have muted (Fig. 2A), but the decreased seasonality in the Dniepr, which discharges into the NW Black Sea, is more surprising since between 1952 and 1984 its annual discharge remained relatively unchanged (Fig. 2B). This presumably reflects water removal for hydroelectric power in the winter and for irrigation in the summer.



Fig. 1. (A) sediment yield versus runoff for Mediterranean rivers, 1000-5000 km<sup>2</sup> in basin area), compared with similar-sized mountainous rivers in New Zealand, Indonesia, Taiwan and the U.S.A. For any given runoff, Mediterranean rivers generally have 2-10x greater sediment yields, primarily the result of long-term poor land use. Data from Milliman and Farnsworth (in preparation). (B) trends in precipitation and runoff (vs. latitude) of selected African and European rivers, 1951-2000. Note the relatively close correlation between the two parameters in sub-Sahara and northern Europe (including the Black Sea: B.S.), but the mostly negative correlation for rivers discharging into Mediterranean (M.S.), reflecting the impact of dams and irrigation.

Changing landuse patterns, particularly land conservation, have meant that many northern Mediterranean watersheds are less farmed and more forested than they were 50-100 years ago. Combined with the trapping of fluvial sediments in reservoirs, sediment delivery to the coastal Mediterranean has declined, often dramatically - even in those rivers whose discharge has remained unchanged (Fig. 2C and 2D). Exacerbating the problem of understanding and managing Mediterranean rivers, the impact

of industrial activities, use of artificial fertilizer, as well as the "ageing" of waters in reservoirs have changed the quantity and character of dissolved solids [2].



Fig. 2. (A) changing seasonality of Ebro at Tortosa before and after major dam construction. Note the decreased annual discharge as well as season variation. (B) Dniepr annual discharge at the river Hydro Dam changed little between 1952 and 1994, but seasonal patterns did change, presumably in response to wintertime use of hydroelectric power and summertime irrigation. (C) and (D) upstream damming of the Danube has led to >50% decline in sediment load despite no change in discharge.

Whether or not such anthropogenic changes are as significant as generally believed (e.g. [3]), the discussion has been considerably compromised by the limited database for many rivers, their estuaries, and surrounding coastal areas. What are the recent changes in discharge, solid and dissolved loads for the rivers draining into the Mediterranean and Black seas? How have these changes affected coastal accretion or erosion, the ecosystem of coastal waters, etc? What has been the effect on coastal fisheries? The answers to some, perhaps many, of these questions may be contained within local and regional databases, but until they are more readily available to the scientific community, a comprehensive regional understanding may remain limited.

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## NONLINEAR RESPONSE OF BLACK SEA PELAGIC FISH STOCKS TO OVER-EXPLOITATION

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### Abstract

A three trophic levels prey-predator model investigates the nonlinear dynamics of the long-term (1960 - 1999) changes in pelagic fish stocks of the Black Sea. The equilibrium analyses first explore the quasi-steady state dynamics of the system under various combinations of the consumption, harvesting and mortality rate values. This knowledge is then used to study the time-dependent nonlinear dynamics and to describe the progression of stocks under temporally varying harvesting conditions. Despite the idealized structure of the model, the simulations reproduce the observations reasonably well. The solutions indicate multiple equilibria of the system and successive "discontinuous" and "smooth" regime shifts between the alternate states controlled by a delicate balance of the consumption and harvesting rates.

Keywords : Black Sea, Models, Fisheries.

Recent studies [1,2] noted the inevitable role of the trophic cascade process under marked changes in the higher trophic level structure of the Black Sea in response to the excessive and continual harvesting of stocks at different periods of the recent past. The quantitative understanding of the likely response of pelagic fish stocks to over-exploitation thus constitutes one of the key issues to gain a deeper insight into the mechanisms that govern the long-term organization of the ecosystem. For this purpose, a simple deterministic model is developed to explore the nonlinear dynamics associated with the long-term stock variations under differing harvesting conditions.

The model is composed of the small pelagic (resource), medium pelagic (consumer) and large pelagic (top predator) groups; the latter involving both large pelagics (with size >90 cm) and dolphins. The small pelagic group grows using resources provided by the lower trophic level, and is consumed by both medium pelagic and top predator groups. As the top predator and the consumer groups compete for a single resource, the predator group feeds on the consumer group as well. For simplicity, demersal stock variations and their interactions with small pelagics are not explicitly taken into account because of their negligible role in the Black Sea fishery after the 1960s. All groups are subject to linear harvesting, and the system is closed by the quadratic mortality terms for the top predator and medium pelagic groups. Further details on the model are given in [3]. The simulated stock and catch variations agree well with the observations despite the simplicity of the model dynamics (Fig. 1).



Fig. 1. Temporal variations of the observed (bold circles) and simulated (open circles) stock biomass (ktons), and the observed (bold squares) and simulated (open squares) catch (ktons) for small pelagics. The straight line represents the fishing mortality of small pelagics  $(yr^{-1})$  used in the simulations.

The small pelagic stock possesses three distinct successive transitions between its low regime (<350 ktons) and high regime (>950 ktons). The first transition (TR1) comprises the period from 1969 to 1973, during which it switches to the high stock regime. The shift occurs at the large pelagic fishing mortality threshold rate of  $f_3 \sim 0.55$ , at which the top predator stock drops below the threshold value of 40 ktons. Upon increasing  $f_3$ to 0.7, the top predator stock decreases further and vanished by the mid-1970s, which coincides with the transitional period from the low to high stock regime of small pelagics. The transition of the medium pelagic stock from the low stock regime (less than 60 ktons) to the high stock regime (greater than 180 ktons) follows that of small pelagics with some time lag.

The high stok regime of small pelagics persists until 1982, after which the

second transition (TR2) during 1983 - 1986 brings the stock back to its low stock regime. TR2 begins at the small pelagic stock harvesting rate  $f_1 \sim 0.6$ . Above this threshold  $f_1$  value, small pelagic stock is continually depleted at the expense of maintaining a steady catch level around 600 ktons. As the stock approaches the low stock regime for  $f_1>0.6$ , the catch then drops dramatically down to  $\sim$  150 ktons within a few years. The medium pelagic stock increases up to 250 ktons until 1984 under low fishing mortality rates around 0.3 - 0.4. Thereafter, as the fishing mortality rate gradually rises to  $\sim$  0.6, the stock starts declining within the high stock regime and finally switches back into the low stock regime during 1988 - 1989 concurrently with small pelagics. At the medium pelagic stock harvesting rate  $f_2 \sim 0.6$ , the catch becomes as high as 120 ktons and then drops abruptly to less than 60 ktons as the stock tends to approach the low stock regime. Thereafter, the medium pelagic stock remains within the low stock regime until the end of the simulation period for decreasing fishing mortality rate to 0.4.

The low stock regime of small pelagics lasts only four years. Once its fishing mortality rate falls below the threshold value of 0.6 by 1993, the stock starts increasing linearly (i.e., the third transition, TR3) and moves into the high stock regime at 1998 when  $f_1 \sim 0.3$ . Although the range of  $f_1$  between 0.45 and 0.60 during the transition governs the ultimate stock size of small pelagics in the high stock regime, the crucial factor which promotes the switch is the specific choice of  $f_2$  values. Values greater than 0.4 support the increase in the small pelagic stock but keep the medium pelagic stock depleted. Smaller values force the transition of small pelagics to take place at the lower  $f_1$  threshold values and to accompany a certain increase in medium pelagic stock. The latter case presents a stock recovery option with the existence of balanced stocks of both small and medium pelagics in the system.

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## INTEGRATED APPROACHES TO MARINE GOVERNANCE. A PERSPECTIVE ON SCIENTIFIC MODELING AND SOCIO-ECONOMIC ANALYSIS

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## Abstract

On the eve of a new EU Maritime Strategy, scientific modeling and socio-economics are increasingly combined, promising a more effective and reliable approach towards sustainable use of marine resources. Presently, several integrated approaches to marine governance are designed and tested within international research consortia. Their research strategy is generally based on the understanding and quantification of the links between (ecosystem) functions and (human) uses, (nature's) services and (societal) well being. This paper aims at highlighting the main issues involved and offers a specific framework for integrating scientific modeling and socio-economic analysis. Topics to be discussed include: a) functions and servises b) scale mismatch, c) coping with non-linearities, d) evaluation of policies and societal objectives.

Keywords : Environmental Economics, Models.

Seas are notoriously complex and scientifically unexplored systems, encompassing highly variable biotic and abiotic components. On the eve of a new EU Maritime Strategy, scientific modeling and socio-economic approaches are increasingly combined, promising a more effective and reliable approach towards sustainable use of marine resources. Presently, several integrated approaches to marine governance are designed and tested within international research consortia. Their research strategy is generally based on the understanding and quantification of the links between (ecosystem) functions and (human) uses, (nature's) services and (societal) well being. What is the role of socio-economic approaches in informing marine policy and governance? And what does the recognition of marine ecosystem complexity entail for such approaches?

The term "socio-economic" approaches encompass a wide range of methodological tools and often quite diverging standpoints. "Speaking truth to power" means communicating to decision makers the appropriate mix of "facts and values" necessary for designing and assessing environmental policies; in this respect, neither pure scientific data nor subjective presumptions alone would be appropriate in informing public policy agencies. We limit the present discussion to four, we believe, central themes within environmental socio-economic approaches: a) functions and services, b) scale mismatch, c) coping with non-linearities and d) evaluation of policies and societal objectives. Ecosystem functions are processes describing physical, biological and chemical interactions in nature. Thanks to joint efforts with natural scientists, our 'production functions' linking natural and engineering processes with economic goods and services are far better understood. But functions are not to be confused with (ecosystem's) services: services are the end-products of functions, direct or indirect, influencing human well-being and therefore valued by humans in market or non market settings [1]. A first step towards a better communication between ecologists and social scientists depends crucially on clarification of terminological issues referred to ecosystem services.

Social sciences have a very limited use for the problem of (spatial) scale. In economics the problem resolves around the aggregation of individual data (microeconomics) into institutional ones (macroeconomics). Still, economics are quite flexible in accommodating different spatial scales by upscaling data from individuals to local, regional, national, supranational scales. Political science takes a different stance, since its main units of theorizing are stakeholder groups (families, trade unions, parties, administrations, etc). The problem is facilitated by appropriate scoping analysis. The methodological framework DPSIR (Drivers-Pressures-State-Impact-Response) offers a convenient platform whereby scale mismatches are made transparent [2].

With respect to economic valuation, two main conclusions can be drawn. Firstly, since we are forced to act in the face of potentially irreversible ecosystem change, we have to be proactive and, consequently, conservative in our management plans. A sustainable use of resources has to take into account the existence of thresholds and other irregularities in the functioning of ecosystems under what is widely known as "safe minimum standards" (SMS) approach ([3]). The above recognition enhances the relevance of *ex ante* economic valuation studies. However, it is plausible to assume that present societal preferences for environmental goods and services are fuzzy and lack articulation. The act of eliciting environmental preference structures with that of *constructing* them. We can

think of three possible ways to understand underlying preferences for environmental goods and services [4]: First, through observed choice, second, through verbal expressions and conversation, and third through observed adaptations due to learning. All three options have been to a lesser or greater degree utilised in the literature, spawning a variety of methodologies [5]. Analysts have investigated a wide range of valuation problems and contexts including, for example, the mismatch between expert and public perceptions of environmental quality in coastal areas; the differences between perceived and actual quality levels and their links to actual policy making and objectives setting; and the potential to combine quantitative and qualitative data using stakeholder focus groups.

The fact remains that complexity of both ecosystems and societies does not cancel out the need for hard choices in the face of both natural and societal uncertainties. As generally understood, environmental evaluation of projects and policies is a generic term relating to the identification, measurement and assessment of environmental impacts. Evaluation is a complex and multifaceted process involving a mixture of scientific and non-scientific approaches, a multitude of criteria and metrics. Evaluation is both a cognitive process as well as an institutional practice. It consists of a prior, analytical phase and a consequent synthetic phase. Analysis here means scientific identification and quantification of natural trends and impacts whereas synthesis is reserved for socio-economic and policy assessment of the impacts. The term valuation on the other hand is usually reserved for comparisons between objects while economic valuation refers to assigning relative values to mutually exclusive objects. Economic values are relative, because they assess the importance of objects/policies always in relation to foregone possibilities for alternative objects/policies. Economic objects/policies valued in this context are mutually exclusive because they are scarce, i.e. one cannot have all of them at the same time. Accordingly, economic values are practically trade-off coefficients denoting the quantity of a good a person is willing to give-up (usually income) in order to secure the consumption of another (environmental quality).

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PANEL 4

# Chemical contaminants and public health

*Modérateur* : Scott W. Fowler

## PANEL REPORT BY THE MODERATOR

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### Keywords : Radionuclides, Monitoring, Metals, Petroleum, Aeolian Arc.

During the introductory session, the Panel Moderator noted that at a similar CIESM Congress some 35 years earlier, the famed explorer Jacques Cousteau had drawn international attention to the health of the Mediterranean by stating his observations had led him to believe that the Mediterranean Sea was "dying" and in fact could be "dead" in a few decades if nothing was done to stop the problems of increasing pollution and overfishing. Fortunately 35 years on, the Mediterranean Sea is far from dead but his comments did more to raise public awareness about the problems of protecting the marine environment and spur international actions to stem pollution in the Mediterranean than much of the sound scientific data being produced by scientists studying the problem at that time. Although over the ensuing years much effort has been put into assessing the degree and extent of chemical contamination in the Mediterranean Sea, an overall lack of baseline information still exists for a broad area of its eastern and southern coasts, as well as for new classes of chemical contaminants that are just now coming to light. It was therefore the task of this Panel to probe and analyze those two aspects in detail and finally debate and suggest approaches and mechanisms for better assessing the overall health of the Mediterranean Sea. To accomplish this the panelists, composed of scientists from both leading national and international institutions, gave seven presentations which dealt with measurement and monitoring of conventional and emerging chemical contaminants in the Mediterranean Sea as well as the ways and means to better integrate ongoing studies, and to build analytical capabilities and monitoring expertise in areas where they are lacking.

With respect to contaminants, a presentation by Francesco Regoli discussed the distribution and bioaccumulation of heavy metals in certain sentinel (bio-indicator) species that have been used to assess metal pollution in both industrialized and relatively clean areas of the Mediterranean. He highlighted the fact that mercury appears to be higher in certain Mediterranean species of top predator fish than in similar species from the Atlantic, and that while the reasons for this observation are far from clear, the increased concentrations might be due in part to the natural mercury anomaly that is present off the northwest coast of Italy. Moreover, his presentation stressed the utility of integrating chemical analyses with determining molecular, biochemical and cellular biomarkers in the species analyzed in order to assess biological effects in the different areas. In one example, using caged mussels placed beneath an offshore drilling platform in the Adriatic Sea, it was demonstrated that early warning signals of environmental stress could be readily detected through specific biomarker analysis. The source and origin of petroleum hydrocarbons along the west coast of Algeria was highlighted in the presentation by Sellali et al. These authors reported the presence of heavy oil contamination in sediments in this sector, most likely derived from the petrochemical complex in the Gulf of Arzew. The very high levels of PAHs noted near Oran were believed to originate from industrial and domestic wastes released from the city, whereas near the outflow of various oueds entering the sea, the hydrocarbons contained a land-based, pyrolytic signal. Their dataset represents one of the first reported for an area of the southern shore where data have consistently been lacking, and it clearly indicates a land-based rather than maritime shipping origin of the contamination.

As concerns emerging contaminants in the Mediterranean, the report of Hélene Budzinski highlighted the need for basic information on the various classes of pharmaceutical substances that have been recently identified in seawater. Her studies have focused on developing analytical techniques for their quantitative measurement in seawater, in particular the use of semi-permeable membrane devices for carrying out integrative sampling. Using these techniques her group has found concentrations of a wide variety of pharmaceuticals in seawater collected off Marseille ranging from a few nannograms to several micrograms per liter, with most of the contamination residing in the dissolved phase.

In terms of strategies for undertaking integrated monitoring studies on contaminants, Hervé Thebault and Alessia Rodriguez y Beana presented results of the first phase of the CIESM Mussel Watch monitoring study of radionuclides using the Mediterranean mussel Mytilus galloprovincialis. Some 20 laboratories from 15 countries were involved in the study, and from that network a regional map for <sup>137</sup>Cs has been produced showing generally very low concentrations in mussels, viz. on the order of 1 Bq kg<sup>-1</sup> or less. Somewhat higher levels were found in mussels from the Black Sea and northern Aegean Sea indicating residual concentrations from Chernobyl fallout. During Phase II the programme will be extended to cover the natural radionuclide <sup>210</sup>Po as well as include some emerging trace contaminants. In connection with the Mussel Watch monitoring approach, Mai Khanh Pham et al. reported that the quality of the data have been verified by ensuring that all laboratories involved participated in a Quality Assurance intercomparison exercise for radionuclides in mussels. The IAEA Marine Environment Laboratories produced a mussel reference material that was analyzed by all the participating laboratories. During the exercise various analytical problems in some laboratories came to light, and capacity building needs were thereby identified. Based on these results and those from nine additional laboratories located outside the region, information values for <sup>137</sup>Cs and several other radionuclides were determined. Further work is presently underway to certify this intercomparison material as an IAEA Reference Material.

Concerning regional programme activities, Michel Warnau presented a concrete proposal for linking and integrating on a basin-wide scale many of the similar monitoring programmes that are underway in the Mediterranean region. Difficulties in project implementation often arise owing to the participating countries having major industrial, agricultural, cultural and regulatory differences. Furthermore current programmes are supported by several different entities including national, regional, European, and international funding bodies, a fact which often leads to overlap in both scope and efforts. These programmes often run in parallel with little or no information exchange amongst them. The proposal aims to better integrate all these projects having similar objectives by coupling, reinforcing and equipping them in a similar fashion which would ultimately result in a synergistic effect thereby enhancing the overall output. Within this integrated effort, key international organizations with expertise in organizing training and capacity building would furnish similar support to all the programmes involved thus making the entire monitoring effort far more cost effective. Furthermore such an approach would lead to enhanced quality assurance of monitoring data since all parties' analytical techniques and methodologies would be unified through inter-comparison exercises of the various analyses. In support of such of obtaining such an integrated monitoring network, Oscar Acuña from the IAEA Technical Cooperation Department explained how IAEA could support such a proposal through its current and future technical cooperation programmes in the Mediterranean and West Asian regions. The overall goal would be to eventually enhance the level of expertise in trace contaminant measurements in participating groups from the southern and eastern rim, in order to bring it up to par with that available in the more developed Mediterranean regions.

Following these formal presentations, the panel was open to comments and discussion and the panelists were queried on a number of points raised by the participants. Regarding conventional contaminants such as metals and hydrocarbons, some participants felt that many contaminant data had already been gathered from a large portion of the Mediterranean and that perhaps it was time to synthesize what is now known before proceeding with more monitoring surveys. There was general agreement that much information had already been obtained through some 30 years of monitoring within MedPol and other programmes, but it was also acknowledged that the geographical distribution of those data was "patchy" at best, and that reliable data still lacked for large areas of the eastern and southern shores of the Mediterranean. It was in these areas that the group felt capacity building was most needed, and that any proposal for an integrated monitoring network should concentrate on reinforcing capabilities in those two areas. In addition to that aspect, other on-going programmes should concentrate more on examining certain emerging contaminants (e.g. pharmaceuticals and caffein, *inter alia*) for which little information, particularly on their biological effects, is presently available. One further suggestion on contaminant priorities, to ensure that sewage wastes were included in any future contaminant monitoring network, was strongly supported by the group and panelists. It was recognized that sewage is considered by international expert groups and public health specialists as one of the top priority marine pollutants needing global attention.

The panel concluded that the first phase of the CIESM Mussel Watch project has been successful, and a reasonably good synopsis of the geographical distribution of <sup>137</sup>Cs was now available. The merits of continuing the project on radionuclides and extending it to other trace contaminants using caged mussels were debated. The levels of  $^{137}\mathrm{Cs}$  found in mussels were very low and it was agreed that, given the low limits of detection for measurements, a 10-50% variation around reported levels would be acceptable. Participating laboratories were therefore urged to continue measuring <sup>137</sup>Cs in mussels, and they were strongly encouraged to analyze <sup>210</sup>Po as well since this natural alpha-emitting radionuclide is responsible for most of the radioactive dose received by humans consuming seafood. The main areas of future focus should be the southern and eastern shores, as well as the entire coast of Italy since routine radionuclide monitoring there had ceased a few years ago. Some questions arose about the use of synthetic indicator materials rather than live "bioindicator"mussels to measure contaminant levels; however, the group concurred that mussels were the preferred choice as long as obtaining information on the bio-available fraction of the contaminant in seawater was the desired endpoint. Finally it was noted that while information on the levels and distribution of trace contaminants is desirable, some effort should be put into transforming these data into fluxes of contaminants through the ecosystem as this type of data is very sparse for the Mediterranean Sea. Such data are extremely important for modelling contaminant transfer and eventually predicting impacts on the marine environment and on public health.

In order to move to a new level of measurement capability and scientific understanding of chemical contamination in the Mediterranean Sea, it was recognized that capacity building was an urgent need for certain areas of the Mediterranean region. Participants enquired how countries could obtain information on technical assistance from international organizations such as the IAEA. It was pointed out that international organizations work strictly through national focal points, and for that reason end users often do not receive potentially useful information because they are not dealing with the proper national counterpart. Countries were therefore encouraged to get in touch directly with the focal points for relevant international organizations (e.g. IAEA) which offer technical assistance and training in trace contaminant analyses. If basin-wide programmes such as the CIESM Mussel Watch do become fully-integrated with other similar initiatives in the Mediterranean sponsored by the European Union and various national bodies, capacity building efforts could be offered to all participants at the same time and thus be made far more cost-effective.
# PHARMACEUTICAL SUBSTANCES: EMERGENT CONTAMINANTS OF COASTAL SYSTEMS

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## Abstract

Beside classical chemical contaminants (PAHs, PCBs, pesticides, ...), we find substances such as pharmaceuticals in coastal waters. This communication will deal mostly with the development of analytical protocols in order to analyze different classes of pharmaceuticals in aquatic systems. These developments involve both extraction and purification methods but also analytical developments for identification and quantification by GC or LC coupled to MS or MS/MS. The use of semi-permeable membrane devices (Polar Organic Chemical Integrative Sampler type) to get access to integrative sampling procedure has been also investigated. All analytical developments have been applied to *in situ* studies in various French estuaries, pointing to the dissolved phase as the most contaminated. *Keywords : Pollution, Monitoring, Sampling Methods.* 

Beside classical chemical contaminants (PAHs, PCBs, pesticides, phtalates, trace metals, dioxins ...), we find pharmaceutical substances in coastal environments [1,2]. They can be classified according to their therapeutic action: hormones, antidepressant, analgesics, antibiotics, lipid regulators, ... Important quantities of these molecules are consumed in our occidental society and are rejected *in fine* in coastal waters via sewage treatment plants (incomplete destruction) [3]. They are increasingly studied as they represent a non negligible environmental risk, considering on one hand the potentially important quantities introduced in aquatic systems and on the other hand the fact that they have been synthesized in order to be biologically active. These compounds could have important toxic effects [4] towards marine organisms but to estimate environmental risks there is a crying need for data documenting the effective contamination of marine environments by these molecules.

Our focus here concerns the development of analytical protocols to analyze different classes of pharmaceuticals in aquatic systems (dissolved phase, particulate matter, and biological tissues). These developments involve both extraction and purification methods such as SPE, SPME and microwave assisted extraction but also analytical developments for identification and quantification by GC or LC coupled to MS or MS/MS.

We have developed an extraction procedure that allows measuring at trace level  $(ng.l^{-1})$  many pharmaceuticals belonging to very different chemical classes: anti-inflammatory drugs, antidepressants, hypolipidic drugs, etc. Reliability and sensitivity have been tested on 18 different compounds (7 neutral compounds and 11 acidic drugs) extracted simultaneously and analyzed with two GC-MS methods. Different applications demonstrate the multi-residue but also multi-matrix characteristics of the developed method.





The use of semi-permeable membrane devices (Polar Organic Chemical Integrative Sampler, POCIS type) [5] in order to get access to integrative sampling procedure (necessary, considering the variability of aquatic contamination) has been also investigated. The aim of the study was to determine the sampling rates (Rs; expressed as effective volumes of water extracted daily) of POCIS device for 14 pharmaceuticals in several conditions of temperature, salinity and analyte concentration. These values are influenced by significant changes in water temperature, salinity. Overall POCIS Rs values were independent of aqueous concentrations. Following laboratory experiments, field surveys were undertaken for qualitative application of POCIS devices in contaminated systems: the Seine Estuary and the Mediterranean coast near Marseilles (Figure 1).

All analytical developments were then applied to several *in situ* case studies. Various French estuaries (Seine, Loire, Gironde, Adour) have been studied as well as marine locations (Arcachon Bay and Marseille coast). In all cases it has been possible to detect quite important concentrations of pharmaceutical substances. Measured concentrations fluctuate between a few nanograms per litre and dozens of micrograms per liter depending on compounds, sampling stations and seasons. The results have shown that while the dissolved phase is the most contaminated, the particulate phase could have a large part in the pharmaceuticals spread in coastal systems. When pharmaceuticals occurrence in solid phase is observed, expressed in ng.g<sup>-1</sup>, some phenomena can be highlighted. High contents have been measured in the upper part of the Seine estuary system (Dam of Poses), with concentrations up to 1,220 ng.g<sup>-1</sup> for ketoprofen or 260 ng.g<sup>-1</sup> for naproxen. The solid phase can participate to a quite important extent to the water column contamination.

Understanding the transfer of these compounds to marine organisms and their toxicity, as well as their impact on human health in relation to environmental contamination, is under progress [6]. There are very few data at this moment on this aspect and investigations are really needed to gain a better knowledge.

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# INTERCOMPARISON EXERCISE FOR RADIONUCLIDES IN MEDITERRANEAN MUSSEL (IAEA-437)

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## Abstract

An intercomparison exercise for natural and anthropogenic radionuclides was organized using a material prepared from the soft tissues of mussels collected in the vicinity of the Grand Rhone river mouth. Seven out of the 15 laboratories participating in the CIESM Mediterranean Mussel Watch Program reported results. Based on these results and on those received from 9 additional laboratories worldwide, recommended values were derived for <sup>40</sup>K, <sup>234</sup>U and <sup>239+240</sup>Pu and information values for <sup>137</sup>Cs, <sup>210</sup>Pb(Po), <sup>226</sup>Ra, <sup>228</sup>Th, <sup>232</sup>Th, <sup>235</sup>U, <sup>238</sup>U and <sup>241</sup>Am. Further work is underway for the certification of this intercomparison material as IAEA Reference Material. *Keywords : Radionuclides, Monitoring, Pollution, Instruments And Techniques.* 

The International Atomic Energy Agency's Marine Environment Laboratory (IAEA-MEL) conducted 44 intercomparison exercises and produced 39 marine Reference Materials (RMs) over the past three decades [1]. This programme responds to an increasing interest of data producers in the quality of analytical data, which parallels the increased public interest in environmental issues and the statutory quality demands placed by governmental institutions on food and environmental data producers. The trends in marine environmental contaminant levels, the emergence of new contaminants and, consequently, of new or improved analytical techniques, set new and rigorous quality criteria in the running of intercomparison exercises and the production and certification of RMs.

A recent intercomparison exercise for radionuclides in Mediterranean mussel, IAEA-437 [2], was organized by IAEA-MEL in response to the request received from CIESM in the framework of its Mediterranean Mussel Watch Program. Around 1080 kg of mussel (Mytilus galloprovincialis species) were collected in Anse de Carteau. Port Saint Louis du Rhône (43°20'S, 5°10'E), France, by the Institut de Radioprotection et de Sûreté Nucléaire (IRSN, France) in June 2003. The soft part of the sample was freeze-dried (0.4 dry/wet mass ratio), ground, sieved to 200  $\mu \mathrm{m},$  then homogenized and bottled in 200 g aliquots under a nitrogen atmosphere. Preparation, storage and conservation for long shelf-life were carried out according to ISO recommendations. Homogeneity tests [2] indicated that the material is homogeneous for the suite of six alpha and betta/gamma emitters and for the range of weights tested. One sample of 200 g was distributed to each of 35 laboratories in November 2004. The exercise was expanded to a world-wide coverage, beyond the group of 15 laboratories participating in the Mediterranean Mussel Watch Program, in order to increase the likelihood of reaching the minimum number of results required for deriving recommended values for an intercomparison material. This was particularly required given the low levels of anthropogenic radionuclides in the sample. The deadline for reporting was extended to allow time for more reports to be submitted and the exercise was finally closed in March 2006, with a total response rate of 68%, respectively 47% for the CIESM Mussel Watch participating laboratories. The data, consisting in massic activities (Bq kg<sup>-1</sup> dry) decay-corrected to the reference date 1 November 2003, reported for 17 natural and 8 anthropogenic radionuclides, were treated according to the standard procedure applied at IAEA-MEL, described in [3] and references therein. Following the IUPAC and ISO recommendations for assessment of laboratory performance, the Z-score methodology was used for the evaluation of results. A preliminary certification of IAEA-385 was carried out according to the ISO Guide 35, the certification as RM remaining to be completed when more data from expert laboratories participating in the certification procedure will be available. For data sets comprising 5 or more accepted laboratory means, median values and confidence intervals (95% significance level) were calculated as estimations of true massic activities. The median values of the data within the confidence interval were considered as the recommended values when:

1. At least 5 laboratory means were available, calculated from at least 3 different laboratories.

2. The relative uncertainty of the median did not exceed  $\pm$  5% for activities higher than 100 Bq kg<sup>-1</sup>,  $\pm$  10% for activities from 1-100 Bq kg<sup>-1</sup> and  $\pm$  20% for activities lower than 1 Bq kg<sup>-1</sup>.

An activity value was classified as an information value when at least 5 laboratory means calculated from the results of at least 2 different laboratories were available. The median activities for the sets of accepted values were chosen as the most reliable estimates of the true values and were

given as recommended and information values. A summary of the preliminary values with confidence intervals for the most frequently reported anthropogenic and natural radionuclides is given in Table 1.

Tab. 1. Preliminary results of the IAEA-437 intercomparison exercise, designed to determine anthropogenic and natural radionuclides in a mussel sample from the Mediterranean Sea. The data received from 24 laboratories were evaluated. All the values are given for the reference date  $1^{st}$  November 2003 and expressed in Bq kg<sup>-1</sup> dry weight. <sup>210</sup>Po data are still under evaluation, therefore they were not included here. \*The values should be corrected for in-growth from <sup>241</sup>Pu.

| Radionuclide          | Median            | Confidence interval<br>(α = 0.05) |  |
|-----------------------|-------------------|-----------------------------------|--|
|                       | Recommended value |                                   |  |
| <sup>40</sup> K       | 381               | 352 - 405                         |  |
| <sup>234</sup> U      | 2.34              | 2.20 - 2.44                       |  |
| <sup>239+240</sup> Pu | 0.0076            | 0.0071-0.0087                     |  |
|                       | Information value |                                   |  |
| <sup>137</sup> CS     | 0.18              | 0.07 - 0.31                       |  |
| <sup>226</sup> Ra     | 0.28              | 0.11 -0.31                        |  |
| <sup>228</sup> Th     | 0.8               | 0.3 - 2.0                         |  |
| <sup>232</sup> Th     | 0.09              | 0.08 - 0.16                       |  |
| <sup>235</sup> U      | 0.08              | 0.03 - 0.12                       |  |
| <sup>238</sup> U      | 1.9               | 1.70 - 2.02                       |  |
| <sup>241</sup> Am*    | 0.006             | 0.004 - 0.022                     |  |

This material provides an adequate test to laboratories confronted with reporting radioactivity data on Mediterranean marine samples. In this mussel sample anthropogenic radionuclides are for many laboratories near the limit of detection of combined radiochemical and (especially) radiometric methods. This is the case in particular for <sup>137</sup>Cs, the certification of which will involve measurements in underground laboratories, equipped beyond the technical capabilities of usual laboratories. Similarly, transuranics would be certified including reports from laboratories using mass spectrometric techniques. CIESM Mussel Watch laboratories could consider adopting periodic intercomparison runs and profficiency tests using a set of materials covering both low, typical Mediterranean, activities and medium activities, above the limit of detection of all the laboratories participating. This approach will allow a more comprehensive assessment of laboratory performance. At the same time, the results from this first intercomparison point to the capacity building needs necessary to address through national and international programmes in case the Mussel Watch Program is planned to continue running in the long term. The RM certification of IAEA-437 is expected for 2007.

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# METALS IN THE MEDITERRANEAN SEA AND MEASUREMENT OF ORGANISMS' HEALTH CONDITION

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## Abstract

Marine organisms are widely used in the Mediterranean for monitoring the presence, diffusion and deleterious effects of trace metals of both natural and anthropogenic origin. Different species can be used as bioindicators and the integration of chemical analyses with ecotoxicological responses allows a better assessment of environmental condition. Such an approach is particularly useful in industrialized areas, for management of harbour activities and to evaluate the impact of off-shore exploitation. *Keywords : Metals, Bio-indicators, Western Mediterranean, Eastern Mediterranean, Monitoring.* 

Investigations on trace metals in the Mediterranean Sea are a matter of growing importance for a better assessment of chemical fluxes, anthropogenic impacts and environmental health perspectives. Mediterranean surface waters contain higher basal concentrations of metals compared to those of the open Atlantic, a feature partly related to the oligotrophic, nutrient-depleted conditions of this semi-enclosed basin, but also to the inflow of Altlantic metal-enriched waters through the Strait of Gibraltar [1]. However, direct inputs represent the major source for trace metals in Mediterranean sediments and biota, with highly different situations according to environmental conditions, the origin, kind and duration of the exposure.

Among the natural sources, the geological anomaly of mercury in the Northern Tyrrhenian Sea is responsible for an elevated accumulation of this element by marine organisms and a consequent biomagnification in food webs; in this respect, Mediterranean top predators (i.e. sharks, swordfish and tuna fish) are characterized by significantly higher tissue concentrations of mercury compared to Atlantic counterparts [2].

The Mediterranean coastline is also exposed to a marked human pressure, being highly populated and subjected to increasing tourism, industries, agriculture, fishery, aquaculture, shipping and harbour activities, to cite only a few. Due to the spatial and temporal heterogeneity of such anthropogenic impacts, it is not possible to generalize the environmental condition in the Mediterranean where pristine environments can be very close to highly polluted sites. Marine organisms are widely used to assess the presence and deleterious effects of chemical pollutants and several species have been characterized for their capability to accumulate both organic and inorganic compounds. The choice of the more appropriate sentinel species depends on the aim of the investigations, with examples reported for algae and plants, sponges, bivalves, gastropods, polychaetes, crustaceans and fish [3]. The utility to integrate chemical analyses with molecular, biochemical and cellular biomarkers has been validated in different environmental conditions, including management and remediation of highly polluted petrol-chemical sites, monitoring of harbours during dredging operations, off-shore activities, oil-spills and accidental releases, sustainable use and protection of coastal environments [4-6].

As examples of ongoing applications, we used various organisms as bioindicators in an industrial site. Besides chemical measurements, mussels (both native and translocated), and various fish species (with different feeding habits and trophic positions) were analysed for a wide spectrum of cellular biomarkers, i.e. specific detoxification systems (cytochrome P450, metallothioneins, peroxisomal proliferation, acetylcholinesterase activity), lysosomal destabilization, oxyradical metabolism and antioxidants, oxidative damages and genotoxic effects. An extremely critical environmental condition was demonstrated with the highest mercury concentrations ever measured in Mediterranean organisms, independently of size, diet and trophic position. Contamination was particularly marked in the proximity of a chloro-alkali plant and analyses of biomarkers allowed to reveal also the exposure to hexachlorobenzene. Two years after the closure of the chemical plant, Hg bioavailability was still elevated, but with different effects in mussels and fish according to the feeding strategy [4].

Another hot issue in the Mediterranean is the management of harbour activities which have a great socio-economic importance, but also represent a major environmental concern as potential sources of chemical contamination. In the last ten years, the intensive dredging operations in harbour areas made it necessary to biomonitor both diffusion of contaminants and biological effects in marine organisms. In this respect, mussels are currently used through active caging procedures, carried out before, during and after the dredging and disposal activities; the combined use of chemical analyses and biomarkers allows to characterize differently impacted areas within the harbour basins, generally revealing a complex temporal variability of such disturbance related to the interaction of environmental, anthropogenic and biological factors. A recent investigation in the harbour of Piombino demonstrated that bioaccumulation of trace metals and polycyclic aromatic hydrocarbons significantly increased with the beginning of dredging operations, causing also marked biological alterations in caged mussels; after the end of such activities bioavailability of trace metals showed a different temporal trend compared to PAHs, and the biological disturbance still remained evident [5-6].

A monitoring protocol with caged mussels has been developed also to evaluate the potential impact of off-shore activities and waters discharged in the Adriatic Sea. Native mussels are seasonally collected from a reference site and transplanted to the investigated platforms. Bioaccumulation of trace metals (As, Ba, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn) in mussel tissues is integrated in a multimarker approach for the early detection of biological responses at several cellular targets. Chemical analyses generally revealed increased levels of Cd and Zn and only limited variations for other elements, partly related to natural fluctuations. Among the biological responses, some antioxidants and lysosomal stability were confirmed as sensitive early warning signals of environmental disturbance, although the overall results allowed to exclude marked biological effects by off-shore activities in the Adriatic Sea [5].

The presented protocols, integrating chemical analyses with a wide array of biological responses in marine organisms, seem to offer a useful and realistic approach for monitoring both the presence and the impact of trace metals and other contaminants in the Mediterranean.

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# SOURCES ET ORIGINES DES HYDROCARBURES DANS LES SEDIMENTS SUPERFICIELS DU LITTORAL OUEST ALGERIEN

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## Résumé

Les polluants pétroliers ont été analysés par GC-FID dans les sédiments superficiels du littoral ouest algérien. Outre la détermination des concentrations en hydrocarbures, cette technique permet de caractériser leurs sources. Les sites étudiés ici sont caractérisés par des rejets industriels (complexe pétrochimique dans le Golfe d'Arzew) et domestiques (dans le Golfe d'Oran). Une source d'apport en hydrocarbures biogéniques terrestres a été mise en évidence dans les zones où se déversent les oueds. *Mots clès : Petroleum, Sediments, Pah, Western Mediterranean.* 

#### Introduction

Les franges côtières algériennes, particulièrement celles de l'ouest (500 km environ), ont été l'objet d'une urbanisation et d'une industrialisation importante cette dernière décennie. Dans le cadre du programme MedPol III, la contamination par les hydrocarbures a été évaluée dans les sédiments superficiels de 3 golfes (Golfe d'Arzew, d'Oran et de Ghazaouet).

#### Matériels et Méthodes

Les échantillons ont été collectés en 1998 dans 10 stations (Fig. 1A et B). Les hydrocarbures sont extraits du sédiment lyophilisé pendant 8 h par un mélange hexane:dichlorométhane (dispositif soxhlet); tous les échantillons ont subi un ajout d'étalon interne (nC32, C18.1 et dihydroan-thracène) afin de déterminer le rendement de l'extraction. La purification et le fractionnement se font par chromatographie sur colonne ouverte avec gel de silice alumine comme adsorbant et selon le protocole IOC [1]. Les fractions 1 et 2 recueillies sont analysées à l'aide d'un GC-FID doté d'une colonne capillaire et d'un injecteur POC (programmed on-column). Un blanc de procédure et un échantillon de référence (IAEA 383) sont analysés avec chaque série d'extraction et les résultats sont exprimés en  $\mu g/g$  PS.



Fig. 1. Localisation des stations appartenant A) au golf de Ghazaouet , et B) aux golfes d'Arzew et d'Oran.

#### Résultats et discussion

L'analyse des hydrocarbures aromatiques polycycliques (HAP) dans les sédiments superficiels de la côte ouest algérienne a révélé que la région oranaise est les plus contaminée. La station "hot spot "(Oran 1 ; soumise aux activités portuaires et industrielles d'Oran, ainsi qu'au principal émissaire d'eaux usées de l'agglomération) présente une concentration en HAP de 2340  $\mu g/g$  PS. De façon surprenante, la teneur en HAP la plus élevée enregistrée dans notre étude (6240  $\mu g/g$  PS) provient de la station de référence d'Oran (Oran 2) qui semble être un lieu d'accumulation des rejets pétroliers et industriels de la ville d'Oran. L'analyse multidiagnostique suggère que la zone d'étude est sous l'influence de rejets directs d'origine pétrolière dans les Golfes d'Oran et d'Arzew. Les stations proches des oueds qui déversent dans les régions de Mostaganem (oued Chélif), Beni-Saf (oued Tafna) et Ghazaouet (oued el Marsa) semblent quant à elles davantage soumises à des apports en hydrocarbures d'origine pyrolytique.

La distribution générale des hydrocarbures totaux présentent la même allure que celle des hydrocarbures aliphatiques et aromatiques: une forte contamination est observée aux stations Oran 1 et 2, suivie par la station côtière d'Arzew (1800  $\mu$ g/g PS). Les autres stations présentent des concentrations qui varient entre 109 et 734  $\mu$ g/g (Fig.2A). Les valeurs déterminées sont légèrement supérieures à celles reportées par des études antérieures dans la même région [2-4]. La distribution du MOPI (Marine Oil Pollution Index) présente des valeurs qui oscillent entre 9,4 à la station côtière de Mostaganem et 15,6 au niveau de la station Oran 2 (Fig. 2B).



Fig. 2. A) Evolution des teneurs en hydrocarbures totaux dans les sédiments superficiels des côtes ouest algériennes et B) du MOPI dans les différentes stations.

De façon globale, l'ensemble des résultats de cette étude suggère que toutes les stations étudiées sur la côte ouest algérienne subissent une forte contamination d'origine pétrolière.

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# MEDITERRANEAN MUSSEL WATCH: A REGIONAL PROGRAM FOR DETECTING RADIONUCLIDES, TRACE- AND EMERGING-CONTAMINANTS

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## Abstract

A regional monitoring program - the CIESM Mediterranean Mussel Watch (MMW) - has been running for a few years, using the mussel *Mytilus galloprovincialis* as unique bio-indicator species. The network consists of some 20 marine environmental laboratories from 15 different Mediterranean and Black Sea countries. As of today, more than 50 sites have been sampled to produce the first distribution map of <sup>137</sup>Cs in coast waters at the Mediterranean basin scale. After a successful MMW Phase I, the objectives of Phase II include extension of monitoring activities to other radionuclides and selected trace- and emerging-contaminants along with enlargement of the network via the association of five additional Eastern Mediterranean countries. *Keywords : Monitoring, Bio-indicators, Nile, Pollution, Bivalves.* 

### Introduction

In the aftermath of the Chernobyl accident, a coordinated research program called GIRMED (Global Inventory of Radioactivity in the MEDiterranean Sea) was launched by CIESM during its 31st Congress held in Athens in 1988, with the objective to assess the regional impact of this major accident. However, as the data collected were usually obtained from various indicator specie, procedures and methods, this made direct comparison of results on spatial or temporal scales difficult. In 2002, a new program started aiming to organize the production of monitoring data on a common basis and to set up an effective observation tool on an extended scale. A dedicated workshop was called to design a permanent Mediterranean Mussel Watch dealing with radionuclides and other trace contaminants [1]. A common agreement was reached on the objectives and the general framework of the monitoring network, including strategies, procedures and methods.

#### Implementation phase

The main objectives are to develop an international trans-Mediterranean infrastructure of cooperating scientists and laboratories aiming at monitoring levels of selected contaminants in coastal waters and to document reliable baseline levels of radionuclides in the Mediterranean and Black Sea coastal waters. Some 20 marine environmental laboratories from 15 different Mediterranean countries are now involved in this international, dynamic network, the first in the region specifically designed to monitor radionuclides before its extension to other selected pollutants.

The selected bio-indicator specie is the Mediterranean mussel *Mytilus* galloprovincialis, widespread in the region and for which background knowledge on biology and physiology is available. In sectors were naturals populations are rare or absent, samples can be obtained from transplanted mussels [2]. More than 50 sites have been sampled so far, usually before and after the spawning season, although the south and east coasts are still poorly documented. Sampling procedures and treatment of samples is homogenous among the participants. Trace level measurements of radionuclides are performed by direct gamma spectrometry as a routine technique. Initial intercalibration of all participating analytical laboratories is a very important step in the implementation phase. This was achieved with the making of a specific reference material (AIEA-437), used to carry out a large inter-comparison exercise across the entire network, financially supported and coordinated by the IAEA-MEL, Monaco and IRSN, France.

### Results

The MMW network has been able in 2005 to produce the first distribution map of  $^{137}$ Cs at the regional level. This artificial radionuclide mostly originated from global fallout of former nuclear weapons is now detected at very low level (usually less than 1 Bq.kg<sup>-1</sup> w.w.) in all Mediterranean coastal waters. However, in the Black Sea and North Aegean Sea,  $^{137}$ Cs activity in mussels is still over one order of magnitude higher than in the Western basin, showing the remaining impact of Chernobyl accident.

### Next steps

The main goals of the MMW Project Phase II are:

- To extend the survey and monitoring activities using the well-established network developed in Phase One (15 countries, 50 stations) by adding up to six additional countries and 36 monitoring stations in order to guarantee

the monitoring coverage of the entire basin.

- To complete the  $^{137}\mathrm{Cs}$  survey with data from the South and East Mediterranean coasts to produce a more comprehensive overview of this contaminant.

- To include the monitoring of the radioactive element Polonium-210 (P-210) and the trace elements: arsenic, cadmium, copper, lead, zinc, silver and mercury.

- To monitor emerging contaminants.

Polonium-210 is a radioactive element that occurs naturally in low concentration in the marine environment. It is also a by-product of phosphate fertilizers and phosphoric acid industries. High levels of <sup>210</sup>Po may represent a health hazard in marine coastal areas. The other trace elements selected also occur naturally in the marine environment, where human activities such as manufacturing, agriculture and mining can dramatically increase their level. Phase Two will put a special emphasis on emerging contaminants, an area of CIESM expertise (see CIESM Monograph on "Novel Contaminants") published in 2004; http://www.ciesm.org/online/monographs/Neuchatel04.pdf). These new generations of pesticides, pharmaceutically active compounds (like tranquilizers, antibiotics, hormones), and industrial chemicals are discharged by hundreds of tons in rivers before reaching coastal waters.

Within the framework of the program, an active collaboration (expertise and/or funding) with the IAEA-MEL (Principality of Monaco), the IAEA/TC (Vienna) and MED-POL (Athens) will be sought. Indeed, the three above mentioned institutions will greatly contribute to the feasibility of the MMWII. For example, the IAEA-MEL will provide expertise in implementing the monitoring program and assist in the AQCS (e.g. by providing appropriate reference materials and helping with the setup/coordination of the inter-calibration exercise).

Results obtained from Phase Two will reliably map the current distribution of Polonium-210 and of the selected trace- and emerging-contaminants in wild and transplanted mussels across the entire Mediterranean Basin. This unique dataset will provide critical information on the particular issue of seafood safety for human health, fishing and aquaculture. The scientific outcomes of the project will be published in international scientific journals, and be made accessible to broader audience as well. All data produced by the participants will be synthesized in a CIESM database, where they will be fully available on-line to all concerned parties.

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# IS THERE A NEED FOR DEVELOPING AN INTEGRATED BASIN-WIDE MONITORING NETWORK TO ENHANCE SUSTAINABLE DEVELOPMENT IN THE MEDITERRANEAN SEA?

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## Abstract

This paper discusses how improving the expertise and capacity of a network at the Mediterranean basin scale would allow reliably surveying and monitoring key pollutants in the coastal Mediterranean environment. This would enhance regional capacity to (1) answer the pressing international demand for assessing the trends in land-based inputs of pollutants and (2) comply with seafood safety guidelines. *Keywords : Coastal Management, Pollution, Monitoring, Ecotoxicology.* 

Many natural and anthropogenic sources of chemical contamination occur within the Mediterranean basin (e.g., widely distributed petrol and mining industries, bauxite processing and geothermal activity in the NW basin, phosphate rock processing along African coasts, intense industrial trans-Mediterranean shipping activities, domestic waste waters from large coastal cities). In addition, the Mediterranean is undergoing striking demographic increases during the summer tourist season, with consequential striking increases in contaminants entering coastal systems through treated and untreated sewage [1].

Although the Mediterranean is surrounded by countries with important industrial, cultural, and regulatory differences, it is nevertheless characterized by a relative geographical homogeneity regarding the use of the coastal zone. Indeed, the tourism-related economy, welfare and fishery activities of human populations rely substantially on the quality of coastal waters. Hence, the aforementioned contamination sources represent threats to the quality of the marine environment and can therefore entail major socio-economic impacts (e.g. tourism, marine resource safety, public health issues). It is thus of prime concern to warrant the preservation of the Mediterranean coastal water quality. This is clearly demonstrated by the various international conventions and programmes (e.g. Barcelona Convention, UNEP-MAP, EU Horizon 2020) and scientific actions (e.g. UNEP-MEDPOL monitoring activities, CIESM Mediterranean Mussel Watch, IAEA Technical Cooperation Projects, EU/Ifremer Mytilos and Mytimed Projects) that are specifically dedicated to the Mediterranean region, some of which from as long as three decades.

These programmes substantially increase available information on the Mediterranean coastal environment available to the scientific community and decision makers. However, reliable field data remain sparse for wide coastal areas, especially along the southern and eastern shores. Nevertheless, the emergence of new threats (hundreds of new molecules are produced every year) and the evidence that those already well known may be more seriously and globally affecting the environment than formerly thought, stress the need to develop integrated strategies to protect both the environment and human health. To do so requires the involvement of the whole region. Indeed, hydrodynamics of the Mediterranean is such that what is happening in the Northern, Western, Southern or Eastern areas will be eventually transferred -even if "diluted" and delayed [2]- to any other part of this semi-enclosed sea. Hence, trying to solve any pollution-related problem requires considering the Mediterranean at the basin-wide scale. This in turn requires the involvement of many partners, working in close collaboration to reach common objectives.

As far as the Mediterranean is concerned, the common environmental objectives to be met should be those set up by the European Union that is undeniably the regulatory driving force in the region, with its long lasting existing legislative background on environment and seafood quality, recently re-enforced by the Water Framework Directive (WFD). In particular, the WFD [3] is implementing EU resolutions to reach the ambitious -but necessary- objective to drastically decrease pollution levels. This objective is also clearly articulated in the EU Horizon 2020 Action Plan [4] aiming at de-polluting Mediterranean coastal waters by 2020. Monitoring the long-term effects of EU environmental policy on the Mediterranean coastal water quality requires, obviously, a large-scale, active network using standardised methodologies and indicator end-points carefully selected. In addition, the unique characteristics of the Mediterranean allow for considering in parallel the bio-monitoring of one or several organisms out of a set of nearly ubiquist bioindicator species such as the mussel Mytilus galloprovincialis, the edible sea urchin Paracentrotus lividus, or the endemic phanerogam Posidonia oceanica [5, 6].

Meeting the ambitious environmental objectives of the EU would require an equally ambitious prospective networking issue. Such a network should have the capacity to reliably survey and monitor key toxic chemicals, biotoxins and pathogens in the environment and seafood. This structure could be achieved rapidly and with high probability of success by coupling, reinforcing and equipping existing networks, as those promoted and supported by the international organisations active in the Mediterranean, viz., UNEP (via its Programme for the Assessment and Control of Pollution in the Mediterranean, MEDPOL), IAEA (via the activities of its Technical Cooperation Department [7] and its Marine Environment Laboratories), CIESM (via its Mussel Watch), and EU (e.g. via the Short and Medium-Term Priority Environmental Action Programme, SMAP, and the National Environment Agencies). Indeed, these organisations are already engaged in bi-lateral collaborations (e.g. CIESM - IAEA-MEL; UNEP-MEDPOL - IAEA-MEL; EU - UNEP-MEDPOL). Thus, the main requirement to generate a multi-lateral, synergetic effort would be to intensify and crosscut current cooperations. Bringing together their long lasting experience in collaborating with Mediterranean countries, sound expertise in transfer of knowledge, in technical training and capacity building, as well as in management of large inter-comparison exercises and databases would result in a synergetic partnership able to generate the necessary task force for building one basin-wide, integrated, multi-disciplinary and sustainable network of teams.

Beside providing Mediterranean countries with technical expertise and analytical capacity, the outcomes of such an operational network will (1) provide End-Users (Mediterranean countries, EU, UNEP-MEDPOL) with a unique, integrated and standardised tool (the network) equipped to assess long-term changes/improvements in the quality of the Mediterranean coastal environment (including seafood of commercial interest), (2) substantially improve the knowledge on the contamination of the coastal environment with reliable and inter-comparable data on key pollutants at the Basin-wide scale (key information for the assessment of temporal trends and for the decision on actions to be taken and legislation to be enforced), (3) consolidate a reliable and sustainable related database, (4) improve multi-lateral communications among Mediterranean countries, (5) improve national expertise to answer international demand on marine pollution regulation (with potential socio-economic impact on export of seafood complying with international guidelines) and (6) promote local, more fundamental, applied or prospective pollution-related research that can benefit from local enhanced expertise and/or equipment.

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PANEL 5

# **Deep Mediterranean Sea - New insights and perspectives**

Modérateur : Roberto Danovaro

# PANEL REPORT BY THE MODERATOR

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## Keywords : Deep Sea Ecology, Deep Sea Basins, Deep Sea Processes, Deep Sea Sediments, Biodiversity.

Panel 5 was conceived with the objective of giving a brief but highly interdisciplinary picture of present knowledge and recent advances in Mediterranean deep-sea research, starting from the geosphere and hydrosphere settings, to microbiology and faunal diversity and ecosystem functioning, to conclude with the presentation of Programmes on Mediterranean biodiversity and ecosystem functioning.

The Panel started with a general overview on deep seas presented by the moderator Roberto Danovaro. Deep-sea sediments, covering 65% of the world surface, are the largest ecosystem on Earth. Here microbial processes, driving nutrient regeneration and global biogeochemical cycles, are essential to sustain primary and secondary production of the oceans. Deep-sea ecosystems are also the largest reservoirs of biomass and key elements/compounds. There are no direct estimates of the value of deep seas. However, since the deep-sea floor covers an area  $\sim 100$  larger than that of shelf, even assuming a deep-sea dollar/ha/yr value 10 times lower than that of shelf, the value of deep sea functions is 10 times higher than that of shelves, and potentially higher than actual estimates of world total ecosystem value. In addition, the census of life in the deep sea is just at the beginning and the largest portion of its biodiversity is still unknown (from 0.3 to 8.3x10<sup>6</sup> species to be discovered). The moderator illustrated also the reasons why the deep Mediterranean Sea can be considered the best existing model to investigate the impact of changes at global scale. The main reasons can be summarized as follows:

1. The Mediterranean is a miniature Ocean (therefore a model of circulation and processes occur at much smaller time scales);

2. There is a long-term history of investigations and impacts in the Mediterranean basin (but not in the deep sea);

3. High deep-sea temperatures, which imply faster responses.

4. Susceptible and sensitive to climate changes (already evident in the deep, relevance of episodic events; EMT, Gulf of Lion);

5. High biological diversity in coastal systems vs. very low biodiversity in the deep.

6. Strong environmental and biodiversity gradients (e.g., West-East gradient in trophic conditions);

7. Complex paleo-ecological history, with periodic mortality events (sapropel formation): scenarios of recolonization;

8. The Mediterranean is the ideal basin for testing factors forcing the evolution of deep-sea life: large proportion of continental margins - source sink hypothesis;

9. The deep-Med contains the most extreme environments for life (e.g., DHABs);

10. The deep-Med is full of hot spot ecosystems at very short distance (cold seeps, deep corals, canyons, slopes, slides, seamounts, anoxic etc).

Deep-sea ecosystems, and the Mediterranean in particular, are highly vulnerable, and increasingly subject to direct and indirect anthropogenic impacts (deep-sea trawling, dumping, oil, gas and mineral extraction, other pollution sources). Moreover, recent findings have revealed that climate change can exert also a significant and rapid impact on deep-sea Mediterranean biodiversity.

The presentation of the first panelist (Miquel Canals) focused on the description of the drivers of Mediterranean deep water sedimentation. Recent observations suggest that the functioning of deep Mediterranean benthic systems, as expressed by particulate fluxes and benthic variables, are characterised by a large interannual variability, which is highlighted by the evidence of episodic or stochastic events, or long-term climate change. Two such large events - the Eastern Mediterranean Transient and the Gulf of Lions cascading - affected significant parts of the eastern and western basins respectively. M. Canals described in detail a highly significant massive sediment transport and seafloor shaping process, not previously documented, and illustrated how Dense Shelf Waters (DSW),

flowing down submarine canyons and slopes, carried large amounts of coarse sediment that eroded and shaped canyon floors (e.g. giant furrows). The main conclusions coming out from this presentation were:

1. This is a mechanism of massive transfer of fresh organic matter, and hence C sequestration, to the deep ocean;

2. DSW flowing down canyons may carry large amounts of highly nutritive fresh organic matter that in intense events (twice from 1993 to 2005 in the Gulf of Lion) reaches the very deep basin thus massively injecting C into the deep ocean;

3. Submarine canyons in the Gulf of Lion drive the deep Western Mediterranean Sea;

DSWC in the Gulf of Lion imprints intermediate and deep waters, and the functioning of the deep ecosystem in the Western Mediterranean Sea;

4. According to predictive models, climate change holds the potential to significantly modify dense shelf water cascading;

5. Global warming will likely lead to a lowering in the frequency of dense shelf water formation, thus reducing the frequency of cascading processes which in turn will cause a severe reduction of the episodes of massive injection of organic matter into the deep ecosystem. The example reported here on the cascade event in the Gulf of Lion is providing new perspectives of investigation and management of the Mediterranean.

Jean Mascle illustrated the geosphere component of the deep-Mediterranean Sea and discussed the present knowledge on the topographic description of the deep Mediterranean seafloor, which is a prerequisite for any subsequent investigation on deep-sea life and ecosystem functioning. He showed the recently published (2005) CIESM/Ifremer high resolution multibeam maps which cover large portions of the seabed morpho-bathymetry in both the Western and Eastern Basin. Additional maps detailing specific areas of the Mediterranean Sea such as the Nile Deep Sea Fan were produced under the same scientific collaboration. J. Mascle also underlined the high scientific value of these maps which provide detailed information on large scale geological processes of the Mediterranean Basin and reveal specific features of the seabed (e.g. mud volcanoes, gas and fluid seepages) which are extremely important to understand biogeochemical processes occurring in the deep.

Anastasios Tselepides illustrated some peculiar aspects of the biology and ecology of deep-sea benthic biota in the Mediterranean, with a specific focus on benthic community structure and function of the deep Eastern Mediterranean Sea. High temperature, high salinity and the strong oligotrophy make this ecosystem very different from all other ocean deep-seas. This difference is also reflected in the species diversity and functional role of the macro- and microbiota of the deep Mediterranean, as illustrated by the author. He also focused on main drivers and recent changes related to climatic events such as the Eastern Mediterranean Transient, which indirectly affected the deep benthic communities. The high vulnerability of the Mediterranean deep sea ecosystem to environmental changes and its close interactions with the upper water column and the coastal ecosystems were underlined.

This talk was followed by a summary on the present knowledge and recent advances in deep Mediterranean microbiology by Christian Tamburini and Gerhard Herndl. They reported the key role of deep-sea prokaryotes (DSP), which are a virtually untapped resource for industrial purposes. Recently, a number of novel metabolic pathways have been discovered, shedding new light on the dark ocean prokaryotes. Non-thermophilic Archaea have been recently found to represent the major source of autochthonously produced organic carbon in the deep sea and play a major role in deep-water nitrification outnumbering bacterial nitrifiers in the oxygen minimum zones of the mesopelagic ocean. Anaerobic anmonium and methane oxidizers have been found in the dark ocean sediments and even more recently, in the deep oceanic water column. The Mediterranean Sea offers unique opportunities to study these DSP as it represents one of the very few seas with warm deep-waters. Results from the CIESM-SUB campaigns have begun to address some key issues in the microbial oceanography, biodiversity and ecosystem functioning in the deep-Mediterranean Sea. The speakers highlighted the large demand of better knowledge of deep-sea processes and the associated microbiota. In particular, there is a need for a Mediterranean Sea Deep Ocean Monitoring Station to assess hydrological, chemical and biological dynamics and for an adequate technology to determine actual metabolic rates under in situ pressure conditions to allow full exploitation of genomic information contained in organisms.

Inge Jonckheere illustrated the key-role of ESF in providing a common platform for its Member Organisations (MOs) to advance European research and explore new directions for research at the European level. Through its activities, ESF serves the needs of the European research community in a global context and in a variety of scientific domains. I. Jonkheere illustrated in detail the EuroDEEP programme (2007-2010), which focuses on ecosystem functioning and biodiversity in the deep sea.

Eva Ramirez presented an outline of the recently ESF-EURODEEP approved programme BIOFUN, which aims to characterize mid-slope, bathyal and abyssal habitats to understand linkages between biodiversity and ecosystem functioning in four key sites with contrasting environmental conditions.

An intense discussion followed the talks, with various interventions from the audience. The main points can be summarized as follows:

a. There is a clear need for investing more in the deep-sea Mediterranean research and to create opportunities for sharing facilities, equipments and infrastructure;

b. There is a need for long time-series measurements, which are necessary to understand natural processes exhibiting slow or irregular change;

c. There is a need to investigate more the southern part of the Mediterranean Sea and to identify tools to involve the southern countries (north African countries) in deep-sea research;

d. specific priority should be given to episodic events (such as the cascade event of the Catalan margin and EMT) and their impact on deep-sea ecosystems.

CIESM and ESF are establishing a very fruitful collaboration, which can be extremely important not only to set up strategic scientific priorities, but also to identify tools for sharing infrastructures and allocate new resources and funding to carry on long term programs. There is a clear need for engaging more the national Mediterranean governments on deep-sea issues and to explain how important and strategic is to invest more in deep-sea research.

# DRIVERS OF MEDITERRANEAN DEEP-WATER SEDIMENTATION

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## Abstract

This contribution is intented to show the relevance of dense shelf water cascading (DSWC) (i) as a sediment transport process able to carry large amounts of sediment to the deep margins and basins in the Mediterranean Sea during short periods of time, and (ii) as an efficient sea floor shaping process.

Keywords : Deep Sea Sediments, Deep Sea Processes, Western Mediterranean, Eastern Mediterranean.

Sediment input to the Mediterranean Sea mostly comes from fluvial sources. Relatively large continental shelves, deep-sea fans and channel-levee complexes have developed off the main river systems. UNEP/MAP/MED POL [1] has estimated an overall sediment flux of 730 M Tm yr<sup>-1</sup> to the Mediterranean Sea, with about 75% entering the eastern basin. The theoretical overall sediment yield is 175 Tm km<sup>-2</sup> yr<sup>-1</sup>, which is close to the global average, and 580 Tm km<sup>-2</sup> yr<sup>-1</sup> if the Nile River is not accounted. The later figure is very high compared to other regions of the world.

While part of the sediment delivered by Mediterranean rivers has contributed to the development of continental shelves, another part has been exported to the deep margins and basins. The classical view is that turbidity currents and associated processes are the main transport mechanisms for sediment to be transferred from shallow to deep.

Megabeds (300-600 km<sup>3</sup>) with distinct characteristics forming the Late Pleistocene to Holocene sedimentary sequence in the Mediterranean abyssal plains have been interpreted as megaturbidites [2, 3]. Those in the Balearic and the Herodotus abyssal plains were formed during the last sea level low stand at 22,000 and 27,000 cal. y. BP, respectively. According to published interpretations, the megaturbidite on the Balearic abyssal plain derived from the southern European margin that is mainly fed by the Rhone river while the Herodotus abyssal plain megaturbidite originated from the continental margin west of the Nile delta [3].

The megaturbidite in the Balearic abyssal plain (60,000 km<sup>2</sup>, 8-10 m thick) has been interpreted as the result of one single event of catastrophic slope failure evolving into a large turbidity current [2, 3]. However, a relatively young event able to release such an amount of sediment should have left a major scar or set of scars in its source area. More than a decade of swath bathymetry mapping of the margins to the north of the Balearic abyssal plain failed to identify such major headwall area. Instead, a large number of deeply incised submarine canyons with their heads cut into the continental shelf have been identified in the Gulf of Lions (GoL) and in nearby margins [4].

Recent in situ measurements have shown that DSWC is able to carry large volumes of coarse sediment that erodes shelf, slope and canyon floors [5]. Current speeds measured in the Cap de Creus submarine canyon, GoL, during the year 2005 cascading event were as high as  $\sim 100 \text{ m s}^{-1}$ . Evidence of energetic sediment transport, seafloor erosion and bottom-current deposits associated to episodic DSWC has been described recently in the Adriatic Sea as well [6]. The most striking evidence of sediment transport and erosion by cascading waters is canyon floor sand-filled axial channels, in-canyon sand beds, contourite drifts, sediment waves, fields of giant furrows, giant comet marks, socurs and erosion surfaces.

Therefore, it appears that DSWC is a highly significant process for massive off shelf sediment transport and seafloor shaping at specific locations in the Mediterranean Basin. The three shelf areas of dense shelf water formation in the Mediterranean Sea (i.e. GoL, Adriatic Sea and Aegean Sea; Fig. 1) would then act as powerful drivers for deep-water sedimentation. More frequent and intense cascading at specific intervals during the Pleistocene climatic oscillations over successively shrinking and expanding flooded shelves, associated to climatically controlled cyclic variations in sediment fluxes from river mouths, could provide an alternate explanation to the turbidite hypothesis for the accumulation of megabeds in the deep Mediterranean Sea. The combination of direct fluvial sediment discharge on the outer shelf and canyon heads during low stands and DSWC has a tremendous potential for transporting large volumes of sediment sthat may eventually contribute to the formation of megabeds in the deep margin and basin, at least in the western Mediterranean.





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# NEW PERSPECTIVES AND CHALLENGES IN THE STUDY OF DEEP-SEA PROKARYOTES - THEIR ROLE IN BIOGEOCHEMICAL CYCLES, AND THEIR POTENTIAL INDUSTRIAL APPLICATIONS

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## Abstract

Deep-sea prokaryotes (DSP) adapted, diversified and evolved over billions of years and represent a virtually untapped resource for industrial purposes. Recently, a number of novel metabolic pathways have been discovered shedding new light on the dark ocean's prokaryotes. Non-thermophilic Archaea have been recently discovered to represent the major source of autochthonously produced organic carbon in the deep sea and play a major role in deep-water nitrification outnumbering bacterial nitrifiers in the oxygen minimum zones of the mesopelagic ocean. Anaerobic ammonium and methane oxidizers have been found in the dark ocean's sediments and even more recently, in the deep oceanic water column. The Mediterranean Sea offers unique opportunities to study these DSP as it represents one of the very few seas with warm deep-waters. Field results from the CIESM-SUB campaigns have begun to address some key issues in the microbial oceanography of the Mediterranean Sea.

Keywords : Bacteria, Deep Sea Processes, Organic Matter.

Microbes are the main drivers of the energy and matter flux in the sea. Essentially all our knowledge on the functioning of the microbial food web in the ocean originates from the surface ocean. However, more than 70% of the ocean's volume is considered the deep ocean and this dark oceanic realm, particularly the bathypelagic water column has been poorlystudied. Consequently, our knowledge on the vertical distribution and functional variability of deep-sea prokaryotes in the ocean's interior are still poorly known despite recent advances in elucidating their phylogenetic and metabolic characteristics.

While the abundance of prokaryotes decreases from the sunlit surface waters to the deep ocean by one to two orders of magnitude and their overall activity by at least two orders, the diversity of DSP is only about 25% lower than in surface waters. Despite their overall low activity, DSP are play a major role in the biogeochemical cycling of material due to the sheer volume of the dark ocean. Heterotrophic DSP are responsible for the processing of refractory organic matter sinking from the sunlit surface layers into the dark ocean's realm. This substrate processing is done under high hydrostatic pressure conditions leading to specific adaptations. Piezophilic (barophilic) bacteria have been isolated from the deep ocean. Based on molecular analyses, the notion emerges that deep-sea bacteria originate from psychrophilic bacteria. This finding, however, is based on studies performed in the deep Atlantic and Pacific. The warm deep waters of the Mediterranean Sea offer here a great opportunity for comparative studies on DSP. It has been shown, using clone libraries and sequencing, that the bacterial community composition of the deep Mediterranean is substantially different from that in the deep Atlantic [1]. Anaerobic ammonia oxidizers have been isolated in the marine environment first in sediments, however, these anammox bacteria have been found recently also in the suboxic waters of the Black Sea and in the mesopelagic waters of the Benguela and Peruvian upwelling area. Anaerobic methane oxidizers, discovered less than 10 years ago, are now found consistently in slope and deep sediments frequently in close association with sulfate reducers. Non-thermophilic Archaea contribute similarly to the total abundance of DSP as Bacteria [2]. While one of the major groups of the Archaea, the Euryarchaea, do not exhibit major variations in their abundance throughout the water column, the other major group, the Crenarchaea, increase in their relative abundance with depth. A major fraction of the mesopelagic crenarchaeal community is oxidizing ammonia [3] and using inorganic carbon as carbon source [4]. Thus, they represent dark ocean chemoautotrophs. Quantitative PCR using the amoA gene of Bacteria and Crenarchaea revealed that crenarchaeal amoA genes dominate over bacterial amoA genes in the oxygen minimum layer of the Atlantic. Whether crenarchaeal nitrification prevails over bacterial nitrification in the oxygen minimum layers of the ocean remains to be shown, however. Generally, the richness of archaeal phylotypes is only about half of the bacterial richness in the deep ocean. Noteworthy, however, is the fact the bathypelagic Crenarchaea are apparently not chemoautotrophs but heterotrophs, utilizing efficiently D-amino acids commonly considered refractory for microbial utilization [5].

Using a genomic approach, [6] detected a number of functional genes from prokaryotic communities of the deep North Pacific responsible for the expression of specific enzymes and the synthesis of polysaccharides and antibiotics. Unexpected pathways for utilizing specific components of organic matter such as D-amino acids, chitin, pullulan and cellulose are mediated by DSP [7].

From all what we know thus far on deep-water microbial food webs, the role of the highly diverse prokaryotic community and its interaction with the unexplained high viral abundance remains enigmatic and awaits investigation. Since the deep waters of the Mediterranean Sea are besides the Sulu Sea the only warm deep waters in the global ocean, the Mediterranean Sea offers unique opportunities for microbial oceanography.

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# **BIODIVERSITY SCIENCE IN THE DEEP SEA: THE EURODEEP PROGRAMME**

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## Abstract

The aim of the multidisciplinary EUROCORES Programme EuroDEEP (Ecosystem Functioning and Biodiversity in Deep Sea), coordinated at the European Science Foundation (ESF, Strasbourg, France) is to further explore and identify the different deep-sea habitats, assessing both the abiotic and biotic processes that sustain and maintain deep-sea communities in order to interpret variations of biodiversity within and between deep-sea habitats, and the interactions of the biota with the ecosystems in which they live. The resulting scientific data are a prerequisite for the sustainable use and the development of management and conservation options aiming at the sustainable use of marine resources that will benefit society as a whole.

Keywords : Deep Sea Ecology, Biodiversity, Deep Sea Processes.

Established in 1974, the European Science Foundation (ESF, www.esf.org) as a non-governmental organisation with 78 Member Organisations (research councils, academies and other national science performing or funding agencies) from 30 countries set up in late 2003 the European Collaborative Research Programmes (EUROCORES) aiming to enable researchers in different European countries to develop cooperation and scientific synergy in areas where European scale and scope is required.

The EUROCORES Programme "EuroDEEP", Ecosystem functioning and Biodiversity in the Deep Sea, focuses on the deep sea, the largest environment on Earth, which contains important mineral and biological resources of interest for science, industry and society. The deep sea is a relatively continuous and highly interconnected environment composed by a wide variety of specific ecosystems, both pelagic and benthic, which sustain particular, and often unique, microbial and faunal communities with a vast yet largely unknown biodiversity [1].

The scientific goal of the various funded EuroDEEP collaborative research projects is to further explore and identify the different deep-sea habitats, assessing both the abiotic and biotic processes that sustain and maintain deep-sea communities in order to interpret variations of biodiversity within and between deep-sea habitats, and the interactions of the biota with the ecosystems in which they live [2]. The resulting scientific data are a prerequisite for the sustainable use and the development of management and conservation options aiming at the sustainable use of marine resources that will benefit society as a whole [3].

The different projects focus on three different aspect of the deep sea biodiversity, namely firstly on biological characteristics and processes in the deep sea, secondly on abiotic processes in deep-sea habitats driving biodiversity variation, and finally on the human impacts and ecosystem management. Each collaborative research project has a specific focus which goes from variation in metazoan biodiversity (species diversity, functional and food web diversity, niches) within and between habitats and ecosystems, over the exploration of the biodiversity of specific deepsea habitats such as seamounts, deep-water coral reefs (fig. 1), vents, gas and fluid seeps, large organic inputs (e.g. wood or whale falls), to the understanding of the biogeochemical pathways that sustain microbial systems and assessing the biodiversity of deep-sea microbes, their control and their possible interactions with metazoans for example in hypersaline anoxic lakes, while other projects will try to unravel population structure and population connectivity in economically important deep-sea fishes. Other investigators will focus on discontinuity layers (spatially confined but pronounced density gradients) and mixing zones in the deep ocean, generated at the border between two different water masses that can be seen as persistent 'deep-sea ecotones'.

The field sites of the different projects are situated in the Mediterranean area or along a trophic gradient, from Eastern Atlantic to the Western, Central and Eastern Mediterranean, at the continental slopes, and at the Mid-Atlantic Ridge (MAR).

The Programme aims at providing the necessary framework and funding for the development of top-quality deep-sea research at the European level in a global context (Census of Marine Life and SCOR/IGBP), particularly building on sharing of national large-scale resources, which are essential for deep-sea research (i.e. ships, ROVs, submersibles, AUVs, deep-towed vehicles, deep-sea sampling equipment, new sensors, etc.) as well as the coordination of efforts amongst scientists and laboratories from the countries involved and links with ongoing projects. EuroDEEP is a Programme for deep-sea biology and ecology that strongly depends and requires collaboration between taxonomists, microbiologists, ecologists, physical and chemical oceanographers and geologists [2].

The launch of the Programme is foreseen for June 2007 and the international, multidisciplinary collaborative research projects are supported particularly by research funding agencies from Belgium, France, Ireland, Italy, the Netherlands, Norway, Poland, Portugal and Spain, and by the European Science Foundation through contract No. ERAS-CT-2003-980409 of the European Commission, DG Research, FP6. EuroDEEP is coordinated by Dr. Inge Jonckheere at the ESF, Strasbourg (FR).



Fig. 1. A deep-water coral reef as an oasis for marine life.

For the latest information, please check the EuroDEEP Programme website: www.esf.org/eurodeep.

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# THE DEEP MEDITERRANEAN SEA: THE LESSONS FROM SYSTEMATIC AND DETAILED SWATH BATHYMETRIC MAPPING

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## Abstract

Detailed morphology of the Mediterranean deep basin, based on swath bathymetric data, directly show the consequences of various active geological processes which shape the present sea floor, including the results of geological hazards. They also provide opportunities to study the impacts of such processes on the deep environments (sediment, biology, microbiology, etc..) and at some stage in the water column. A synthesis of the most recent data is presented and briefly discussed.

Keywords : Swath Mapping, Western Mediterranean, Eastern Mediterranean.

For a decade systematic swath bathymetric mapping of the deep Mediterranean Sea has been progressively conducted by several European oceanographic and hydrographic Institutions, mainly from France, Italy, Spain, Greece, the Netherlands, Israel and Germany.

Geosciences-Azur laboratory (Villefranche sur Mer) and Ifremer Geoscience mapping office (Brest) have jointly conducted a project to compile syntheses of all swath data made available in a cooperative framework comprising most of the national Institutions involved.

This resulted first in the publication in 2000, under the sponsorship of CIESM and Ifremer, of a Morpho-bathymetric Map (DTM at 500 m) and of an acoustic Image of the Mediterranean Ridge and surrounding areas [1], and, in 2005, of two new Morpho-bathymetric Maps (DTM at 500 m) of the Mediterranean Sea western and eastern basins, respectively [2] (Figures 1 and 2). Detailed maps of the morphology of the Mediterranean Egyptian Margin (DTM at 100 m), and of its acoustic signature, were produced by Géosciences-Azur and CIESM in 2003 [3]. The same group is now working on the most recent swath bathymetry synthesis of the Mediterranean Sea (at a 4.000.000 scale, DTM 500 m), which will incorporate the most recent results made available (south of Spain, Balearic plain, Calabrian ridge, Algerian margin and several areas from the Aegean and Eastern Mediterranean seas).



Fig. 1. Morpho-bathymetry of the Western Mediterranean Sea as in 2005, from [2].

Based on 100 m (Nile Margin) or 500 m DTM, these various maps have already revealed the importance of distinct active geological processes, which are directly imprinted on the seafloor in absence of important erosion. They also stress the drastic contrasts between the Neogene Western Mediterranean Basin, which results from successive back arcs opening, and the much older, Mesozoic, Eastern Mediterranean Sea, where subduction and collision processes, and huge sedimentary loading contribute to generate widespread compressive tectonics and lead to massive mud and fluid expulsions directly on the sea floor.

Beside their obvious geological values, the availability of these syntheses appears quite significant with respect to most other oceanographic fields of study in the Mediterranean Sea. For example a precise knowledge of deep circulations cannot now be assessed without detailed bottom topography as extracted from swath mapping data. Recently the discovery of numerous brines, fluid vents and mud volcanoes on several areas of the deep Eastern Mediterranean basin has strongly modified our understanding of geochemical and biological processes operating in the water column and on the sea floor. Gas plumes, delivering large quantities of gas in the sea water, widespread bacterial mats growing nearby fluid vents, associated worms, lamellibranchia, sea urchins, etc., are now frequently observed and sampled on the basis of detailed bathymetric maps. More recently scientists had even access to swath bathymetric data recorded using an AUV equipped with swath system (Bionil expedition of the ESF Mediflux.program).



Fig. 2. Morpho-bathymetry of the Eastern Mediterranean Sea as in 2005 from [2].

This provides the possibility to obtain, for seafloor areas up to several km<sup>2</sup> wide, DTM at 1 meter precision (and even 50 cm in some case!) and thus to fill the gap in scales between direct in situ observation (from towed cameras, submersibles or ROV) and geophysical data. Near bottom swath bathymetry is opening a new era for the study of seabed processes whether they are geological, geochemical or biological, and for the management of seagoing operations.

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# BIOFUN: BIODIVERSITY AND ECOSYSTEM FUNCTIONING IN CONTRASTING SOUTHERN EUROPEAN DEEP-SEA ENVIRONMENTS: FROM VIRUSES TO MEGAFAUNA - A EURODEEP PROJECT PROPOSAL

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## Abstract

What little we know of deep-sea ecosystems indicates that they host one of the highest biodiversities on the planet as well as important mineral and biological resources, which are increasingly being exploited. Understanding deep-sea biodiversity and ecosystem functioning, from viruses to megafauna, is essential to assess the impact of natural and anthropogenic factors and provide management options. The Mediterranean, in particular, is a unique system for such studies, characterised by homeothermia and a steep gradient of increasing oligotrophy towards the East. BIOFUN, a EuroDEEP project proposal, aims at investigating and comparing deep-sea sites across a trans-Mediterranean transect and in the Eastern Atlantic.

Keywords : Abyssal, Bathyal, Biodiversity, Deep Sea Processes.

The bathyal and abyssal ecosystems are the largest habitats on Earth, covering over 60% of its surface, and one of the least explored. What little we know indicates that the deep oceans have biodiversity levels amongst the highest on the planet [1, 2], much of which undescribed, as well as important mineral and biological resources are increasingly being exploited. However, the impact of deep-sea exploitation on the habitat and its fauna, often including long-lived species with long recovery times to disturbance, is still poorly understood [3, 4]. There is also accumulating evidence to the effects of climate change in the composition and structure of deep-sea communities and baseline studies are required to provide initial data from which to detect long-term ecosystem changes and their causes. The gap in knowledge of marine biodiversity has been recognised by the Census of Marine Life programme, which was at the origin of the EuroDEEP initiative to address the need for thorough description of species and understanding deep-sea ecosystem functioning, its links to the global biosphere and potential long term changes caused by natural and anthropogenic forces. The Mediterranean Sea is a unique environment for deep-sea studies [5, 6]. It is a close sea with high salinity and oligotrophy. Furthermore, one of the most important characteristics of the deep Mediterranean Sea is that it is homoeothermic below 200-300 m depth, with temperatures of 13-14°C reaching abyssal. This homeothermia has two major implications: first, there is no thermal barrier to the bathymetric distribution of the deep fauna; second, the high temperature increases the rate of degradation of the sinking particles, resulting in a higher refractory index of the organic matter reaching the seafloor. This is especially important in a sea that is characterised by a strong longitudinal trophic gradient with increasing and intense oligotrophy towards the East. However, our knowledge of Mediterranean deep-sea communities below 1000 m is poor, the effects of homeothermia and oligotrophy mostly unknown and the relationships with Atlantic fauna yet to be established. With increasing anthropogenic and natural (climate change) impact on deep-water communities [3, 7, 8], it is timely and critical to investigate the deep-sea ecosystem biodiversity and functioning, providing the necessary baseline information to propose management and conservation options.

The aim of BIOFUN is to characterise, under an ecosystem approach, two deep-sea habitats - the mid-slope and abyssal plain - including for the first time the analysis from viruses to megafauna, to understand the linkages between biodiversity patterns and ecosystem functioning in relation to environmental conditions along a gradient of increased oligotrophy from West to East. The BIOFUN team proposes a multidisciplinary coordinated research programme to investigate the Algerian-Balearic Basin (1000-3000 m), the Ionian Sea including the Messina Abyssal Plain (1000-4100 m depth) and the Levantine Basin (1000-3100 m depth) in the Mediterranean and the Galicia Bank in the Atlantic. The programme is organised around a coordination workpackage (WP0) and 4 scientific workpackages: WP1- Physicochemical characteristics of the habitats; WP2- Community structure: census of biodiversity and biogeography; WP3 - Ecosystem functioning: food web processes and life-history patterns; WP4- Linkages between ecosystem functioning and biodiversity: tools for disturbance evaluation. The sampling programme is based on 3 major multidisciplinary BIOFUN cruises to be conducted in 2008 (depending on shiptime and funding): two trans-Mediterranean cruises using the new Spanish RV Sarmiento de Gamboa and the Italian RV Urania and a cruise to the Galicia Bank with the Dutch RV Pelagia. Other associated cruises will also provide samples for BIOFUN, such as the Italian trans-Mediterranean VECTOR cruise on board *RV Universitatis*, French geophysical investigations of the W Med, German cruises on board *RV Meteor* and *M.S. Merian* for Central Mediterranean and Greek shiptime on board *RV Philia* for East Mediterranean. The cruises will use a variety of sampling equipment, including CTDs, sediment traps, current-metres, long-term moorings, benthic trawls, sledges, corers, landers and direct observation systems to sample both the habitat and its associated fauna.

The BIOFUN Collaborative Research Project proposal comprises 7 individual projects (CSIC, Spain; CNR, Italy; NIOO and NIOZ, Netherlands; UGent, Belgium; CEFREM, France; NUIG, Ireland) and 3 associated projects (UNIVPM, Italy; HCMR, Greece; SNG, Germany) with a wide range of expertise and strong history of collaborations. The project also aims at interacting with a number of major European and international initiatives, such as the deep-sea CoML projects COMARGE and CeDAMar, the EU funded HERMES project, CIESM-SUB and MarBEF, to maximise the results from the efforts conducted internationally. BIOFUN also proposes interactions with EurOBIS as a depository for taxonomical data and with CoML-DESEO (Deep-Sea Education and Outreach) to share the project's results with society. The BIOFUN project proposal has received positive evaluations by the international EuroDEEP Review Panel and is currently in the phase of budget approval by the respective National Funding Agencies. At this stage, no guarantees concerning funding or final project decision have been made yet.

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# BENTHIC COMMUNITY STRUCTURE AND FUNCTION OF THE DEEP EASTERN MEDITERRANEAN SEA

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## Abstract

During the last 20 years, new technological developments and the application of advanced environmental monitoring methods in concert with a proliferation of multidisciplinary research programmes have gradually changed our perception of the structure and function of the deep Mediterranean deep Sea. It is now considered a dynamic environment linked to upper water column processes and also influenced by major geo-morphological features (abyssal basins, seamounts, submarine canyons, etc.) that shape its benthic community structure. Keywords : Deep Sea Ecology, Zoobenthos, Deep Sea Processes.

Reviews on the biology and ecology of the Mediterranean deep sea have been published in recent years [1-3]. Studies of the Eastern Mediterranean bathyal and abyssal fauna have revealed significant correlations between faunal abundances and biomass, and factors indicating food availability, all being at very low levels compared to temperate regions [4]. The abyssal basins of the Eastern Mediterranean are extremely unusual deep-sea systems. With water temperatures at 4000 m in excess of 14°C (rather than <4°C for the deep oceanic basins) the entire benthic environment is as hot as the water around a hydrothermal vent system, but lacks the vents rich chemical energy supply.

The Mediterranean also differs from other deep-sea ecosystems in terms of its species composition [5]. Acanthephyra eximia appears to have functionally replaced Eurythenes gryllus, the dominant deep-sea scavenging crustacean throughout most of the world's oceans, while Chalinura mediterranea (a much smaller grenadier) has retained the role of Coryphaenoides armatus. Typical deep-water groups, such as echinoderms, glass sponges and macroscopic foraminifera (Xenophyophora) are absent in the deep Mediterranean, while other faunistic groups (fishes, decapod crustaceans, mysids and gastropods) are poorly represented compared to the NE Atlantic.

Barriers to colonisation of the Mediterranean include the differences in temperature, salinity, and food supply between the Atlantic and Mediterranean, as well as the existence of shallow sills. Despite these difficulties and the relative youth of the system a deep-sea fauna has developed, although it is impoverished compared to that of the oceans. Even if the deep Mediterranean is generally considered a "biological desert", times do come when certain areas display such high benthic activity as to be characterised as "benthic hotspots" [4]. These areas are in most cases located at the mouth of submarine canyons that transport, through flush flooding, sediment failure and dense shelf water cascading, large amounts of sediment and organic matter to the deep sea [6]. Large-scale hydrographic changes (Eastern Mediterranean Transient, EMT) have also been implicated in enhancing the productivity of the euphotic zone and indirectly the structure of the underlying deep benthic communities [7].

Recently it was concluded that deep-sea fauna is highly vulnerable to environmental alteration, and that deep-sea biodiversity can also be affected by very small temperature changes [7]. Thus the potential large-scale consequences of climate change are already evident in the structure of deep-sea communities. The impoverished "energy-thirsty" deep-sea benthic microbial community in the Eastern Mediterranean has been found to respond rapidly to inputs of fresh organic matter [8]. Microbial communities have been investigated at several sites around the deep Eastern Mediterranean Sea [9] and found to be characterised by the existence of a well developed (consisting of several levels) benthic microbial loop.

The use of molecular-based techniques and the construction of large clone libraries of the 16S rRNA genes have revealed that the total sequence richness of bacterial communities inhabiting the energy poor sediments of the Eastern Mediterranean is extremely high (Figure 1) and comparable to estimates obtained from microbiota inhabiting terrestrial ecosystems [9]. This could be an adaptation that has evolved so that a system under starvation stress is able to utilise any quantity or quality of organic matter available.



Fig. 1. Rarefaction analysis of 16S rDNA sequence heterogeneity in clone libraries from deep-sea sediments worldwide. Total numbers of screened clones are plotted against unique operational taxonomic units (OTUs). Library 1 derived from the deep Eastern Mediterranean Sea from a depth of 2970 m [9]. Libraries 2 and 5 originated from the Japan Trench at a depth of 6400 m (Li et al., 1999. Mar. Biotechnol. 1: 391-400). Library 3 derived from the Suruga Bay at a depth of 1159 m and library 4 from the Japan Trench at a depth of 6379 m (Li et al., 1999. Biodivers. Conserv. 8: 659-677).

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PANEL 6

# Warning signals

*Modérateur* : Enric Sala

# PANEL REPORT BY THE MODERATOR

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## Keywords : Bio-indicators, Biodiversity, Species Introduction.

Our environment is exhibiting changes at an unprecedented rate. Some of these changes involve ecosystem shifts with serious consequences for ecosystems and society. It is thus imperative that we develop a series of indicators to detect significant changes that are easy to measure and representative across scales. This panel consisted of six presentations followed by a debate on multi-disciplinary, international programs and initiatives and on scientific tools to detect significant physical, hydrological and biological signals of climate change and ecosystem shifts.

Dov Rosen presented the CIESM/IOC MedGLOSS Programme, conceived to provide data on absolute and relative sea level change using an array of field stations. Between 2001 and 2006 sea level rise in the Mediterranean was about 4mm per year, and the projected sea level rise may be higher than previously thought, as suggested by new data on the fast melting of Acctic ice. Another program, MedAlert, will measure sea level on a series of stations along the North African shores. The main objective of this program will be to act as an early warning system for tsunamis: the Mediterranean has suffered 10% of the world's tsunamis since 1901, and 25% of tsunamis in recorded history. The new warning system will be of paramount importance for preparing local communities to such events.

Isabelle Taupier-Letage highlighted the importance of continuous measurements to further understand oceanographic features that occur at mesoscales, such as eddies. Mesoscale eddies form everywhere in the Mediterranean, and they have an important role in determining the productivity of open waters, which in turn influences the distribution of marine mammals, pelagic fishes and thus fisheries. The CIESM Programme TRANSMED aims at using ships of opportunity such as ferries to collect data on basic variables (e.g., temperature, salinity, rainfall) along regular routes. A pilot study conducted on two transects between Marseille and Algier, and Marseille and Tunis illustrated the scale of a mesoscale eddie north of Algeria. I. Taupier-Letage discussed the need for observation networks across the Mediterranean, including moorings, ships of opportunity, gliders, and Argos profilers. She emphasized the need for a closer interaction between oceanographers and meteorologists to provide more accurate predictions of changes.

Many ecologists are concerned with precision and carry out small scale studies, because detailed measurements at extensive spatial scales are often impractical. Since experimental ecology focuses mostly on the microscale and since satellites deal with macro-scales only, intermediate scales are often neglected. Ferdinando Boero presented some "macrodescriptors"that would act as warning signals at scales larger than most traditional scientific studies. These macrodescriptors are highly informative of the state of an ecosystem, and are detectable even by casual observers. For instance, most tourists are able to observe jellyfish or algal blooms. The value of these observations lies in numbers: single observations are considered anecdotes, but hundreds of consistent observations become reliable information. The macrodescriptors are aimed at macroscopic events such as ecosystem shifts, including the shifts from fish to jellyfish, algal forests to barrens, and temperate to tropical biota. Macrodescriptors include gelatinous plankton blooms, red tides, mucilages, seagrass leaves and shells washed on the shore, vertical distribution of gorgonians, sea urchin barrens, arrival of alien species, and disappearance of native species.

Enric Sala synthesized the dramatic shift that Mediterranean coastal marine ecosystems have suffered, and proposed a minimum set of indicators of human impacts. Major drivers of change of Mediterranean coastal ecosystems are overfishing and fishing down food webs, destruction of habitats, pollution, microbialisation of the water column, invasive species, and global warming. These stressors act in synergy and have homogenized and accelerated the turnover of the ecosystem. On rocky coasts, this means a shift from dominance of large vertebrates and native algal forests to impoverished fish assemblages dominated by planktivores and turf or barren benthic communities. The change has been general, across habitats, and is typically understood as a reversal of ecological succession that is associated with an increase of the turnover rate of the community. Ecological theory can be used to develop easy-to-measure indicators of human impact, such as proxies of the turnover rate. For example, on rocky coasts good indicators of impact and ecosystem health are total vertebrate biomass, and biomass of native algal canopy. Such indicators, however, cannot be applied in the south shore, where most of the coastline consists of soft-sediments.

The Mediterranean Sea now harbours more than 500 introduced species, many of which have become invasive. Bella Galil stressed the importance of using invasive species as a warning of global change. Alien species are more likely to occur in environments that are already degraded by human activities, and could thus be used as indicators of biological integrity. Global warming is an added factor that changes the conditions and probably facilitates invasions, hence the value of CIESM surveys of invasive species across the Mediterranean.

Adi Kellerman discussed the views and activities of ICES with regard to invasive species. He presented some examples from northern Europe where invasive species colonized substrates that had been historically occupied by native species, but vacant at the time of invasion. Many of these species were introduced through aquaculture. Initially, the economic benefits of aquaculture activities seemed to overweigh their environmental impacts, but quickly became conspicuous. A legislation is already in place to prevent accidental introductions, but the problem is the lack of regulations, implementation of technical measures, and better science for risk and impact analysis.

After the presentations a lively discussion touched on several key issues associated with change of Mediterranean ecosystems, and on how to evaluate this fast change in relation to that which occurred through evolutionary times. Our expectations of what is natural become lower generation after generation. The lack of meaningful baseline information on the environmental status of the Mediterranean Sea before the start of modern marine science makes it difficult to assess the degree of human impacts. Indeed, some even discuss whether the loss of biodiversity is truly worrisome. However, the settlement of more than 500 alien species, the collapse of fisheries throughout the basin, and the dramatic ecosystem shifts are sufficiently clear signals of ecosystem degradation.

This discussion also reminded us how ineffective scientists typically are when it comes to communicating scientific findings to the public. While scientists discuss whether statistically significant differences represent ecologically significant changes, the public is left confused and remains ignorant of the change. More efforts are sought from scientists to improve transfer of knowledge and raise public awareness.

# MACRODESCRIPTORS: LOOKING AT SIMPLICITY TO UNDERSTAND COMPLEXITY

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## Abstract

Macrodescriptors inform in a simple way about the state of complex systems, and can help in detecting biological responses to global change. Possible macrodescriptors are: gelatinous plankton blooms, mass mortalities, red tides, arrival of alien species, disappearance or retreat of common species (such as gorgonian corals), changes in seasonal phenomena, increase in population size of species that alter habitat features (e.g. sea urchins leading to sea urchin barrens), accumulation of shells or *Posidonia* leaves on beaches, state of the populations of habitat forming species. These, and many other descriptors can be evaluated with no special instruments to obtain easy-to-take and informative data on the state of changing environments.

Keywords : Biodiversity, Bio-indicators, Global Change, Monitoring.

In a period of fast change, it is important to understand if and how the biological components of ecosystems are answering to changes in chemicophysical features of the environment. The evaluation of biodiversity at species level is extremely important, but it inevitably requires specialized expertise and long research programmes. Some macro-expressions of biodiversity, however, can become macrodescriptors that sum-up the state of ecological systems. These descriptors are evident, but they are often neglected by scientific literature, or are treated in isolation, whereas proper organization of their perception gives the opportunity to reconstruct the history of particular systems, leading to better understanding of current situations. The history of the Adriatic Sea, for example, is marked by a series of macrodescriptors that might be linked with each other (Fig. 1) [1].



Fig. 1. The macrodescriptors of Adriatic Sea history. The blooms of the medusa *Pelagia noctiluca* are identified as the trigger of a series of events that changed the ecological setting of the whole basin.

A "healthy" period characterized by high yields in fisheries was followed by a series of events that, when seen as connected parts of a history, can acquire greater significance than when considered one by one. These events, here considered as macrodescriptors, were: 1 - massive blooms of the medusa Pelagia noctiluca, probably exerting high predation pressures on planktonic and nektonic populations; 2 - dinoflagellate red tides, representing the biological response to the traditionally high nutrient availability of the Adriatic when a well structured carbon sink is absent (due to Pelagia predation); 3 - benthic mass mortalities, often caused as a side effect of toxic algal blooms; 4 - increased fisheries pressure, caused by a decrease in the natural populations, leading to the disappearance of common species (e.g. the clam Tapes decussatus); 5 - deliberate introduction of alien species (e.g. the clam Ruditapes philippinarum) to re-build over-exploited natural populations; 6 - pelagic or benthic mucilages, probably linked to huge carbon availability for bacteria; 7 - blooms of gelatinous filter feeders, quickly exploiting microscopic primary producers. These events "describe" the history of the Adriatic and most were and are recorded even in the local press whenever they occur. Each of them has been studied in isolation, as if not part of a "history". At present, the Adriatic goes through a mixture of multiple states that can be classified within the macrodescriptors listed above.

A similar situation, with different actors, has been described for the Black Sea [2], with a pristine period in the Sixties-Seventies, in which gelatinous plankton was dominated by *Rhizostoma pulmo*, a second period, in the Seventies-Eighties, in which *Aurelia aurita*, became prevalent, a third

period in the Eighties-Nineties when *Mnemopsis leydi* arrived and monopolized the system, with catastrophic impact, and a fourth period, from the late Nineties to present, in which the arrival of *Beroe ovata* buffered the impact of *Mnemiopsis*.

These changes in the biotic components of the ecosystems might be generated by shifts in the outcome of biotic interactions. In other cases, the biota responds in a dramatic way to even very brief changes in physical conditions, as happened with the mass mortality of gorgonian corals observed in 1999 across the Ligurian Sea due to a sudden deepening of the summer thermocline [3]. This event showed that some evident and longlived organisms, such as gorgonians, cannot bear high temperatures, even for very short periods. The upper depth in their distribution thus might be a sharp tool to measure changes of the summer thermocline, especially in a period of global warming. Desertification is matter of great concern in terrestrial habitats, but is less perceived as a problem in marine systems. Desertification of marine habitats can be produced by human activities, such as date mussel fisheries, or by the abnormal growth of sea urchins that, with their grazing, lead to the so called sea-urchin barrens. Both types of desertification often coexist [4]. The perception of desertification is immediate, and its mapping through a network of observatories would be highly informative of the state of marine systems.

Other possible macrodescriptors include the presence of alien species, changes in the distribution, population size and activity of evident native species such as marine mammals and fish, and the accumulation of *Posidonia* leaves and shells on beaches. The organization of a network of observers that immediately detects evident change, recording its origin and distribution, could provide a monitoring of the state of marine systems. Since macrodescriptors are reported even in the press, data mining in journals and magazines, as a complement to scientific literature, might lead to historical reconstructions that will be of great help in understanding the present state of marine ecosystems and will also provide some hints to depict future scenarios.

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# UNDERSTANDING SIGNALS OF ECOSYSTEM DEGRADATION - HOW TO RESTORE MARINE FOOD WEBS?

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# Abstract

Mediterranean marine ecosystems are on an ongoing trajectory of degradation that equals a reverse ecological succession. Local and global disturbances interact at different temporal and spatial scales, creating positive feedback loops that enhance biodiversity loss, simplify the structure of food webs, diminish resilience, inhibit the recovery of biodiversity, and homogenize marine communities. Human activities can homogenize marine biodiversity via three main processes: (a) by accelerating food webs (increasing the turnover of communities via fishing down food webs and enhancing microbial activity), (b) by causing pollution- or warming-mediated mass mortalities of marine organisms, and (c) by facilitating the dominance of invasive species. To restore ecosystem structure and all the services we are losing along this trajectory of degradation we need to understand, among other things, how to restore food webs and enhance ecological succession. *Keywords : Food Webs, Coastal Systems, Bio-indicators, Biodiversity*.

# NON-NATIVE SPECIES WORLDWIDE: THE VIEWS AND ACTIVITIES OF ICES

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## Abstract

Introduction and spreading of non-native species pose a major threat to ecosystems worldwide. Mariculture and increased trade and shipping are the human activities contributing to the dramatic increase in recent years. Two ICES Working Groups were established to develop the expertise necessary to provide advice on the problem. One of the products is a Code of Conduct for shipping and ballast water. *Keywords : Biodiversity, Species Introduction, Aquaculture.* 

Global activities in marine aquaculture began to increase dramatically in the 1950s and 1960s. This included the search for fish, shellfish, and plant species whose biology was well known and which already had achieved or could achieve success in extensive cultivation. These species were potential candidates for movement to new locations in the world for the purpose of establishing new fisheries and new aquaculture resources. Such animals and plants that are not native to these new locations are defined as species transported intentionally or accidentally by a human-mediated vector into aquatic habitats outside their native range. In addition to the intentional or accidental introduction of non-native species from aquaculture, the release of exotic organisms via ships (ballast, hull fouling, etc.) has become a pressing issue with profound implications for fisheries resources, aquaculture, and other activities. Global trade has provided a vehicle for many opportunistic and specialist species to vastly extend their range. The shipping vector is probably one of the oldest means for the introduction of marine species. Ballast water management guidance, and for some areas required ballast water exchange, are intended to preclude transfer. However, standards and governance regulation are still lacking on a global scale. Other human-mediated vectors include recreational water activities (boating, diving, fishing), commercial activities including fishing, live seafood discards, etc. [1]. In addition, the extent of the various contributions to overall introductions is poorly documented, although the large number of species with planktonic life history stages suggests that ballast is a significant source of species.

For many years, the economic benefits of aquaculture outweighed concerns about secondary impacts. Unfortunately along with the success of aquaculture, several challenges have surfaced over the past decades relating to the global translocation of species to new regions:

- environmental and economic impacts of introduced and transferred species, especially those that may escape the confines of cultivation and become established in the receiving environment;

- genetic impact of introduced and transferred species, relative to the mixing of farmed and wild stocks as well as to the release of genetically modified organisms;

- inadvertently coincident movement of harmful organisms or pathogenic and parasitic agents associated with the target (host) species.

Molluscan aquaculture species cultured or once cultured in European countries include the soft-shelled clam *Mya arenaria* (introduced by the Vikings), the oyster *Crassostrea gigas* (and *C. angulata*), the Manila clam *Tapes philippinarum*; and the American oyster *Crassostrea virginica* [2, 3]. These species illustrate unwanted consequences of unmanaged introductions. *Crassostrea gigas* brought with it is own parasites and a host of associated species, including an oyster drill (*Ceratostoma inornatum*) and a parasitic flatworm (*Pseudostylochus ostreophagus*). Diseases have also been associated with several of the species. The Atlantic salmon *Salmo salar* is susceptible to an infectious salmon anemia that spread throughout aquaculture farms in Norway, Atlantic Canada and the U.S. and in Scotland. Although the source of the disease was unknown, the same virus was involved in all the outbreaks.

An example of genetically modified organisms impacting local communities is the introduced smooth cordgrass *Spartina alterniflora* and the native *S. foliosa* which have formed a hybrid that is more aggressive than either species [4]. *Spartina alterniflora* is a native salt marsh grass in the north western Atlantic that was deliberately introduced to stabilize California coastal areas, but has proven to clog channels, outcompete native species, threaten species dependent on native plants, and accelerated the loss of mud flats that serve as a source of food for migrating shore birds. Ecological impacts: Although the American oyster has not been successfully established as an aquaculture species, at least five species were associated with its introduction, including the slipper limpet *Crepidula fornicata*, a predatory snail *Urosalpinx cinera*, the false angel wing (bivalve) *Petricola poladiformis*, the polychaete *Clymenella torquata*, and the ostracod *Eusariella zostericola*. Of 23 species or taxa associated with *G. gigas* introductions, at least 5 species and 4 possible species or representatives of taxa were present after 15 years [2]. Not included in the previous survey is the alga, *U. pinnatifida* that is believed to have come into southern France and Italy with *C. gigas* and deliberately farmed in northern France where it has spread to the U.K., Belgium, Spain, Netherlands and possibly Portugal by shipping, recreational boats and/or oysters [5]. This large kelp has a wide temperature and salinity tolerance and has become the dominant species in some areas during its growing season.

The Chinese mitten crab Eriocheir sinensis has damaged river banks in Europe and the US, threatens native communities as it feeds on native plants and animals, causes a nuisance through mass migrations, interferes with fishing activities by ruining nets, feeding on bait and captured fish, and carries a parasite (lung fluke) that can be transmitted to humans (http://www.nhm.ac.uk/nature-online/life/otherinvertebrates/chinese-mitten-crabs/assets/18feat\_mitten\_crab.pdf). The crab has been reported in several European countries as well as the Russian Federation, Iran, and North America (USA) (http://www.issg.org/database/species/distribution.asp?si=38). ICES has adressed these concerns early through its Working Group on Introductions and Transfers of Marine Organisms (WGITMO), and through its ICES/IOC/IMO Working Group on Ballast and other Ship Vectors (WG-BOSV). In 1973, Council adopted the first version of what was to become an internationally recognized "Code of Practice" on the movement and translocation of non-native species for fisheries enhancement and mariculture purposes. The Code (updated last in 2005) takes a precautionary approach to introductions and focuses on principles designed to limit impacts and support environmentally sound introductions and transfers.

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# FROM MEDGLOSS SEA LEVEL WATCH TO MULTI HAZARD SEA LEVEL ALERTS (TSUNAMI, METEO-MARINE EXTREME EVENTS)

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## Abstract

MedGLOSS was established by CIESM and IOC/UNESCO a decade ago, to monitor sea level in the Mediterranean and Black Sea. After a process of stations upgrading to GLOSS standards until 2005, the disasters induced by the Indian Ocean tsunami and the Katharina hurricane raised awareness for the need to upgrade MedGLOSS stations to be able to detect a variety of sea level induced hazards, some relatively frequent (seasonal, yearly, every few years) others rare (decades, centuries). The February 2007 IPCC climate change assessment report further confirms this need to upgrade MedGLOSS to provide low latency data and early alerting of extreme events detected. *Keywords : Sea Level, Time Series.* 

The MedGLOSS sea level monitoring network was established jointly by CIESM and IOC/UNESCO a decade ago, to serve as a densified regional sub-system of the global GLOSS network of sea level stations and enable provision of data for long-term relative and absolute sea level variation for national, regional and global operational oceanography models and for monitoring tectonic movements and rates at the sea level stations. Progress has been achieved during 2002-2005 by joint work with the European Sea Level Service in the ESEAS-RI research infrastructures project partly funded by the EC FP5 research program via establishing common standards of data processing and analysis methods, stations upgrading to near real time monitoring and Continuous GPS stations installations at the key sea level stations. However, following the dramatic encounters of the Indian Ocean tsunami event on 26 December 2004 and of the Kathrina hurricane over the New Orleans coastal area in September 2005, it became clear that the MedGLOSS stations can and must assume additional duties, by low latency detection and alerting of signals of multi hazard types of sea level variation. Among these we note the occurrence of tsunami events (the Mediterranean inducing fast rising/lowering sea level changes), more frequent meteo-tsunami atmospheric pressure fluctuations induced events (few minutes - to be monitored with a low latency of 10 to 30 seconds), anomalous sea level rise at the coasts from storm surge induced by strong and/or prolonged onshore winds as well as by high storm wave heights via radiation stress growing in the surf zone towards the shoreline or set-down by strong offshore winds (few hours to days - to be monitored by a latency of minutes to hourly), plus a combination of the latter with spring or neap tides and climate change-induced sea level rise and other oceanographic circulation processes in the Mediterranean and the Black sea by world wide processes such as the North Atlantic circulation and the El Nino/La Nina. To meet increasing funding needs, the MedGLOSS focal center, at the Israel Oceanographic & Limnological Research (IOLR) coordinated the preparation and submission of research proposals. One of these, named MedAlert [1] was submitted to the Mediterranean region commission of the Global Climate Observing System (jointly established by WMO, UNEP, IOC/UNESCO and ICSU) and was included in its new Action Plan for the Mediterranean. Sea level rise assessed by the new IPCC report is lower than its previous 2001 assessment (although the climate warming is even more dramatic), but a number of contributions were not taken into account. Based on the previous warming forecast scenarios and applying a new indirect assessment method, Stefan Rahmstorf [3] assessed higher sea levels by the end of 2100. Given the higher warming assessed by the new IPCC report, and applying Rahmstorf method, one reaches even higher sea level rise by the end of the century. The sea level rise, together with the forecasted climate warming-induced increased frequency of extreme storm events, make MedGLOSS an important tool for the monitoring, detection and early warning of sea level induced hazards at various time scales.

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PANEL 7

# **The Marmara Sea and connecting straits** *Modérateur* : Michel Rixen

# PANEL REPORT BY THE MODERATOR

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## Keywords : Marmara sea, Bosphorus, Dardanelles, Hydrology, Models.

Operational oceanography in the Mediterranean and the Black Sea has been evolving rapidly in the last decades. Despite recent initiatives, the inter-disciplinary monitoring and modeling of the Marmara Sea and Turkish Strait System (including outflows) still remains a challenging task and deserves increased attention due to the systems role in limiting exchanges and interactions between the basins and various environmental, navigation, and security considerations.

Panel 7 was devoted to recent advances in understanding this complex hydrodynamic and bio-geochemical system and in improving our corresponding prediction skills in the area. It was also meant to strengthen ongoing scientific efforts and to set the grounds for future international collaboration.

The session started with a general introduction by the panel moderator, emphasizing the complexity of the Turkish Strait system, which comprises the Marmara Sea, a buffer zone, and two very narrow straits, the Bosphorus and the Dardanelles respectively, and stressing its maritime and ecological importance. Standard monitoring and modeling techniques do not apply in the area and require the development and implementation of ad-hoc approaches to the problem: trawl-safe moorings, high resolution models, etc.

Sukru Besiktepe presented a general introduction to the circulation, hydrography, biology and chemistry of the area and highlighted the importance of the Mediterranean inflow as the only major source of dissolved oxygen input for the Black Sea.

Villy Kourafalou reviewed the interactions between the Dardanelles outflow and the Aegean and its implications on the basin-wide circulation and operational modeling and stressed the importance of a real-time monitoring of the Dardanelles outflow area for reliable predictions in the Aegean.

Tulay Cokacar presented recent modeling results of the Bosphorus flow dynamics, the role of hydraulic control of the sills in the strait, and the potential contribution of friction in controlling exchanges in the strait.

Vassilis Zervakis contrasted two major climatic regimes found in the Aegean, controlled by the estuarine state of the Dardanelles outflow, its impact on the Aegean ecosystem and various trophic levels up to fisheries stocks.

Birol Kara presented the analysis of wind speed variability over the Marmara Sea derived from Quickscat and stressed the importance of appropriate resolution in forcing fields for interdisciplinary modeling efforts.

Sulyman Tugrul presented a detailed analysis of nutrient fluxes in the Turkish Strait System and stressed the importance of the area in recycling most of the Black Sea input, concluding that there is a net dissolved nutrient export from the Marmara Sea to the Black Sea.

Ewa Jarosz reviewed present and future scientific efforts in the Turkish Strait System advocating the importance of using *ad hoc* mooring and unstructured grid techniques to improve our forecast skills for the area.

The panel discussions addressed many inter-disciplinary issues for a successful environmental management of the Turkish Strait System, which are summarized below with their recommendations:

- observational efforts in the area should focus on near-real-time cost effective, low maintenance sensors and instrumentation;

- there is an increased need for long-time series of inter-disciplinary measurements for climate studies purposes. Long-lasting operational

oceanography efforts may directly contribute to these requirements;

- the area is 'tsunami' sensitive and the monitoring networks should be integrated accordingly;

- appropriate resolution for atmospheric forcing is needed to ensure reli-

able prediction of the hydrodynamic and coupled bio-geochemical models; - the Turkish Strait System and corresponding outflow are highly interconnected, which requires a joint coupled observational and modeling effort:

- in-depth turbulence studies are required to achieve successful modeling in the straits because of their particular hydrodynamic and hydraulic flows;

- many research resources are available in the area but they should be better advertised and integrated.

# PHYSICAL AND BIOGEOCHEMICAL VARIABILITY OF THE MARMARA SEA

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## Abstract

A comprehensive set of data collected during 1986-2000 and satellite observations reveal seasonal and interannual variability in the physical, chemical and biological properties of the Marmara Sea. Incoming Black Sea and Mediterranean Waters with contrasting properties set-up the basin characteristics.

Keywords : Marmara sea, Circulation, Hydrography, Geochemistry.

#### 1. Introduction

The Sea of Marmara, the central feature of the Turkish Straits System (TSS) linking the Black Sea through the Bosphorus and Dardanelles Straits to the Aegean Sea, is a relatively small, intercontinental basin with a surface area of  $11500 \text{ km}^2$  and a volume of  $3378 \text{ km}^3$ . The Marmara Sea is occupied by two water masses of distinctive physical and biochemical properties, separated by a permanent halocline. An upper layer, 15-20m deep, of brackish water flows in from the Black Sea and a lower layer of the saline water of Mediterranean origin.

## 2. Physical structure

The mean upper layer circulation is anti-cyclonic, mainly driven by the southward flowing Bosphorus jet in the enclosed domain. However, this anti-cyclonic circulation is altered by local wind forcing. For example, during periods of low influx from the Bosphorus, strong winds from the south can disintegrate basin-scale gyres into smaller scale eddies. The Bosphorus inflow is well defined, except during the periods of low discharge in autumn and winter, when the jet becomes weaker and tends to flow along the west coast [1].

As the upper layer of the Marmara Sea is occupied by brackish Black Sea water flowing through the Bosphorus, and the renewal time of the upper layer is short ( $\approx$ 4 months), the biochemical structure of Marmara Sea surface waters reflects Black Sea coastal water characteristics. (Figure 1)

## 3. Chemical structure

Mediterranean water, entering from the Dardanelles, supplies the subhalocline layer. The negatively buoyant plume of well-oxygenated water is the only means by which deep waters are renewed and partially compensates for the oxygen consumed through the degradation of organic matter sinking from the upper into the lower layer. Yet the sub halocline waters remain permanently deficient in oxygen, as a result of the internal balances of diffusion, advection and consumption. The depth to which the plume penetrates is a function of the seasonal characteristics of the inflow density (modified in the Strait) and the weak interior stratification. As shown by observations, the paths of the Dardanelles inflow in the Marmara Sea play a crucial role in the distribution of the biogeochemical variables.

The saline Mediterranean waters entering through the Dardanelles, initially poor in nutrients and almost saturated with oxygen, become enriched 10-fold with dissolved inorganic nutrients while oxygen decreases to 1-2 mg/l. These Mediterranean waters with modified chemical properties eventually leave the Marmara basin through the Bosphorus.

The oxygen utilization in the water column occurs mainly due to the sinking of particulate organic carbon generated by biological production at the surface. The sinking of large organic particles leads to a decrease in dissolved oxygen below the pycnocline. However, the sub-halocline waters of the Marmara Sea are due to the oxygen-rich Dardanelles inflow and thus the decrease in DO is not sufficient to cause anoxia.

### 4. Biological properies

In the Marmara Sea, incoming solar irradiance can penetrate to the lower limits of the pycnocline and the light is reflected at around 500 nm, with very low reflectance (2 %) at surface. In addition, the Marmara Sea is a typical example of the Case II waters, as the light absorbance is driven by the presence of particulate matter and the yellow substance is relatively high.

Light penetration is limited to the depth of the pycnocline and thus both phytoplankton biomass and primary production are always confined within the upper layer. Annual primary production occurs in the upper 10 meters of the water column and is estimated to be 500-550 g C m<sup>2</sup> year<sup>1</sup>. The

annual cycle of phytoplankton (as inferred from satellite chlorophyll measurements) in the Marmara Sea includes biomass peaks in winter-spring and fall, which is characteristic of Black Sea coastal waters.



Fig. 1. Distribution of salinity in the Marmara Sea during September 1995.

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# MODELLING THE BOSPHORUS FLOW DYNAMICS

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## Abstract

A 3D dimensional, bottom-following sigma-coordinate Princeton Ocean Model of the Bosphorus Strait is used to reproduce the observed flow and stratification characteristics. The simulations are extended to several oil spill scenarios to explore their impacts along the strait. The model successfully reproduces the typical two-layer, quasi-steady exchange flow system, which is shown to experience another hydraulic control at the northern sill near the Black Sea entrance of the strait. *Keywords : Bosphorus, Models, Danube Delta.* 

The Bosphorus Strait is a long ( $\sim$  30 km), narrow (<3.0 km), and shallow (<80 m) waterway between the Black and Marmara Seas. It consists of two oppositely flowing currents: the upper layer coming from the Black Sea with a salinity ranging from 18 to 20 psu, and the lower layer coming from the Aegean Sea with a salinity ranging between 36 and 38 psu. It lies along the high oil tankers traffic route from the Black Sea, which makes the strait a high risk area for oil spill accidents.

The three dimensional, time dependent, primitive equations, bottomfollowing sigma-coordinate Princeton Ocean Model is used to reproduce its observed flow and stratification characteristics. The simulations are extended to several oil spill scenarios to explore their impacts along the strait. The model resolves the strait with a grid distance of 100 m in both along and cross-channel directions. It extends 7 km into the Black in order to simulate the underflow structure along the underwater channel at its northern end. There are 21 sigma levels in the vertical with finer resolutions near the surface and the bottom. The maximum vertical grid spacing is about 5 m within the deepest section ( $\sim$  80 m) of the channel. Forced radiation open boundary conditions are imposed on both sides for the normal velocity component, whereas the tangential velocity component is set to zero. The forced radiation open boundary conditions are adjusted to provide the flow conditions consistent with the observed sea level elevation difference of 30 cm along the strait.

The model successfully reproduces the typical two-layer, quasi-steady exchange flow system that is to be hydraulically adjusted by a series of morphological features (Fig. 1). Three successive hydraulic controls occur within the southern 10 km zone: first near the southern exit due to convex bending of the channel, then at the southern sill and at the constriction section of the strait. The exchange flow system is shown to experience another hydraulic control at the northern sill near the Black Sea entrance of the strait.



Fig. 1. Simulated Sigma-t (kg m<sup>-3</sup>) and horizontal current (m s<sup>-1</sup>) distributions versus depth along the main axis of the channel. Sigma-t contours (black lines) are plotted at an interval of 1 kg m<sup>-3</sup>. The color bar gives the current speed with negative (positive) values for the upper (lower) layer. Triangles denote supercritical flow conditions identified by the Richardson number less than 0.25.

# NRL STENNIS' FIELD AND MODELING EFFORTS IN THE TURKISH STRAITS SYSTEM, THE BLACK SEA AND THE AEGEAN SEA

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## Abstract

Large bodies of water are often interconnected through narrow channels or sea straits. The exchanges of water, heat, salinity, and regional biochemical properties through these straits influence the larger regional scale oceanography and are governed by complex physical processes. Thus, two new Naval Research Laboratory (NRL) programs focus on strait dynamics and their impact on the dynamics of adjacent seas. The area of interest for these two programs is comprised of the Turkish Straits System (TSS) and adjacent seas (Black and Aegean Seas). The observational program is primarily focused on the Bosphorus and Dardanelles Straits. During the one-year field work, current, salinity, temperature, and microstructure measurements will be carried out within and near these two straits. The modeling effort will encompass the TSS, Black, and Aegean Seas by combining a structured grid, high-resolution regional hybrid coordinate ocean model with a baroclinic finite element-based model. The Black and Aegean Sea basins will adopt implementations of the structured grid, HYbrid Coordinate Ocean Model (HYCOM). In the TSS, the unstructured grid, finite element ocean model (DG-ADCIRC) will be applied. DG-ADCIRC is the newly developed, baroclinic ocean model based on an inherently conservative, discontinuous Galerkin, finite element methodology, and is well-suited to represent the complex dynamics of the narrow and shallow TSS. *Keywords : Black Sea, Aegean Sea, Models, Hydrology, Remote Sensing.* 

# WIND SPEED VARIABILITY OVER THE MARMARA SEA

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## Abstract

Between 2000 and 2006, wind speed measurements were collected over the Marmara Sea by the SeaWinds scatterometer on the QuikSCAT satellite, at a spatial resolution of  $0.25 \times 0.25$  degree. Relatively small inter-annual variability was noted in the monthly mean wind speeds. Typically, wind speed during summer was weaker (by approximately 2 m/s) than that observed in winter. This remotely-sensed wind data set is intended for various air-sea interaction studies and modeling efforts in the region.

Keywords : Marmara sea, Wind/font, Remote Sensing, Models.

### 1. Introduction

The Marmara Sea is an inland sea, connected to the Black Sea and the Aegean Sea through the Bosphorus and the Dardanelles straits, respectively. It therefore represents the only linkage between the two basins. Although the Maramara Sea is greatly influenced by various oceanographic features (e.g., ocean currents, temperature, and salinity) of the Black Sea and the Mediterranean Sea via the Aegean Sea, detailed information on local physical and dynamical processes is sparse. This is mainly due to the lack of fine resolution ocean models and near-surface atmospheric forcing products over the Marmara Sea.

Given the reasons mentioned above, in the Marmara Sea there is an urging need for fine spatial resolution oceanographic data. Thus, we will present herein the inter-annual variability of wind speed, which is one of the key atmospheric variables driving ocean circulation. This will be accomplished by using satellite-based wind measurements, which are gridded at a resolution of 0.25 x 0.25 degree over the region.

## 2. Changes in Monthly Wind Speed

The measurements of wind speed and direction over the ocean surface were obtained from the SeaWinds scatterometer on the QuikSCAT satellite. The SeaWinds scatterometer is an active microwave sensor, providing an average of two observations per day. A scatterometer measures the strength of signals returned from each location at several angles. These backscatters are then used to determine the wind direction and speed, calibrated to the neutral stability at a height of 10 m above the sea surface [1].The gaps in the coverage are filled by using a variational method.

(a) Neutral wind speed (m  $\rm s^{-1})$  at 10 m above the sea surface in February



Fig. 1. Equivalent neutral wind speeds processed from the 0.25 x 0.25 degree resolution QuikSCAT measurements.

As evident from Figure 1, the 10 m wind speed does not change significantly for a given month, i.e., could be considered uniform over the Marmara Sea. However, it can change from one year to another (e.g., 2005 to 2006) for a given month and is especially evident in August. Winds are relatively strong from November through February during 2000-2006 (Fig. 2). Overall, the variability in wind speed is small. This is partly due to the fact that a resolution of 0.25 degree is still not sufficient to exhaustively describe wind trends over the small Marmara Sea.



Fig. 2. Areal averages of monthly mean neutral wind speeds at 10 m above the sea surface over the Marmara Sea from 2000 through 2006.

## 3. Conclusions

Wind data from QuikSCAT are not very accurate near coastal regions involving the Bosphorus and Dardanelles Straits, as the satellite footprint may include land areas near the coast. To overcome this problem, there is a need for new technology (available, but not currently in place, as of this writing). QuikSCAT is characterized by unique, specific biases which are partially due to sampling artifacts.

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# ON THE DARDANELLES OUTFLOW IN THE AEGEAN SEA:IMPLICATIONS ON THE BASIN-WIDE CIRCULATION AND OPERATIONAL MODELING

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## Abstract

The Mediterranean Sea and the Black Sea are connected through the Turkish Straits System and the biophysical processes that control the Aegean Sea circulation and ecosystem dynamics. The outflow of waters of Black Sea origin in the Aegean Sea through the Dardanelles Strait is a key mechanism in the coupling of the two basins. Results from observational and modeling studies will be employed to highlight the critical role of the outflow in the Aegean Sea dynamics, with implications on basin-wide Mediterranean flow and water mass characteristics. Improvements on operational forecasting in the Aegean and Eastern Mediterranean regions require comprehensive measurements of the Black Sea waters outflow to be used in the understanding and numerical representation of the Straits dynamics. *Keywords : Aegean Sea, Dardanelles, Danube Delta.* 

The Dardanelles outflow contains waters of Black Sea origin (BSW) that are generally cooler and with higher nutrient content than those of the oligotrophic Aegean Sea [1]. This allows the outflow to be detected in sea surface temperature (SST) and ocean color imagery [2]. The BSW is also fresher and responsible for the overall lower salinities in the northern Aegean; in this area, the frontal zones are related to the spreading of BSW above the saltier modified Levantine Intermediate Water (LIW), which originates in the southern Aegean [3-7].

A recent study of the Aegean Sea circulation, based on drifters deployed at different seasons [8], reveals the presence of an intensified rim current system that is consistent with the buoyancy introduced by the Dardanelles outflow and the prevailing along-axis wind forcing from the north. The overall tendency of the buoyancy forcing is to lead a cyclonic circulation around the Aegean. The dominant northerly winds favor downwelling along the western Aegean coast that tends to enhance the buoyancy driven current system; both buoyancy and wind forcings seem to contribute to a jet-like flow along the Evia island, which forms the major pathway for BSW waters to reach the southern Aegean, thus bridging the Black Sea and the Eastern Mediterranean. Implications on larger scale circulation and decadal time variability have been discussed in [5].

Based on a network of oceanographic buoys and a set of atmosphere and ocean numerical models, the Hellenic Center for Marine Research has developed the operational POSEIDON system, which has been providing regional sea monitoring and short term (72 hour) forecasts of meteorological and oceanic conditions in the Aegean Sea since 1999 ([9],[10]). The nesting in larger scale models and new environmental components of the system (pollutant and nutrient transport modeling) allow predictions associated with ecosystem functioning and dispersion forecasts of oil-spills or other pollutants in case of accidents in the Aegean Sea or the Eastern Mediterranean. As the POSEIDON operational system enters a new phase of development with substantial improvements in both its observational and modeling components, a new parameterisation of the Dardanelles outflow is essential to minimize current uncertainties in exchange rates and water properties, a result of observational limitations and the lack of a coupled Aegean and Black Sea modeling system.

Numerical experiments will be presented that highlight changes in the simulation of Aegean circulation features, depending on different representations of the Dardanelles plume. Analysis of hydrographic data [11], along with model and drifter computed particle trajectories will elucidate the influence of the Dardanelles outflow on Aegean circulation features and the sensitivity of model predictions on subtle changes in the representation of the development and evolution of the Dardanelles plume.

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# NUTRIENT EXCHANGE FLUXES BETWEEN THE BLACK SEA AND MEDITERRANEAN THROUGH THE TURKISH STRAIT SYSTEM (MARMARA SEA, BOSPHORUS AND DARDANELLES)

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## Abstract

A comprehensive set of data collected between 1990 and 2001 allows us to estimate the volume and nutrient fluxes in the Turkish Strait System (Bosphorus, Marmara Sea and the Dardanelles), which is characterized by contrasting hydrochemical properties originating from the adjacent seas, *viz.* the salty Northeastern Mediterranean and the brackish Black Sea. Nutrient exchange fluxes in the straits vary markedly with season, due to changes in both the concentrations and volume fluxes. The majority of the Black Sea nutrient input to the Marmara Sea accumulates in the lower layer of the latter and is then exported to the Black Sea via the salty Bosphorus underflow of Mediterranean origin.

Keywords : Eastern Mediterranean, Black Sea, Bosphorus, Dardanelles, Hydrology.

The Black Sea is connected to the Mediterranean through the Turkish Strait System, which has a two-layer flow regime and distinctly differenth ydro-chemical properties during the year [1]. The Blak Sea inflow is nearly two-fold greater than the volume of the salty Marmara water flowing into the Black Sea on an annual basis [2]. The counterflows in the straits increase in spring-early summer and then weaken markedly during autumn, depending upon water balance conditions in the adjacent seas, especially fresh water input to the Black Sea [3]. Similarly, the nitrate and phosphate concentrations in the brakish Black Sea surface flow in the Bosphorus display drastic seasonality [4]. The concentrations increase by 10-50 fold from summer to late autumn and winter months; e.g., during the summer-early autumn period, when the consumption of nutrients via photosynthes greatly exceeds their supply from external and internal sources, nitrate concentrations reach as low as 0.1-0.2  $\mu$ M whilst phosphate values drop to 0.02-0.05  $\mu$ M.. During the bloom in the Western Black Sea, the inflow to the Marmara basin is poor in DIN and DIP.

The salty Mediterranean water enters the Marmara basin with very low nitrate and phosphate concentrations for most of the year; however, it is enriched by about 10-fold (nitrate: 8-12  $\mu$ M; phosphate: 0.7-1.2  $\mu$ M) during its stay in the basin and reaches as far as the Western BlackSea with modified chemical properties.

The seasonal volume fluxes and associated nutrient concentrations compiled in Table 1 and 2 have been used to estimate seasonal DIN and DIP fluxes in the Straits. Comparison of the seasonal chemical fluxes reveals that the DIN fluxes in the straits vary markedly with season, due to changes in both the DIN concentrations and volume fluxes. The winter DIN input from the Black Sea to the Marmara basin is about 4.64 x 10<sup>8</sup> moles, 20 times the autumn influx. A similar but less pronounced seasonality appears in the Marmara DIN input to the Aegean Sea via the Dardanelles.

Tab. 1. Seasonal & annual nitrate fluxes in the Bosphorus and Dardanelles straits.

|                      | Season | BOSPHORUS                          |                        | DARDANELLES            |                                   |                        |                      |
|----------------------|--------|------------------------------------|------------------------|------------------------|-----------------------------------|------------------------|----------------------|
| Flow type<br>(layer) |        | Volume                             | NO3 conc.              | NO <sub>3</sub> flux   | Volume                            | NO <sub>3</sub> conc.  | NO3 flux             |
|                      | 9      | (*10 <sup>9</sup> m <sup>3</sup> ) | (mmol/m <sup>3</sup> ) | *10 <sup>8</sup> moles | (10 <sup>9</sup> m <sup>3</sup> ) | (mmol/m <sup>3</sup> ) | *10 <sup>8</sup> mol |
| Upper                | Spring | 200                                | 1,32                   | 2,64                   | 307                               | 0,2                    | 0,61                 |
| Upper                | summer | 158                                | 0,42                   | 0,66                   | 194                               | 0,12                   | 0,23                 |
| Upper                | Autumn | 105                                | 0,22                   | 0,23                   | 142                               | 0,3                    | 0,42                 |
| Upper                | Winter | 145                                | 3,2                    | 4,64                   | 234                               | 0,36                   | 0,84                 |
| Upper                | Annual | 608                                | 1,29                   | 8.17                   | 877                               | 0,24                   | 2,1                  |
| Lower                | Spring | 94                                 | 9,17                   | 8,62                   | 202                               | 1,14                   | 2,3                  |
| Lower                | summer | 76                                 | 10,46                  | 7,95                   | 112                               | 0,47                   | 0,52                 |
| Lower                | Autumn | 49                                 | 9,34                   | 4,58                   | 87                                | 0,88                   | 0,76                 |
| Lower                | Winter | 68                                 | 9,81                   | 6,67                   | 158                               | 1,62                   | 2,55                 |
| Lower                | Annual | 287                                | 97                     | 278                    | 559                               | 1.03                   | 613                  |

On an annual basis, the Black Sea influx to the Marmara Sea is about four times greater than the DIN outflux to the Aegean basin via the Dardanelles, indicating that a large fraction of the DIN input from the Black Sea is converted to particulate and dissolved organic nitrogen compounds by photosynthetic activity in the Marmara Sea. DIN loads carried by the Bosphorus and Dardanelles undercurrents to the adjacent seas, however, display an opposite behavior. Indeed, on an annual basis, the Aegean DIN input (6.13 x  $10^8$  moles) to the Marmara lower layer is much less than the outflux (27.8 x  $10^8$  moles) to the Black Sea through the Bosphorus. In other words, the observed large stock in the Marmara deep basin is provided by particle snows (21.7 x  $10^8$  moles of nitrogen/year in the form of

labile PON) from the productive Marmara surface layer waters. Seasonal variations in the DIP fluxes via the exchange flows in the Straits are less pronounced than those estimated for DIN (Table 1). The Black Sea DIP input to the Marmara basin increases by nearly four times from autumn to winter ( $4.02 \times 10^7$  mol-P). A similar seasonal flow can be generated from the DIP input to the Aegean Sea via the Dardanelles Strait. On an annual basis, the Black Sea DIP input to the Marmara upper layer via the Dardanelles. On the other hand, the annual DIP outflux ( $27.9 \times 10^7$  mol-P) from the Marmara lower layer to the Black Sea via the Bosphorus is about 10-fold the input ( $2.57 \times 10^7$  mol-P)/year) from the Aegean Sea.

Tab. 2. Seasonal & annual phosphate fluxes in the Bosphorus and Dardanelles straits.

|                      | Season | BOSPHORUS                                    |                                                 | DARDANELLES                                    |                                             |                                                 |                                              |
|----------------------|--------|----------------------------------------------|-------------------------------------------------|------------------------------------------------|---------------------------------------------|-------------------------------------------------|----------------------------------------------|
| Flow type<br>(layer) |        | Volume<br>(*10 <sup>9</sup> m <sup>3</sup> ) | PO <sub>4</sub> conc.<br>(mmol/m <sup>3</sup> ) | PO <sub>4</sub> flux<br>*10 <sup>6</sup> moles | Volume<br>(10 <sup>9</sup> m <sup>3</sup> ) | PO <sub>4</sub> conc.<br>(mmol/m <sup>3</sup> ) | PO <sub>4</sub> flux<br>*10 <sup>6</sup> mol |
| Upper                | Spring | 200                                          | 0,05                                            | 1,00                                           | 307                                         | 0,06                                            | 1,84                                         |
| Upper                | summer | 158                                          | 0,03                                            | 0,47                                           | 194                                         | 0,03                                            | 0,58                                         |
| Upper                | Autumn | 105                                          | 0,05                                            | 0,52                                           | 142                                         | 0,05                                            | 0,71                                         |
| Upper                | Winter | 145                                          | 0,14                                            | 2,03                                           | 234                                         | 0,09                                            | 2,10                                         |
| Upper                | Annual | 608                                          | 0,07                                            | 4,25                                           | 877                                         | 0,06                                            | 5,26                                         |
| Lower                | Spring | 94                                           | 0,92                                            | 8,65                                           | 202                                         | 0,05                                            | 1,01                                         |
| Lower                | summer | 76                                           | 0,99                                            | 7,52                                           | 112                                         | 0,03                                            | 0,34                                         |
| Lower                | Autumn | 49                                           | 0,91                                            | 4,46                                           | 87                                          | 0,05                                            | 0,43                                         |
| Lower                | Winter | 68                                           | 1,07                                            | 7,27                                           | 158                                         | 0,05                                            | 0,79                                         |
| Lower                | Annual | 287                                          | 0,97                                            | 27,84                                          | 559                                         | 0,05                                            | 2,79                                         |

In conclusion, estimates of DIN and DIP exchange fluxes in the straits indicate that there is net DIN and DIP export from the Marmara to the Black Sea via the Bosphorus undercurrent. The Marmara upper layer acts as a sink for DIN input from the Black Sea and a large fraction of labile nutrients is accumulated in the lower stratum, with a nearly constant N/P ratio of about 8-10. Interestingly, the DIN input from the Aegean Sea to the Marmara basin exceeds the importation from the Marmara Sea via the Dardanelles Strait.

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# THE ROLE OF THE DARDANELLES OUTFLOW ON THE AEGEAN ECOSYSTEM

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## Abstract

The Dardanelles outflow of Black Sea-originated waters plays a major role not only in the thermohaline functioning of the North Aegean Sea, but also with regard to its ecological character. The buoyancy input from the Dardanelles significantly influences the North Aegean buoyancy budget, while the input of organic matter determines its ecological functioning. The variability of the Dardanelles outflow induces shifts of the North Aegean ecosystem from a state driven by the microbial food web (during periods of estuarine functioning) to another driven by the new production of organic matter (after periods of dense-water formation) The implications of such shifts can be traced up to the higher trophic levels.

Keywords : Aegean Sea, Dardanelles, Water Convection, Primary Production.

The North Aegean thermohaline functioning is greatly influenced by the buoyancy input from the Dardanelles [1], which in turn is controlled by the volume exchange through the Turkish Straits [2] and the density of the outflowing Black Sea waters. During periods of high buoyancy inflow (which is the norm), the North Aegean behaves as a dilution basin. Anomalously low buoyancy inflow from the Dardanelles combined with winter cooling result in episodic, massive dense water formation. Two such incidents have been recorded, in 1987 and 1992-1993 [1].

The Dardanelles outflow also plays a critical role in determining the characteristics of the Aegean Sea ecosystem. During the "normal" periods of estuarine functioning, the Black-Sea originated waters enrich the North Aegean with organic carbon and nitrogen [4], thus maintaining a microbial-loop based production in the region, in contrast to a multivorous food-web of the South Aegean [5, 6]. This enrichment of Northeastern waters entails a gradient in the oligotrophic character of the ecosystem in the Aegean Sea, which is also reflected in the fisheries and the distribution of the Greek fishing fleet [7]. During the long periods of estuarine functioning, the decomposing organic matter results in a gradual depletion of dissolved oxygen and accumulation of inorganic nutrients in the deep basins of the North Aegean. Thus, during estuarine periods, the deep basins progressively become nutrient reservoirs for the Aegean Sea.

When the estuarine periods are interrupted by episodes of massive dense water formation, the ecosystem functioning of the North Aegean may exhibit similar shifts. These incidents are aided by a reduction of the buoyancy exchange between the Aegean and the Black Sea, which may also be accompanied by a reduction in the inflow of organic matter to the Aegean. Furthermore, the upwelling of the inorganic nutrients stored in the deep basins throughout the estuarine periods may provide the basis for extensive new production in the North Aegean. Thus, a transition from a microbial loop-based to a new production-based ecosystem could be taking place.



Fig. 1. Time series of mackerel (gray) and anchovy (black) landings at the port of Alexandroupoli, North Aegean. The triangles denote times of massive dense water formation in the North Aegean Sea.

The ecosystem response to the dense-water formation events of 1987 and 1992 has not been studied in detail, mostly due to lack of data from that period. While the response of the primary producers has not been witnessed, a strong influence on the pelagic zooplankton [8] and benthic community [9] in the Cretan and Levantine Seas has been recorded. The magnitude of these findings cannot be explained by the nutrient upwelling in the euphotic zone in these regions [10]. However, the overturning of the water column of the Aegean (and the consequent nutrient upwelling) was much more intense in the regions north of the Cyclades than the South Aegean Sea [1]. In this work we assess the amount of nutrient upwelling in the North Aegean during the dense-water formation period, and estimate the organic carbon production that such an infusion could support. Due to the unfortunate lack of chl- $\alpha$ -monitoring space-borne sensor at that time, we attempt to indirectly assess chl- $\alpha$  concentrations through the monitoring of ocean colour, exploiting NOAA-AVHRR images. The response of the pelagic zooplankton community cannot be studied, as there are no measurements from the Aegean at that time; however, the response of the higher levels of the food chain can be indirectly assessed through the North Aegean fishery landings records. Analysis of the pelagic small fishes (known to be most sensitive to changes in environmental conditions), sardine and anchovy, as well as the anchovy predator mackerel, reveal that the fishery landings increased significantly over the 1-3-year period which followed the major dense-water formation events of 1987, 1992 and 1993 (Fig.1).

These findings suggest that the North Aegean food-chain, which under mild conditions is based on a regenerated-production cycle fed by the infusion of organic matter through the Dardanelles, may shift to a newproduction based regime through the upwelling of inorganic nutrients, when the exchange with the Black Sea weakens in conjunction to severe winter conditions.

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Géosciences marines

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APPORTS DE L'OUED ISSER ET RÔLE DU CANYON D'ALGER DANS LA DYNAMIQUE DES SÉDIMENTS DU PLATEAU CONTINENTAL DE LA BAIE DE ZEMMOURI EL-BAHRI

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Résumé

La marge algérienne se différencie des autres marges méditerranéennes, par ses caractères morphologiques, structuraux et sédimentologiques. La nature des dépôts semble évoluer vers une régression progressive, mais rapide de la sédimentation carbonatée du pléistocène supérieur.

Mots clès : Sedimentation, Continental Margin, Algerian Basin.

La baie de Zemmouri El-Bahri se situe à l'est immédiat de la baie d'Alger. Très largement ouverte vers le Nord, elle s'étale sur une cinquantaine de kilomètres.

L'oued Isser constitue le principal émissaire. Le plateau continental, très étroit, occupe entre 2 et 6 kms de largeur. Il est entaillé par deux canyons sous-marins fortement encaissés débouchant sur de vastes vallées sous marines, comme le canyon d'Alger et celui du cap [1] (Fig 1).



Fig. 1. Le plateau continental de la Baie de Zemmouri El-Bahri, entaillé par les deux canyons sous-marins d'Alger et du cap Blanc.

On étudie la répartition des paramètres sédimentologiques autour des têtes de canyons et sur le plateau adjacent. La répartition de ces paramètres sédimentologiques sur le plateau et la marge permet de reconstituer la dynamique du matériel détritique depuis les zones d'apports jusqu'aux milieux de dépôt. Dans les cas favorables, certains traceurs peuvent aussi établir les chronologies de dépôts en différenciant les environnements actuels des environnements passés qui ne sont plus alimentés désormais.

Le gradient d'envasement s'avère partout extrêmement rapide, surtout autour et dans l'axe du canyon, tandis que l'environnement sur le plateau est beaucoup plus silteux. Dans le secteur occidental de la baie, les isoteneurs en lutites sont représentées par des liserés plus ou moins marqués qui traduisent un gradient rapide vers l'envasement total (>à 90% des teneurs en lutites). L'isobathe 50m marque le début de l'envasement circalittoral. Les teneurs en lutites dans le secteur oriental sont marquées par un envasement plus progressif sur tout le plateau. Cet envasement est perturbé dans la frange côtière, prés de l'embouchure de l'oued Isser par des auréoles de concentration supérieures à 50% entre 10 et 30m de profondeur. Cet envasement précoce résulte de la floculation électrochimique du matériel argilo colloïdal à l'interface eau douce - eau salée à proximité des embouchures [2] (Fig 2).

Il en résulte à court terme la constitution d'une formation prodeltaïque; ce phénomène se trouve au débouché de tous les émissaires autour de la Méditerranée [3]. Les analyses granulométriques ont permis de définir deux grands ensembles de faciès caractérisant la sédimentation actuelle sur la marge; les faciès terrigènes constitués de faciès sableux, lutitique, vaseux et le faciès bioclastique formé par le coquillier.

Les grands traits du recouvrement sédimentaire des dépôts actuels et récents de la plate-forme continentale algérienne font ressortir deux sédimentations, l'une organogène à la limite du plateau continental, l'autre constituée de dépôt terrigène.



Fig. 2. Gradient d'envasement dans les différents secteurs de la Baie de Zemmouri El Bahri. L'envasement précoce résulte de la floculation électrochimique du matériel argilo colloïdal à l'interface eau douce - eau salée à proximité des embouchures.

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INFLUENCE OF THE SEDIMENT CHARACTERISTICS ON FORAMINIFERAL DISTRIBUTION IN THE KAŠTELA BAY (ADRIATIC SEA)

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Abstract

Foraminiferal distribution, granulometric composition, carbonate and organic matter contents were determined in recent sediments of the Kaštela Bay. The results indicate that foraminiferal distribution strongly depends on organic matter content, which is in direct correlation with granulometric composition and carbonate content.

Keywords : Sediments, Adriatic Sea, Foraminifera.

Introduction

The study performed at 9 stations in the Kaštela Bay, which is located in the central part of the eastern Adriatic coast. The Kaštela Bay is oval shaped, semi-enclosed bay, with surface of about 61 km² and 1.4 km³ total volume, separated from open sea by the Island of Čiovo and the Split Peninsula. The Bay is the most populated area on the Croatian coast, with develop industry in its eastern part.

Materials and Methods

Surface sediment samples(0-2cm) were collected using Van Ween grab sampler during the summer 2005. Immediately after sampling, the samples were frozen, stored at a temperature of -20 °C and freeze-dried in the laboratory.

Foraminiferal assemblages were studied from the fraction larger than 125 μ m, on the aliquots containing about 300 foraminiferal specimens. The granulometric composition, carbonate and organic matter contents were determined too [1].

The aim of this study was to determine if there are any dependences between foraminiferal distribution and other investigated parameters.

Results and Discussion

According to foraminiferal distribution non metric Multi Dimensional Scaling (MDS) algorithm shows dissimilarity relations between stations [2]. Three groups are separated:

Station7 differs from all other stations having highest foraminiferal density (number of foraminifera on 1 g dry sediment), coarse grained sediment, highest carbonate and lowest organic matter contents. Epifaunal spesies Asterigerinata mamilla, Cribroelphidium decipiens and Lobatula lobatula dominate the assemblage. Stations 1, 3, 6 and 9 are characterised by the lowest foraminiferal density (55-102 on 1 g dry sediment), lowest carbonate content and higher fine grained sediment. At these stations Textularia agglutinans, Ammonia tepida and Bulimina aculeata are dominant species. Stations 2, 4, 5 and 8 represent intermediate conditions concerning above mentioned groups, with Cribroelphidium decipiens and Ammonia tepidaas dominant species. These results indicate that in the Kaštela Bay foraminiferal distribution strongly depends on organic matter content, which is in direct significant relationship with granulometric composition and carbonate contents.

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DYNAMICS OF FORAMINIFERAL ASSEMBLAGES IN THE SEDIMENTS IN FRONT OF THE CETINA RIVER MOUTH, CROATIA

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Abstract

Bottom sediment characteristics and composition dynamics of foraminiferal assemblages in samples taken in front of the Cetina River mouth indicate that this is stable envoronment with the occasional input of large amount of terrigenous material. In this sedimentary environment relative large number of shallow water benthic foraminiferas was found (236) with prevalence of individuals from *Quinqueloculina*, *Ammonia* and *Haynesina* genera.

Keywords : Adriatic Sea, Foraminifera, River Input, Sediments.

The sediment cores (up to 12 cm long) were collected at two stations (P1 and P2) in front of the Cetina River mouth (eastern shore of the Adriatic Sea) over the period of one year (four sampling campaigns: May, August, November 2003 and April 2004). The spring of the Cetina River is situated in non-carbonate rocks and its drainage basin is made of carbonates (Cretaceous) and flysch deposits (Upper Eocene) [1]. The main reason why Cetina River carries a large amount of material and deposits it at the river mouth is the weathering of Flysch. The Cetina River has a torrental character with big and rapid flow changes (the average flow at the river mouth is 116 m³/s) [2]. The stratification of the water column is present at the mouth, in the upper layer there is the low density fresh water, and at the bottom there is the high density sea water [3], which shows characteristics of the salt wedge estuay.

The granulometric analysis revealed sandy sediment at the P1 station (10 m depth) through the core length in all samplings. At the P2 station (30 m depth) the bottom sediment type, found in the samples collected in May and August 2003, was silty sand throughout the core, while the sediment collected in November 2003 and April 2004 was sand. It is assumed that the change of the sediment from the finegrained (silty sand) into the mediumgrained (sand) is the result of river Cetina's hydrodynamic influence and the input of new material during heavy autumn and spring rain, which had preceded these two samplings.

The micropaleontologic analysis was performed on the total assemblages at both stations due to a small number of stained individuals. The preservation of foraminiferal tests was generally good. The biological diversity of the foraminiferal assemblages at the P1 station was from 37 to 63 species in each sampling. At the P2 station the biological diversity was somewhat higher with the number of species ranging from 56 to 75 in each sampling. The seaward increase of species diversity is in accordance with the change of sediment substrate. The more finegrained and richer with organic detritus the sediment is, the more acceptable it is for the life of shallow water foraminifers. Foraminiferal assemblages at both stations (P1 and P2) were of moderate diversity (index S(H) - between 2.96 at the P1 station and 3.83 at the P2 station in November 2003) and of small domination (D - between 0.03 at the P2 station in May and November 2003 and 0.09 at the P1 station in November 2003). At the P1 station in all samplings individuals from Quinqueloculina seminula and Ammonia *tepida* species were the most abundant, but constituted only up to 20 %of the total assemblage. On the other hand, at the P2 station the most abundant individuals were those from Pseudoparrella exigua, Haynesina depressula and Ammonia tepida which also constituted up to 25% of the total assemblage. The abundance of P. exigua species decreased along with the change of sediment type in the samples from November 2003 and April 2004. This could indicate that this species is sensible to changes of sediment substrate, which in this case means that it prefers the finegrained sediment. Interesting enough, the abundance of H. depressula and A. tepida species did not change significantly with the change of the sediment type. The epifaunal species were more represented in the sand (up to 75 %), which is found at the P1 station (in all four samplings) and the P2 station (November 2003 and April 2004). However, in the silty sand, found at the P2 station (May and August 2003), the epifauna - infauna ratio was in balance (35 - 50 % respectively). The ratio of infaunal and epifaunal species was in accordance with the bottom sediment type. The unusually high ratio of individuals of epifaunal species from the family Miliolida

(up to 45 %) at the P1 station could partly be caused by the input of dead individuals from the nearby meadows of *Posidonia oceanica* seagrass.

Although the samples were taken from the river mouth area, the measured bottom water salinity was ~ 38 , which is in accordance with the normal marine environment. However, this does not exclude the salinity decrease during high river water input. In summary, the moderate diversity of foraminiferal assemblages (236 species) indicates that this is a stable environment with occasional stress (most probably periodical salinity decrease). This can be related to the fact that in almost all samples there was a constant occurrence of individuals from *Quinqueloculina, Ammonia* and *Haynesina* genera, which are described as euryhaline genera typical of the environment with variable salinity [4].

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A NEW BATHYMORPHOLOGICAL MAP FOR STROMBOLI VOLCANO

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Abstract

The Island of Stromboli is the emergent summit (about 12 km^2) of a large and steep-sided edifice, rising over 3000 m above the surrounding seafloor, comparable in size to the Etna volcano. In recent years, new surveys have been carried out in the area, and the acquisition of multibeam swath bathymetry have greatly enlarged the knowledge of the morphology of the submerged portions of Stromboli down to its base. A new bathymorphologic map of Stromboli and surrounding seafloor is presented, where the main volcanic and erosional-depositional features are mapped, enhancing the role of mass wasting and dismantling processes in the evolution of the volcanic edifice. *Keywords : Aeolian Arc, Tyrrhenian Sea, Bathymetry*.

Stromboli, together with Panarea and minor islets, represents the emerged portion of a 45 km-long volcanic belt of the eastern Aeolian Archipelago, lying on thin continental crust on the Southern Tyrrhenian margin. Although most (95%) of the areal extent of the Stromboli volcano lies underwater, the knowledge on its evolution is mainly based on studies on the very tip of the cone. Recent surveys, carried out in 2002-2006 aboard the oceanographic Italian ships *Urania, Universitatis* and *Thetis* and positioned with GPS and differential GPS, allowed to obtain a complete high-resolution multibeam bathymetric coverage of the submerged flanks of Stromboli and surrounding areas. Multibeam Seabat models 8160, 8101, 8111 and 8125 have been used. Data processing was performed with nonconventional procedures, to recover the maximum possible precision and resolution. Bathymetric data were integrated with the acquisition of high-resolution seismic and side scan sonar data; surficial sea-bottom sampling was also performed through grab and dredge operations.

The Stromboli composite volcano is broadly symmetrical about a NE-SW trending axis, along which the major vents and eruptive fissures are located, likely controlled by regional tectonic stresses. This is still more evident in the submerged setting of the volcanic edifice; inparticular, the early development of Stromboli along a NE-SW alignment is witnessed by the shallow-water NE and SW portions of the volcanic edifice, showing well-developed abrasion platforms, likely related to Late-Quaternary sea-level fluctuations and covered by reworked terraced volcaniclastic sequences. The new bathymetric data set depicts the Stromboli submerged flanks from the coast down to the base of the volcanic edifice; the Stromboli Canvon surrounds it to the East and to the North. This is a huge erosional feature originating from the northern Sicilian margin and collecting sediments from the Calabrian slope and the central-eastern Aeolian Islands down to the bathyal plain (Marsili Basin), to over 3000 m of depth. To the Southwest, a saddle (with a minimum depth of 1275 m) connects Stromboli with the nearby Panarea volcano. Northeast of Stromboli, about one nautical mile from the island, the sea-stack of Strombolicchio is the remnant of an earlier volcanic center, whose conical summit has been dismantled and deeply abraded down to 100-180 m, leaving a wide subcircular abrasion platform.

Mass wasting and dismantling processes are widely diffused at all possible scales along Stromboli submarine slopes, indicating that flank instability is a very common process on island volcanoes.

One of the most relevant new results, apart from the general improvement in the definition of main volcanic, erosional and depositional features, is in fact the discovering of several megablocks at the foot of the eastern submerged Stromboli flank. They are present below 1000 m of depth and are mostly concentrated around 1550-1750 m, being likely the result of one or more large-scale debris avalanche events occurred on the eastern side of island. This evidence enlarges the knowledge on the volcanological and structural evolution of Stromboli, where a sequence of lateral volcanotectonic collapses is known to have affected mainly the western side of the island, the relevant features being recognized on land [1] and in the offshore [2]. The recurrence of large-scale destructive events along both the western and eastern flanks of the edifice suggests that structurallycontrolled instability occurs at both sides of the main NE-SW oriented axis of intrusion, likely due to a combination of slope unbuttressing and oversteepening and to magmatic dilation effects.

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UTILISATION DES MINERAUX LOURDS COMME TRACEURS DE LA DYNAMIQUE SÉDIMENTAIRE ENTRE SIDI FREDJ ET MAZAFRAN (ALGÉRIE)

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Résumé

La minéralogie du faciès sableux superficiel a défini un cortège minéralogique lourd et léger correspondant essentiellement à la fraction granulométrique comprise entre les tailles 400-160 et 160-63 um.L'interprétation des cartes minéralogiques nous a permis de mettre en évidence plusieurs directions de transits littoraux:.- L'association minérale est constituée de:-minéraux transparents : quartz -calcitedolomite- aragonite- micas- sphéne - tourmaline- pyroxène- barytine.-minéraux opaques : pyrite- marcasite- hematite- goethite. La distribution de la phase minérale (lourde et légère) devant le principal oued (mazafran) et les oueds secondaires (larha- ridja- sidi- menif et ain- ezzebda) montrent que ces minéraux sont probablement originaires de la fragmentation continentale (plaine de la Mitidja et l'atlas blidéen) et par le démantèlement des affleurements rocheux de Sidi Fredj et du massif de Chenoua.

Mots clès : Coastal Processes, Infralittoral, Mineralogy, Sediment Transport.

L'étude minéralogique de la zone infra-littorale de la baie de BOU-ISMAIL (Algérie) a été réalisée en fonction de la morphologie littorale, sous marine et de la dynamique sédimentaire. Géologiquement, une étude des formations rencontrées au niveau du bassin versant nous a permis de déterminer les différents minéraux susceptible d'être transférés en milieu marin et participer ainsi à la sédimentation marine.

En effet, les minéraux rencontrés dans la plaine de la Mitidja (sédimentaire), à Sidi Fredj (métamorphique), ou au Chenoua (éruptif) confirment la présence de ces derniers au niveau du plateau continental tels que les Micas, Tourmaline, Zircon, Pyrite, et Hématite. Certains de ces minéraux peuvent être transformés lors du transfert du milieu continental vers le milieu marin [1]

Le régime hydrologique de l'oued Mazafran fortement lié au climat semi aride de la région avec des périodes sèches et des périodes pluvieuses détermine des érosions intenses au niveau des bassins versants suivis d'apports fluviatiles (solides et liquides) assez conséquents (mois de mars) ce qui explique les fortes teneurs lutitiques (rapprochements des lignes d'isoteneurs) au front de ce dernier [2].

L'étude hydro climatique de la zone concernée a fait ressortir :

Une prédominance des vents de secteur occidental en période hivernale et des vents de secteur oriental en période estivale

En mer, et en période hivernale les houles provenant de l'ouest sont plus puissantes que les houles est et nord-est de la période estivales qui elles sont plutôt plus fréquentes.

Mineralogie

La minéralogie du faciès sableux a défini un cortège minéralogique "lourd "et "léger "correspondant essentiellement à la fraction granulométrique comprise entre les tailles 400-160 μ m et 160-63 μ m, suivant les coupures adoptées par les laboratoires de sédimentologie[3].



Fig. 1. Répartition de la fraction minérale lourde 160-63um.

La fraction minéralogique lourde se concentre plutôt dans les tailles fines (160-63 μ m) que dans les tailles plus importantes (400-160 μ m).pour cela nous nous sommes intéressés uniquement à la première coupure; ce qui

expliquerait également l'usure de ces minéraux avant leur dépôt (fig.1) .

Du fait des difficultés rencontrées, dues à des problèmes techniques dans l'enrobage des minéraux en grains et n'ayant pu estimer les pourcentages, nous avons opté pour une estimation globale des minéraux. On notera toutefois la présence de quelques minéraux légers dans cette fraction : ceci serait dû à leur entraînement dans leur chute par d'autres minéraux, ou en agglomérats malgré les différents lavages et séparations.

Conclusion

L'interprétation des cartes minéralogiques nous a permis de mettre en évidence :

Un transit latéral des minéraux parallèlement à la côte, résultant des courants de dérive littorale induits par les houles de direction est nord-est (été), et ouest (hiver)

Un transit transversal des minéraux de la côte vers le large (vu la discontinuité des rides d'avant côte) résultant des courants de retour, engendrés par la houle Nord-ouest qui redistribue le matériel vers le large par l'intermédiaire des chenaux inter rides creusés par ces derniers.

La distribution de la phase minérale lourde et légère devant le principal oued (Mazafran) [2] et les oueds secondaires (Larha, Bridja, Sidi-Menif, et Aïn Zebda) montrent que ces minéraux sont probablement originaires de le fragmentation continentale (plaine de la Mitidja et atlas blidéen) et par le démantèlement des affleurements rocheux de Sidi Fredj et du massif du Chenoua.

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EMCOL (EASTERN MEDITERRANEAN CENTRE FOR OCEANOGRAPHY AND LIMNOLOGY): A NEW EUROPEAN RESEARCH CENTRE FOR NATURAL HAZARDS AND ENVIRONMENTAL CHANGE STUDIES

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Abstract

EMCOL is a new research centre at Istanbul Technical University, housing a group of earth scientists and state-of-the-art laboratory and field infrastructure in the fields of natural hazards and environmental changes in marine and lake basins. It is specialized in high-resolution core analysis for the stratigraphic records of paleoclimatic and paleoceanographic changes, and engaged in various geological and geophysical surveys in marine and lake basins. EMCOL is interested in carrying out with other groups international collaborative projects in the Eastern Mediterranean region.

Keywords : Eastern Mediterranean, Paleoceanography, Geochemistry, Geophysics, Global Change.

EMCOL (Eastern Mediterranean Centre for Oceanography and Limnology) at Istanbul Technical University is established with the following objectives:

1. To set upstate-of-the-art laboratory and field infrastructure that will be used extensively in marine and lake studies, including *natural hazards and environmental changes*, so that the output will be comparable with that from European, American, and other worldwide centres of excellence,

2. To develop highly qualified first- and second-generation researchers in interdisciplinary marine and lake studies at ITU, covering a wide range the fields such as under water earthquake geology, tsunamis, submarine land slides, floods, climate change and environmental pollution, and

3. To enhance interactions in projects and idea exchanges between ITU researchers and those in the EU countries.EMCOL is presently being supported by 3-year EC FP6 SSA-2 project (Contract No. 17490). It has started serving the needs of researchers working in the Eastern Mediterranean regions in the areas of Natural hazards and environmental changes, involving imaging of sea and lake sediments and analyzing important proxies in sediment cores. With the EMCOL facilities it is now possible to map active faults and submarine landslides, determine high resolution records of past earthquakes and tsunamis that are essential for earthquake and tsunami risk assessment. The same facilities can also be used for determination of the high resolution sediment records of sea-level, climate and ecological changes. The EMCOL's laboratories and field facilities include:

1. Core Analyses Laboratory housing: (i) ITRAX Core scanner for submm-scale resolution XRF multi-element analyses, digital X-ray radiography and colorscanning of cores (Figs. 1and 2), (ii) MSCL core logger with gamma-ray density,magnentic susceptibility, p-wave and electrical resistivity sensors.



Fig. 1. EMCOL's ITRAX core scanner does XRF analysis, digital radiography and colour scanning of sediment cores at sub-mm scaleresolution.



Climate oscillations with 25-30 yr period

Fig. 2. ITRAX analysis of a core from the Black Sea showing climaticvariations of 25-30 year period.

2. Sedimentology Laboratory, with laser grain size analyzer and mechanical sifter, smear slide preparation and optical microscopy.

3. Geochemistry Laboratory with TOC/TICanalyzer (total organic and inorganic carbon analyses) and fossil separation facility for isotope analyses.

4. Wet Core laboratory for sample description, digital photography, geomechanical tests, descrete sampling, and wet-sieving for microfossils.

5. Cold Core Storage Room for storing and archiving sediment cores at $4^{\circ}C$.

6. Field Equipment Storage facility with sub-bottom profiler (chirp-type), a platform with Uwitec tripod for lake coring and sediment sampling, 6 m boat with engine, various corers, such as submersible vibrocorer, piston corer, Kajak corers, Livingstone piston corer, grab, and equipment for shoreline drilling.

In addition to the EMCOL facilities, Sample Preparation, GIS, Remote Sensing and Tree Ring laboratories of the Eurasian Institute of Earth Sciences will be available for research projects. EMCOL has already started carrying out its own research projects and collaborative research projects with European and American research groups. All developments on the EMCOL can be followed on its web-site (http://www.emcol.itu.edu.tr), concerning the laboratories, equipment and training courses and employment opportunities for young scientists.

INVESTIGATION OF HYDROTHERMAL VENTS IN THE AEGEAN SEA USING AN INTEGRATED MASS SPECTROMETER AND ACOUSTIC NAVIGATION SYSTEM ONBOARD A HUMAN OCCUPIED SUBMERSIBLE

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Abstract

In June and July of 2006 a research program was undertaken to investigate areas of suspected hydrothermal venting at the Greek islands of Milos and Santorini. This program utilized the HCMR Thetis research submersible equipped with a navigation tracking system and in-situ chemical sensors. This integrated sensor payload successfully mapped and chemically characterized hydrothermal venting in real-time. *Keywords : Aegean Sea, Chemical Analysis, Instruments And Techniques, Mapping, Hellenic Arc.*

The 2006 project PHAEDRA investigated Aegean Sea hydrothermal venting near the islands of Milos and Santorini. In order to conduct field work at these sites, the authors developed novel technologies into the HCMR Thetis human occupied submersible, including an Ethernet communication system, navigation tracking system, and in-situ chemical sensors -including a Gemini in-situ mass spectrometer, CTD, dissolved oxygen sensor, and manipulator arm triggerable Niskin bottles for post-dive gas chromatographic analysis. A total of three dive missions were conducted with Thetis and the payload sensors; two at Milos, and one inside the Santorini caldera. The first dive was an operational test of the instrument systems at a depth of approximately 60 meters in a hydrothermally inactive area near the southern coast of Milos. Submersible sensor data collected during the dive mission did not reveal any anomalous temperature spikes (temperature deviating no more that 0.02 °C about a mean of 14.82 °C) and no mass spectrometer values indicative of hydrothermal venting activity. Visual inspection of the ocean floor by the submersible's crew corroborated the in-situ data. Post-dive gas chromatographic analysis of water samples did not reveal any increases in dissolved gas concentrations associated with hydrothermal venting. The second dive mission was conducted in an area southeast of the Fyriplaka volcano containing hydrothermal vents to depths of 115 meters [1]. Examination of the site revealed filamentous white microbial mats, possibly Thioploca [2], along with sulfurous mineral deposits, and water column chemical anomalies at a depth of approximately 100 meters. In-situ mass spectrometer measurements at the site indicated significant concentrations of sulfides (in the presence of dissolved oxygen) and elevated carbon dioxide. Minor increases in methane were also recorded. Post-dive processing and merging of chemical data with navigation data indicated highly localized hydrothermal venting on horizontal length scales of approximately Â; meter (Figure 1).

CTD records indicated temperature increases of up to 0.12 °C in the overlying water column at the venting sites. Gas chromatographic analysis of water samples collected during the dive indicated significantly elevated carbon dioxide, and methane concentrations up to 0.18mM, but did not indicate the presence of sulfides. However, decreased dissolved oxygen of approximately 270mM were measured, suggesting that any sulfide collected in the Niskin bottles may have reacted with the dissolved oxygen. In comparison to the first dive site, the second site exhibited a 104% carbon dioxide concentration increase and a 15.3% dissolved oxygen decrease. Methane concentrations were below the gas chromatograph's detection limits at the first dive site. The increased carbon dioxide, hydrogen sulfide, and methane concentrations correspond well with vent gas composition found at nearby shallow water sites [3], suggesting that they are part of the same vent system.

The third dive mission using the integrated chemical sensor/navigation system was conducted in the Santorini caldera in an area of suspected active volcanic or hydrothermal venting at a depth of approximately 350 meters. Real-time data collected during this dive did not indicate any significant variation in methane, oxygen, or carbon dioxide concentrations, nor any sulfides or other dissolved gases associated with volcanic venting. Despite the absence of apparent venting activity, areas of small (approximately 0.5 m high) flocculent seafloor mounds with yellow-orange coloration were observed, suggesting high concentrations of oxidized iron. Post-dive GC analysis of water samples did not indicate any significant

variation in gas concentrations, suggesting that these sites were not hydrothermally active. The authors would like to thank the Hellenic Center for Marine Research and the United States NOAA Office of Ocean Exploration for their support of this research program.



Fig. 1. Map of hydrogen sulfide concentrations measured during Milos Dive #2 using the Gemini mass spectrometer. Lighter coloration indicates increasing sulfides.

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PALYNOLOGICAL EVIDENCE FOR CLIMATIC CHANGE DURING THE LATE QUATERNARY

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Abstract

Pollen analysis was carried out on three cores collected from the Marmara Sea. Pollen assemblages display slightly different composition in the eastern and western parts of the Marmara Sea. Artemisia exists in the cores KL 97 and DM18 but does not occur in core DM 13. In addition, *Picea* points to woodland vegetation more like the present moister mountain forest in the Southern Black Sea where it occurs on the north slopes of the mountains. Cores DM18 and DM 13 from the Central basin, show different stratigraphic distributions of major pollen species. The pollen records of the sediment cores include several types of vegetation, from step to semi-desert taxa, to those of upland broad -leaved deciduous and coniferous forests. *Quercus* is the most common tree pollen all of cores, reflecting the eastern Mediterranean warm-dry summers and mild-wet winters. Total AP and NAP percentages, and changing abundance of individual tree and herb taxa allowed us to distinguish four different zones in studied cores.

Keywords : Deep Sea Basins, Sea Of Marmara, Sapropel.

The intracontinental Marmara Sea is a unique waterway situated between the Black and Mediterranean Seas to which it is connected by the Turkish Strait System (TSS: Bosphorus and Dardanelles) The Marmara Sea includes various types of several depositional environments such as shelves, slopes, deep basins and ridges. The shelf area is subject to accumulation of mainly coarse-grained siliciclastic terrigenous sediments with biogenic sediment contribution, particularly in the southern part where it widens and receives large riverine input [1-4]. The sediment deposits of this small basin provide excellent records for determining the water exchanges between the twomarine realms during the Late Quaternary in relation to the paleoceanographic evolution of the region. Previous investigations indicate the occurrence of sapropelic layers [5-6].

Pollen analysis was carried out on three cores collected from the Marmara Sea. The gravity cores DM 13, DM 18 and KL 97 were collected during the cruises of R/V Sismik1 and R/V Meteor, respectively. The core DM 13 and DM 18 were collected from the western ridge of the Marmara Sea at a water depth of 710 m, with sediment recoveries of 300 cm and 420 cm, respectively. KL 97 was collected from the Eastern Basin of the Marmara Sea at a water depth of 1094 m and it has a length of 540 cm. The sediment samples for pollen analysis (~1 cm ³fresh material) were treated using standard methods [7-9]. This method includes HCl, HF, and KOH digestion, before staining with safranine and mounting with glycerine jelly. After HCl digestion, *Lycopodium* spores were added to obtain estimates of palynomorph concentration per cm³. The pollen percentages are based on total pollen, excluding spores. Ages of the pollen zones were obtained by AMS and ¹⁴C dated methods.

The pollen records of the sediment cores include several types of vegetation, from step to semi-desert taxa, to those of upland broad -leaved deciduous and coniferous forests. *Quercus* is the most common tree pollen all of cores, reflecting the eastern Mediterranean warm-dry summers and mild-wet winters (Davis 1965-1985). Total AP and NAP percentages, and changing abundance of individual tree and herb taxa allowed us to distinguish four different zones in studied cores.

Core DM 13 was collected from the western ridge of the Marmara Sea at a water depth of 710 m, with a recovery of 3 m. The oldest sediments are found in core DM 13. two units are identified in core DM13 highest total pollen count between 80 and 100 cm, which reaches about 900 grains cm^{-1} , is coeval with the sapropelic layer in this core. Pollen zone D at the base of the core (from 200 to 290 cm) is characterized by a high value of AP (arboreal pollen), ranging between 80 and 90 % of total pollen, and consequently, the percentage AP is low. Quercus is the dominant arboreal pollen type, followed by irregularly increasing amounts of Pinus and Juniperus. Chenopodiaceae is the most abundant in nonarboreal pollen. In Zone C, between the 120-190 cm, the arboreal pollen sum increases against non-arboreal pollen (up to 91%). The percentage of Quercus does not vary but Pinus increases. Chenopodiaceae dominates the NAP (non-arboreal pollen), but decreases at the base of the zone C. In Zone B (120-60 cm), the pollen sum increases and corresponds to a sapropelic layer. Quercus, Pinus and Juniperus increase and reach maximum values whereas the Chenopodiaceae start to decrease. In Zone A, the distributions of the most abundant AP species, such as Quercus and Pinus, do not show significant fluctuations.

In core DM 18, the highest pollen count is between 245 and 355 cm, reaching about 800 grains cm^{-1} and corresponding to the sapropelic

layer. Zone C between 400 and 245 cm contains high arboreal pollen sums. *Pinus* and *Abies* increase and reach their maximum values whereas *Artemisia* decreases. In Zone B, between 245 and 90 cm, *Quercus* increases whereas *Pinus* and *Abies* decrease. Zone A is characterized by the lowest value of total pollen.

Core KL 97 from the deep eastern basin shows high variable sedimentation rates. The total pollen sum displays the highest value at around 260 cm, corresponding to the sapropelic layer. Zone D, located between 400 and 500 cm, consists of high values of AP. *Artemisia* reaches a maximum value in zone C. Between the intervals 140 and 280 cm in zone B, *Quercus* pollen fluctuation in this core. Pollen distributions do not fluctuate significantly in zone A.

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CALCULATED SEDIMENTATION RATE IN THE KRKA RIVER ESTUARY USING VERTICAL DISTRIBUTION OF $^{137}\mathrm{CS}$

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Abstract

Sedimentation rate in the Krka River estuary was calculated from vertical ¹³⁷ Cs distribution in sediments. Calculated sedimentation rate was 2 mm/a upstream of the Prokljan Lake, 4-5 mm/a at the Guduča River mouth in Prokljan Lake and 3-4 mm/a in other parts of the lake. In the lower part of estuary, sedimentation rate was very small, less than 1 mm with exceptions in deepest parts of estuary in front of city Šibenik where sedimentation rate was approx. 3 mm/a.

Keywords : Adriatic Sea, Estuaries, Radionuclides, Sedimentation.

The Krka River estuary was formed during the Holocene transgression. Located between Skradinski Buk waterfalls (calc-tufa barrier) through the Prokljan Lake to the St. Nikola fortress, the estuary has a total length of 22 km (Fig 1).



Fig. 1. Krka River estuary, with sampling locations and four different sedimentation areas recognized. Inset: Characteristic ¹³⁷Cs activities in sediment profiles at investigated locations.

The hydrogeologic drainage area of the Krka River is approximately 2427 km². The estuary bottom gradually deepens from 2 m, below the waterfalls, to 42 m in front of Fort St. Nikola. It is typical karstic highly stratified estuary with fresh/brackish surface layer flowing seawards and bottom seawater counter-current moving upward. Input of terrigenuous clastic material into the Krka river estuary is relatively small [1], with main input of the particulate material in the Krka River estuary *via* small Guduča River (Fig 1) inflowing into the Prokljan Lake [1], [2]. The Krka River carries larger quantities of fresh-water (on average 55 m³/s) than the Guduča River (on average less than 1 m³/s). However, a number of calc tufa barriers along the Krka River, upstream of the town of Skradin, significantly reduce suspended material transport [1], [2], [3].

The bottom sediment samples were collected by a scuba diver using handdriven plexyglas corers, at 6 locations in the Krka River Estuary. Prior to the gamma-spectrometry measurements, the sediment samples were dried at 106°C during 24 hours, counted in a special vessels, sealed and stored for at least 4 weeks in order to allow a radioactivity disintegration of a gaseous 222 Rn. The samples were counted on an HPGe detector with an 8192 channel analyzer. The system was calibrated using the standards supplied by Amersham International, IAEA-306 and IAEA-314. Sedimentation rate was calculated using the vertical distribution of 137 Cs, (Fig 1 inset).

Sedimentation rate in the estuary was found to be very low (0,27 mm/a) based on ¹⁴C measurements [1]. First attempts using ¹³⁷Cs distribution indicated sedimentation rate higher than 2 mm/a ([4]). According the prevailing origin of accumulated material and sedimentation rates, four main sedimentation areas in the Krka River Estuary were recognized [5]. Anthropogenic radionuclides may be released in the environment owing to nuclear explosions, testing of nuclear weapons and discharge of effluents from nuclear facilities. Anthropogenic radionuclide ¹³⁷Cs with half life of 30,18 a first time entered in the environment as a product of atomic explosions in 1945. Since the Second World War, more than 2400 nuclear weapon experiments have been conducted worldwide [6] and as a result ¹³⁷Cs spread around the world and become good sediment marker.

In the III sedimentation area where most of the deposited material is carried by the Krka River, calculated sedimentation rate was 2 mm/a, while in the Prokljan Lake where recent sediment consists mainly of particles of terrigenous flysch transported by the Guduča River (IV sedimentation area) was 3-4 mm/a. The highest sedimentation rate was measured at the Guduča River mouth (4-5 mm/a). In the II sedimentation area deposited material is mixture of particles from two main sources: marine carbonates and terrigenous flysch, and the sedimentation rate is less than 2 mm. In the I sedimentation area where carbonate marine sedimentation prevails, sedimentation rate is probably less than 1 mm/a, with an exceptions in the deepest parts of estuary where sedimentation rate is approximately 3 mm/a. This deepest area is located at the center of the lower part of the estuary and acts as a kind of sediment trap (Fig 1).

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OVERALL TECTONIC PATTERN OF THE ALGERIAN MARGIN: EVIDENCES FOR ACTIVE FOLDING AND THRUSTING FROM THE 2003 AND 2005 MARADJA CRUISES

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Abstract

In this presentation, we give a first overview of the strain pattern of the north Algerian margin from a new set of high resolution swath bathymetry and seismic data acquired during the 2003 and 2005 MARADAJA cruises led in the frame of a French-Algerian research Project. We produce the first tectonic sketch of the Algerian margin and show evidences for recent (mostly Quaternary) deformation on the slope and the deep Algerian Basin, resulting in the formation of perched basins on the slope and at the foot of the margin. Folds frequently develop in response to the the play of thrust ramps and flats, triggering slides, turbidity currents and debris flows that are observed all along the margin. Several places display paleodislocations at the sea floor. We attempt to link these observations to historical earthquakes, typically covering the 6.5-7.5 magnitude range, as depicted by the 2003 Boumerdes earthquake.

Keywords : Algerian Basin, Bathymetry, Continental Margin, Geomorphology, Tectonics.

Although severely shaked by historical and recent earthquales (e.g.,[3]), North Africa did not receive much attention until now concerning natural threats from the sea. The recent Boumerdes earthquake has dramatically recalled that this area represents the outer limit of a wide deforming zone that encompasses the Tell and Atlas domains on landand that accommodates much of the 4-8 mm/yr of relative plate convergence between Africa and Europe, from west to east.

In this paper, we first report on the area off the 2003 Mw 6.9 Boumerdes earthquake, where we have identified about 5 main fault-propagation folds 20-35 km long, leaving prominent cumulative escarpments on the steep slope and in the deep basin [1]. Fault activity creates Plio-Quaternary growth strata within uplifted areas such as a rollove rbasin on the slope and piggy back basins in the deep ocean. Most thrusts turn to fault-propagation folds at the sub-surface and are organized as overlapping ramps and flats, although the fault dips are not easy to image. The two main slip patches of the 2003 Boumerdes earthquake are spatially correlated to two segmented cumulative scarps recognized on the slope and at the foot of the margin. The overall geometry indicates the predominance of back thrusts inverting the previously passive margin and implying underthrusting of the Neogene oceanic crust.

Then we have tried to map the offshore boundary between the external and the internal zones of the Maghrebides [2]. The internal zones are relics of the so-called Alkapeca block that is assumed to belong to the former European plate and is found onshore in the Kabylies for instance, and further west in the Moroccan Rif. We identify major changes in the morphology that could correspond to transitions in the lithology or to faulting.



Fig. 1. Map of the 19 main fault segments identified off Algeria during the MARADJA 2003 and 2005 cruises, together with the onland main faults known, plotted on shaded bathymetry and topography.

We finally present a study of the breaks in the seafloor topography, correlate them to seismic lines (Chirp, high resolution, or 6- or 24-channel seismics) in order to determine their rooting and relative activity through time. We identify about 19 main faults (Figure), often associated to folds, and interpret them as parts of a large zone of transpression that shaped the Algerian margin during the Neogene. Most of them represent thrusts striking nearly perpendicularly to the present-day maximum stress direction. Especially, 3 large faults systems, striking ENE-WSW to E-W, rather similar to those found off Boumerdès, have been identified off Mont Chenoua, Annaba and the Great Kabylie. Other fault systems seem deeper off Skikda and Djidjelliareas: although less expressed in the morphology, they clearly fold and tilt recent sediments at depth, including pre-Messinian layers, and trigger large-scale slumps of recent deposits, in connection with Messinian salt movements towards the deep basin. From the position and geometry of the recent and active structures reported, we explore their link to the instrumental and historical seismicity, discuss their possible space and time evolution, and try to correlate the strain evolution (apparently, from Pliocene to Upper Quaternary) to other tectonic events found in the Betics or in the Tell-Atlas mountain belts. It appears that the length of faults reported matches quite well the magnitude range (6.5-7.5) of historical earthquakes.

We conclude that a significant part of the Africa-Eurasia plate motion may indeed be absorbed in recent times by an active, complex thrust fault system located near the foot of the Algerian margin, which has to be considered for better assessing seismic hazards in the future.

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LE SYSTEME TURBIDITIQUE PROFOND DU NIL : FONCTIONNEMENT ET FACTEURS DE CONTROLE AU COURS DU QUATERNAIRE RECENT

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Résumé

Ce travail, basé sur l'analyse et l'interprétation de prélèvements (carottes kullenberg et calypso) calibrées avec des données acoustiques (sismique 3,5 kHz et multifaisceaux), propose une reconstruction du fonctionnement sédimentaire récent (derniers 250 ka) du système turbiditique profond du Nil (STPN).

Mots clès : Eastern Mediterranean, Nile, Deep Sea Processes.

Une étude stratigraphique détaillée et basée sur plusieurs outils a éténécessaire pour dater des séries sédimentaires riches en événements gravitaires et s'étendant sur plusieurs cycles glaciaire/interglaciaire. C'est l'établissement d'une écostratigraphie basée sur les assemblages de foraminifères planctoniques et calibrée avec des outils isotopiques et téphrochronologiques qui a permisd'atteindre une résolution d'étude proche de 2000 ans.

Les résultats obtenus ont permis d'interpréter l'ensemble des éventails localisés ausein de la marge comme un système multi-source. En effet, contrairement la majorité des grands STP vaseux modernes, alimentés par une source ponctuelle, le domaine profond de la marge nilotique comprend plusieurséventails de taille réduite dont certains ont été alimentés en mêmetemps.

L'analyse détaillée des faciès et séquences sédimentaires apermis de mettre en évidence un fonctionnement sédimentaire lié auxconditions environnementales affectant le bassin versant du fleuve Nilet son delta. Ainsi, dans le STPN, le forçage climatique nuance leforçage glacioeustatique classique et l'origine des modèles stratigraphiques actuels [1]. Les contrastes climatiques de l'Afrique nord orientale permettent notamment l'alimentation d'éventails turbiditiques pendant des périodes de haut niveau marin. Les cruesmajeures du Nil sont également l'origine de processus de transport et de dépôt jusque-l peu documentés.

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COLD-WATER CORAL REEFS AROUND EUROPE - HOTSPOTS FROM THE CENTRAL MEDITERRANEAN

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Abstract

Living deep-water coral ecosystems are far more prominent in the central Mediterranean as previously known. New sites of living corals have been identified and challenge the existing ideas of cool-water coral community distribution within the Mediterranean. *Keywords : Biogeography, Biodiversity, Cnidaria, Continental Slope, Eastern Mediterranean.*

Europe is surrounded by huge deep-water build-ups mainly formed by *Lophelia pertusa* and *Madrepora oculata* [1]. These cold-water reefs form almost a barrier reef type system in a water depth from 1000 m in the south up to 200 m in the north. The Mediterranean so far has been known as a site of mainly dead cold-water coral assemblages dating from different glacial times. Occurrences of living corals are mainly restricted to isolated spots [2].

During R/V METEOR cruise M70/1 starting from La Valetta/Malta and ending in Heraklion/Crete in fall 2006 investigations concentrated on the central Mediterranean bathyal communities and their fossil left-overs. This cruise was a milestone cruise for the EU's FP-6 HERMES Project. Bathyal coral ecosystems were investigated along the steep margins of selected continental slope and seamount settings in the central Mediterranean Sea. New sites of cold-water corals (*Lophelia pertusa, Madrepora oculata, Dendrophyllia cornigera, Corallium rubrum*) have been identified using deployments of the deep-sea work-class ROV QUEST of MARUM, Bremen along the slopes of Malta Trough, Sicily Strait, Palinuro Seamount, off Santa Maria di Leuca, and Bari Canyon. With this ROV we were able to obtain high quality samples, video footages and stills to produce geo-referenced habitat maps.

After the Messinian Salinity Crisis, bathyal coral communities re-entered the Mediterranean Sea during the Late Pliocene. While the modern systems are poorly known, an excellent documentation of submerged Late Pleistocene and emerged Early Pleistocene fossil coral communities exists especially in southern Italy. Conducted radiocarbon-dating on Pleistocene corals indicate a former distribution peak during the Marine Isotope Stage 3, both in the central NE Atlantic and Mediterranean Sea. Since then, the bathyal coral ecosystem is in decline, at least in the Mediterranean Sea. The causes for this decline seem to be linked with the warming of the intermediate and deep Mediterranean water masses and with - episodic strongly reduced amounts of dissolved oxygen in the water column. Next to the better understanding of the bathyal ecosystem response to global change, we produce habitat maps of present-day coral communities, their associated biodiversity and analyse geochemical signatures of the skeletal biota, as well as sedimentary and physical oceanographic environment. Our new findings require a re-evaluation of the controlling factors so far described governing the distribution of living deep-water coral ecosystems

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HIGH RESOLUTION GEOPHYSICAL SIGNATURE OF ACTIVE SEEP-RELATED STRUCTURES OFFSHORE EGYPT

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Abstract

Fluid-escape structures of a large variety of types are found all over the Nile Deep Sea Fan. Mud volcanoes and authigenic carbonate crust structures were first identified from multibeam bathymetry and backscatter data. Recent *in-situ* geological observations, geochemical sampling and analyses, and new high resolution geophysical records provide further constraints on the type, distribution, intensity and functioning of these structures.

Keywords : Nile, Geophysics, Tectonics, Volcanology.

Fluid escape structures on the Nile Deep Sea Fan, including large mud volcanoes located above gas chimneys, pockmarks and carbonate crust structures [1], were investigated during the NAUTINIL (2003), MIMES (2004) and BIONIL (2006) expeditions (EUROMARGINS-MEDIFLUX project). Explored and surveyed with the *Nautile* submersible [2] and the *EdgeTech DTS-1* high resolution deep towed side scan sonar [3] (operated at a frequency of 75 kHz and coupled with a 2-8 kHz chirp sediment sounder), these structures were found to be characterized by an intense seepage activity, principally dominated by hydrocarbon gas emissions (mostly methane) [4]. Several gas plumes were detected in the water column from side scan data above Isis and Amon mud volcanoes, as well as above pockmark fields.

Seafloor mapping analysis combining multibeam data, high resolution backscatter imagery and detailed geological maps based on in situ observations provide accurate information on the distribution and activity of seep-related structures [5]. Shallow depth subbottom sediment profiler records reveal wipe out and disturbed areas explained by ascending fluids. Acoustic mosaics and geological observations point to broad seafloor areas covered with carbonate crusts. The amplitude of the acoustic backscatter presents spatial variability, which we relate to the type and intensity of present or past seepage activity, e.g. the presence of a variable distribution and thickness of carbonate crust pavements. The feeder channels of the mud volcanoes do not exceed a few tens of metres in diameter near the seabed. Lateral extents of ascending fluid channels in carbonate covered areas, as shown by wipe out dimensions, may reach a maximum of several tens of meters. The full set of collected surface geophysical data indicate that the distribution and functioning of seep-related structures is controlled by the local and regional tectonics in connection with a complex fault network including deep crust-rooted faults and shallower ones associated with salt tectonics and slope instabilities.

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ANALYSE CARTOGRAPHIQUE ET STRUCTURES GÉOLOGIQUES DU PLATEAU CONTINENTAL ATLANTIQUE MAROCAIN(TANGER-OUED SOUSS)

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Résumé

L'application de méthodes appropriées à des cartes telle que l'analyse des caractères anomaliques et graphiques du réseau d'entailles, associés aux études de surface, peuvent se révéler très intéressantes. Dans le cas du plateau continental atlantique marocain elles ont permis de définir cinq domaines. Les limites séparant ces domaines ne paraissent pas avoir la même importance. *Mots clès : Bathymetry, Continental Shelf, Geomorphology, Passive Margins, Tectonics.*

Le domaine Nord (Tanger-Sebou) correspond aux zones rifaines et prérifaines avec des directions structurales sensiblement NO-SE, auxquelles sont associés des axes de plis à grand rayon de courbure. La moitié sud de cette zone serait l'expression de la continuité de la grande subsidence du Rharb (Jaaidi E.B., 1981) [1], d'autant plus que le réseau hydrographique et les conditions climatiques permettent un transport et des apports vers l'océan d'une fraction solide relativement importante.

La Meseta septentrional (Sebou-El Jadida), domaine très tectonisé, se caractérise par une orientation générale hercynienne (N20 à N40) et des changements de directions forts nombreux. Deux directions semblent marquer particulièrement la région. La première, orientée E-O, localisée au-delà de l'isobathe 100 m et qui serait la manifestation en mer de l'accident décrochant Rabat-Tiflet (Michard A. 1976) [2]et la seconde, orientée NE-SO et localisée en deçà de l'isobathe 50m s'intégrant par-faitement dans l'anticlinorium de Casablanca.

La Meseta méridionale, avec une présence simultanée des directions E-O et NE-SO et qui sont probablement la manifestation d'une surimposition des accidents atlasiques sur les accidents hercyniens de la meseta marocaine donnant à la région un aspect en mosaïque. Par ailleurs, l'aspect tourmenté du plateau, semble être lié à des irrégularités topographiques ou/et lithologiques dues vraisemblablement à des crêtes qui pourraient être des grès littoraux ou des dunes lithifiées (El Foughali et al., 1985) [3]. La nature salifère des séries géologiques secondaires ne sont pas étrangères à cet état. Enfin, la région est caractérisée par la présence d'une discontinuité importante au large de Safi celle-ci se trouve dans le prolongement en mer de la faille de Safi, cette faille est décrochante avec un jeu senestre.

De Oued Tensift à cap Rhir, et malgré des données fragmentaires, on note la présence de directions E-W à NE-SW, expression probable des contraintes alpines ayant abouti à la formation du Haut Atlas (El Foughali A., 2002) [4].

La dernière zone comprise entre Cap Rhir et Oued Souss est caractérisée par des directions N 80 à N 100. Ces directions semblent bien reparties sur l'ensemble de la région avec cependant une densité plus élevée juste au sud de Tarhazout. Cette région comporte par ailleurs, deux axes, grossièrement parallèles l'un juste au large de la ville d 'Agadir, l'autre constitue pratiquement le prolongement de oued Souss. Ces axes orientés Est-Ouest près de la côte, changent de direction vers les deux tiers du plateau. Le 1^{er} a tendance à devenir ESE-WNW et semble entamer la direction du canyon d'Agadir, le second, devient ENE-WSW et semble prolonger l'accident sud atlasique. En outre, ce secteur semble très affecté par des accidents décrochants.

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GEOCHEMISTRY OF SHELF SEDIMENTS FROM THE GULF OF ANTALYA, TURKEY, EASTERN MEDITERRANEAN SEA

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Abstract

Investigation of Holocene sediment cores from the Gulf of Antalya, southern Turkey revealed that low carbonate siliciclastic mud derived from the coastal hinterland is the dominant sediment type deposited in this region. Terrigenous components in sediments were represented not only by higher organic carbon contents but also higher Cr, Ni and Mg concentrations. Anthropogenic influences can be recognized by slightly higher Pb and Zn contents in upterline.

Keywords : Continental Shelf, Eastern Mediterranean, Sedimentation, Geochemistry.

To study the geochemical characteristics of shelf sediments in the Gulf of Antalya, in 1999, 7 gravity cores were collected (with 20 to 149 cm sediment recovery) onboard R/V Bilim of METU at water depths of between 18 and 101 meters. Selected sediment samples were then subjected to grain size. carbonate, organic carbon and multielement analysis. Available seismic profiles [1] suggest that the sediment cores studied here must have been deposited during the Flandrian transgression, following the lowstand of sea level since 18.000 yrs B.P.

Sediments covering the shelf seafloor in the gulf are mainly composed of siliciclastic silt and clay, the mud with percentages of between 2 and 99. Sand and gravel is contained 1 to 98 %. Although most of these clastic material is derived from the weathering of geological source rocks [2] on coastal hinterland, coarser-grained constituents are indicative of relatively higher energy and benthogenic conditions in inner- to mid-shelf areas. The carbonate contents with values from 20 to 80 % can be explained by the presence of both fine-grained terrigenous and carbonate mud and planktonic-benthic organism remains. Therefore variation in both grain size and carbonate distribution down the cores reflect changes in depositional environmental and terrestrial conditions with space and time.

The organic carbon contents fall in the range of 0.16 to 3.29 % and usually do not exceed 2 %. These values can not solely be related to higher organic productivy in the shallow-water areas, they rather indicate land-based sources. Of course, the finer-grained the sediments the higher contents the organic carbon.

The concentrations of Al, K, Na, P, Ti, Fe, Mn, Li and some other lithophile elements measured in sediments are largely comparable with those of average crustal rocks [3]. However, the slightly higher concentrations of Cr (10-114 ppm), Ni (3-144 ppm) and Mg (1.1-2.5 %) are indicative of a particular geological source, the land-based ophiolites of the gulf [2]. The ophiolites and associated mineral deposits are known for their higher Cr, Ni and Mg contents [4]. The levels of Pb and Zn concentrations in the sediments varied between 7 and 100 ppm and 12 and 69 ppm, respectively. Nevertheless, the highest contents of these two elements particularly in the topmost core sections could be explained by other than the geological sources (i.e., anthropogenic).

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A THREE LAYERS MODEL FOR THE TURBIDITY CURRENT: AN INVERSE PROBLEM TO INFER THE IGNITION CONDITION FROM TURBIDITE DEPOSITS

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Abstract

An innovative approach is here proposed, to use governing equations of a turbidity current (TC) to infer the hydrodynamic ignition conditions (*sensu* [1]) for velocity, height, and concentration of the current. All this is made through the comparison between analytical solutions for change in bed elevation and field data measured in the Messinian turbidite deposits of the Central Apennines, Italy. *Keywords : Currents, Inverse Methods, Sedimentation, Analytical Methods.*

In order to provide a simple model which take into account the features of a TC described in several tank experiment [2-3], a three layers model for a TC is here introduced (Fig. 1). The dynamics of the three layers are represented as a function of the Richardson number Ri. From this analysis results that, into the basal layer (Layer 1, Fig.1), under conditions of severe density gradient, damping of the turbulence occurs (Ri > 1). This condition causes a net loss of sediments during the current deceleration. All this allows an analytical definition for the change in bed elevation h(x), where x is the downstream coordinate. In order to provide an analytical solution for h(x), the governing equations of a steady-depletive depositional TC [4] has been analytically solved. The analytical solution for h(x) will allow us to infer, as an inverse problem, the ignition condition for velocity, height and concentration (namely U_0 , h_0 , and C_0 respectively) of a depositional TC. All this is made through the comparison between such analytical solution and stratigraphycal field observations carried out in the Messinian turbidite deposits (Central Apennines, Italy). Practically, it is possible to search for a best-fit of bed elevation field values with those provided by the analytical solutions, varying the ignition conditions U_0 and h_0 . As an example, the shape of a single bed elevation as a function of the ignition condition U_0 and h_0 is shown in Fig. 2, for a grain size D = 0.2 mm. In synthesis, the thickness decay as a function of the ignition conditions U_0 , h_0 can be summarized as: i) for fixed U_0 and D, increasing h_0 gives an increase of the length of the deposits; ii) for fixed h_0 and D, increasing U_0 gives an increase of the length of the deposits; iii) for fixed U_0 and h_0 , increasing D gives a decrease of the length of the deposits.



Fig. 1. Three layer model for turbidity current where $d \ll h_2 < h_3$. The stick diagrams represent the velocity u(z) and the line represents the density r(z).



Fig. 2. Analytical decays of the sedimentary body as a function of the ignition condition U_0 and h_0 for the case D = 0.2 mm.

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IN-SITU TEMPERATURE MEASUREMENTS AND GEOCHEMICAL POREWATER DATA SUGGEST HIGHLY DYNAMIC RECENT ACTIVITY OF ISIS MUD VOLCANO, EASTERN MEDITERRANEAN SEA

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Abstract

In-situ temperature measurements and geochemical porewater data from Isis mud volcano were obtained during the Nautinil and Mimes cruise in 2003 and 2004, respectively. The observations show a high level of recent activity and reveal significant changes in both the temperature and chlorinity profiles from the center of the mud volcano. Coupled geothermal and geochemical models demonstrate that the changes cannot be explained by simple variability of upward fluid flow and suggest the presence of an additional, effective cooling and mixing process, which could be related to gas ebullition or seawater circulation.

Keywords : Mud Volcanoes, Eastern Mediterranean, Models, Temperature, Geochemistry.

The Nile deep-sea fan is the most important sedimentary accumulation in the eastern Mediterranean. Two geophysical mapping campaigns conducted in 1998 (Prismed II) and 2000 (Fanil) resulted in a first detailed morphostructural description of this deep-sea fan [1-4] and led to the discovery of several circular and sub-circular sedimentary structures on the upper slope of the eastern province. Up to a few kilometers in diameter and generally showing a low relief of a few tens of meters, these mud volcanoes or so-called 'mud pies' have been described as surface expressions of deep-seated gas chimneys [4]. Isis mud volcano (Isis MV) is located at a water depth of approximately 1020 m. In contrast to the more complex structure of the neighboring Osiris and Amon mud volcanoes, Isis MV shows a very distinct camenbert-shaped morphology with relatively steep flanks and a gently domed top elevated between 20 and 40 m above the surrounding seafloor.

Detailed geothermal and geochemical investigations of Isis MV have been carried out during the Nautinil (2003) and Mimes (2004) cruises within the framework of the Euromargins/Mediflux project [5]. Sediment temperatures of more than 40 $^{\circ}$ C at 10 m below the seafloor at the center of the mud volcano indicate an exceptionally high level of activity. Rapidly decreasing temperature gradients away from the center support the hypothesis of an axisymmetric dynamic functioning of Isis MV. At the center, pore water profiles show a rapid decrease of chlorinity within the uppermost meter of the sediments, whereas the chlorinity of cores taken at short distances away is equal to bottom water values.

The data obtained during the two cruises reveal significant changes in both the sediment temperature profiles and the geochemical porewater profiles of cores from the center of the mud volcano. In 2003, in-situ measurements revealed a slightly convex-upward temperature profile with a gradient of up to 2.78 $^{\circ}$ C/m at depths between 2 and 7 m below the seafloor. When the measurements were repeated at the same location in 2004, the sediment temperatures had decreased by more than 5 °C at approximately 7 m below the seafloor and the previously observed convex-upward curvature of the profiles had disappeared. The temperature gradient did not exceed 2.3 °C/m, corresponding to a decrease in heat flow of about 17 percent with respect to the measurements in 2003. The chlorinity profile of the piston core that was sampled during the Nautinil cruise in 2003 showed a rapid decrease from the seawater concentration of about 608 mmol/kg to less than 170 mmol/kg less than 1 m below the seafloor. An equally sharp transition was observed in the chlorinity profiles of the cores that were sampled during the Mimes cruise in 2004. However, at this time the chlorinity decrease was shifted to a sediment depth of 0.5 to 1 m and the transition zone was overlain by normal seawater concentration in the upper part of the cores.

A one-dimensional coupled model of heat transfer and solute transport in the upper sediment column has been developed to analyze the observed changes and to characterize the associated processes. The model results indicate that the variations in the temperature and chlorinity profiles exceed the effects that may be expected from simple heat conduction and solute diffusion. Neither the rapid temperature decrease nor the downward shift of the chlorinity step observed between 2003 and 2004 can be explained by varying rates of upward fluid flow. Instead, the model suggests the presence of an additional process that leads to cooling of the sediment column and flushing of the upper meter of the sediment with seawater at the same time. In order to identify this process, the role of gas ebullition and the possibility of seawater circulation within the upper meters of the sediment column are currently investigated. New insights into the dynamics of the activity of Isis MV are expected from the Bionil cruise in 2006.

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CONTAMINATION STATUS OF FLYSCH-DRAINING RIVERS OF CROATIA AND SLOVENIA, FLOWING TO THE NORTH ADRIATIC SEA

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Abstract

Stream sediments from flysch rivers Rižana, Dragonja, Mirna, Raša and Rječina, flowing to the North Adriatic Sea, have been studied by detailed mineralogical, chemical and geostatistical methods. Levels and sources of major and trace elements determined by ICP-MS method in sediment fraction <63 μ m were used as a data set for statistical analysis. Cluster analysis of Q-modality showed that according to geochemical composition of sediments Rižana forms a separate cluster. Raša, Dragonja and lower stretch of Mirna belong to the second cluster, while Rječina and upper stretch of Mirna belong to the third cluster. Sediments reflected anomalous concentrations of 20 elements, when using the same data set and two dimensional scatter box diagrams from program STATISTICA 6.0. Most anomalous values were found in Rižana and Rječina rivers, what can be of concern because they are used as sources of drinking water. Raša, Mirna and Dragonja present clean environments.

Keywords : Adriatic Sea, Sediments, Pollution.

Introduction

The region of flysch-draining rivers is presented in Figure 1. There are some papers describing Raša River from different aspects [1, 2]. In these papers, trace metal transport was studied from land to sea and sedimentation processes were studied accordingly. Geochemistry of sediments was studied by us in Rižana and Dragonja Rivers [3] and also in Rječina River [4]. Geochemistry of sediments from Raša and Mirna Rivers studied in this work have not yet been reported.



Fig. 1. The region of flysch rivers.

The aim of the work is to apply statistical analysis on the geochemical data set of sediments from flysch region, from which is possible to obtain the information about the current state of these important water resources for Croatia and Slovenia.

Experimental

Surface sediments were collected, wet sieved and dried at 80 °C. The sediment fraction <63 Îijm was analyzed in Actlabs commercial laboratory, Ontario, Canada, using ICP-MS method, with program Ultratrace 2. Program STATISTICA 6.0 was used on 27 up to now collected samples.

Results and discussion

Q-modality cluster analysis was performed on total data set. Sampling stations were grouped in three clusters. Cluster 1 has two locations, both from Rižana River. Cluster 2 has 13 locations from Raša, Dragonja and the lower stretch of Mirna River. Cluster 3 has 12 locations from Rječina and upper stretch of Mirna. In Table 1 are presented elements with extreme and / or outlier values in particular locations. Toxic elements Cd, Sb, Pb and Hg have extreme in sample 18, what is in upper flow of Rižana. Samples of Rječina River show outliers with respect to toxic Cu, Zn, Sb, Cd and Pb. This finding can be of concern, because the sources of Rižana

and Rječina are used as drinking water supply. Raša, Mirna and Dragonja represent clean environments.

Tab. 1. Elements with extreme and/or outlier values in particular locations.

Element	Extreme sample	Outlier sample	Element	Extreme sample	Outlier sample
Na	23, 113, 105		Sb	18	95, 96, 97, 98
Р	18	3	Ba		107
S	23, 105	3	La	18	0
Ca	20, 22		Ce		18
Mn	10	18	п		18
Cu		95, 96, 97	Pb	18	98
Zn		97,98	Bi	18	¢.
Se	18		Th		95
Cd	18	97	U	18	
Sn		19	Hg	24	18, 22

Conclusions

Geochemical and statistical investigations of flysch-draining rivers flowing to North Adriatic are of supraregional interest.

-Q-modality cluster analysis has shown that, with respect to element distribution, Dragonja and lower stretch of Mirna are similar to Raša; upper stretch of Mirna is similar to Rječina, while Rižana is completely different from other rivers.

-The most contaminated is Rižana River, follows Rječina, while Mirna, Raša and Dragonja represent clean environments.

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REMOTE SENSING INVESTIGATING OF COASTLINE AND LAND USE CHANGES IN KIZILIRMAK DELTA

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Abstract

Deltas are very important systems due to their unique features which is very vulnerable. Remote sensing has been widely used in various applications for ocean and coastal investigation. In this study focused on applying remote sensing technology to monitor the rapid varying of coastline and land-use changes of Kızılırmak Delta. Which are very difficult to be measured timely and quantitatively. LANDSAT TM, LANDSAT ETM+ and ASTER data were used to in this study to obtain the information about coastline and land-use change. *Keywords : Black Sea, Remote Sensing, Gis.*

Kızılırmak Delta is the biggest deltas along the southern margin of Black Sea. It is approximately 21,700 ha area. The Kızılırmak Delta was formed by sediments deposited by the Kızılırmak River which is the longest river in Turkey and drains an area of 78 646 km², 1355 km length, 5.9 (km3/y)3 water input to the Black Sea. Average annual sediment load and water inputs of the Anatolia rivers are estimated at 24 million *t/y* (ca 20 of the total sediment carried into Black Sea) and 40 km3/y. The delta as a whole is 56,000 ha in extent and wetland area is 16.110 ha. Shallow lakes found on delta area. Large parts of the site are flooded during winter and spring. The average annual rainfall is 719 mm. It contains dunes, beaches, seasonal marshes, wooded areas and shallow lakes (the depth of the lakes is on average 1.5 m. max. 3 m. in spring). All the lakes are fresh (except Balık Lake which is brackish as a result of its connection to the sea).



Fig. 1. Perspective view of KIZILIRMAK Delta (Aster, 2004).

The statement that remote sensing application on Deltaic areas and wetlands has a complex character. Delta and Wetland are complex systems themselves due to the fact that physical, chemical, biological, hydrological and geological processes interact there. Moreover, there are strong connections between delta and its surroundings, which link delta and wetland and adjoined areas to unique systems. The spatial distribution and linkages among land and water of environmental parameters is of key importance in particular sciences which is essential to understanding their interconnectedness. The repetitive acquisition and synoptic capabilities of remote sensing technologies can be exploited to provide timely spatial data for coastal GIS, enabling detection and monitoring of coastal zone of deltas. GIS for coastal zone is used to store information with a geographic parameters to investigate interactions among different parts of systems, which is described by collected data and information, and to manage complex and delicate environmental structures of coastal zone. A standard GIS is a computer based decision support system for the manipulation and analysis of spatial information in which there is an automated link between data and software for entering, storing, transforming, measuring, combining, retrieving, displaying and performing mathematical operations on thematic data that have been registered to a definite coordinate system [1].

In this study, satellite data (LANDSAT TM,1980; LANDSAT TM,1987; LANDSAT ETM, 1999 and ASTER, 2004) and DTM (ASTER data) (Figure 1) data was used for coastline and landuse change.

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THE MEDITERRANEAN-BLACK SEA CONNECTIONS

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Abstract

We present the results of phosphorus analyses in sediments from Core SIN97 01-GC retrieved on the Cretan Ridge. Because the only source of this element to the oceans is the runoff from the continents, the relation of this element with climate is straightforward. The sedimentary phosphorus record provides also information about anoxia, circulation, water stratification, and represents a powerful tool to trace paleocirculation changes and possible connections between the Eastern Mediterranean and the Black Sea in the last 30.000 years. *Keywords : Black Sea, Levantine Basin, Sea Level, Paleoceanography.*

Sea-level changes are a topic of considerable scientific interest and increasing economic and social importance for their impact on epicontinental seas and semi-enclosed basins. In particular, they have a tremendous impact on coastal areas, the boundary between land and sea, with important consequences for ecosystems and populations living there. Thus, the study of past sea-level changes in these areas is essential to understand how far the environment has changed and how far the response of the environment would go.

The Mediterranean Sea, a complex system subdivided in several basins interconnected by straits and sills, is a natural laboratory for studies on climate and sea-level changes. In the past, many areas of this basin have experienced variations in sea level, which, as a feedback, have influenced its oceanography and geochemistry. Presently connected to the Eastern Mediterranean are the Marmara and Black Seas.

Despite the extraordinary number of researches dealing with the paleoceanographic history of this region [e.g., 1], there are still hotly debated topics concerning the evolution of the area. They deal with:

1 - The nature and mechanisms that controlled the Mediterranean - Black Sea connections.

2 - The exact timing of the connection re-opening.

3 - The environmental interplay between the Black Sea and the Eastern Mediterranean Sea.

Solving these paleoceanographic and paleoenvironmental issues will bring new insights into the evolution of this sensitive region and will provide new information on the behavior of inter-connected and semi-enclosed basins under the impact of sea-level and climate changes.

Using a multi-proxy study of sediment from the Cretan Ridge, we try to reconstruct the history of the opening and closure of the connections between the Eastern Mediterranean and the Black Sea, in relation to sealevel (regional and global) and climate variations. Our research focuses on the last 30.000 years, from the dawn of human civilization to present days. The Cretan Ridge was chosen as it represents the gateway that could intercept the signals of possible in/out-flows between the Black and the Mediterranean Seas.

Our approach will include (1) paleontological studies of benthic and planktonic foraminiferal assemblages, (2) AMS-¹⁴C and U/Th dating, and (3) geochemical studies of sediments (oxygen and carbon isotopes of foraminifers shells and serpulids, alkenons, phosphorus and organic matter, XRF).

We present here the preliminary results of the phosphorus content in sediments from Core SIN97 01-GC retrieved on the Cretan Ridge. Because the only source of phosphorus to the oceans is the runoff from the continents, its relation with climate is straightforward. The sedimentary phosphorus record provides also information about anoxia, circulation, water stratification [2], and represents a powerful tool to trace paleocirculation changes and possible connections between the Eastern Mediterranean and the Black Sea.

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MULTI CHANNEL HIGH RESOLUTION SEISMIC REFLECTION SURVEY IN SIGACIK GULF (IZMIR) AND SURROUNDING REGIONS: FIRST OBSERVATIONS

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Abstract

High resolution seismic reflection data were collected onboard R/V K. Piri Reis, research vessel of Dokuz Eylül University, in Sigacik Gulf (Seferihisar-Izmir) and surrounding regions in August-2005. On 17 October 2005, a series of earthquakes occurred in the same area just two months after the cruise. Seismic cross-sections indicate fault zones which probably caused earthquake series. *Keywords : Aegean Sea, Seismics, Tectonics.*

Introduction

Sigacik Gulf (Izmir) and surroundings have significant seismic activities. There are few articles about the area that illustrate the tectonic activity in the bay.

Previous Multi-channel seismic reflection study shows that Izmir Gulf and surrounding regions are widely deformed by N-S to NE-SW trending active transpressional strike-slip faults, reverse faults and some E-W normal faults. Normal faults are cut by strike-slip faults [1], [2].

The study area and surrounding regions are under the effects of seismic activity. This seismic activity is concerned under Western Anatolia and general Aegean tectonic regime. The seismic activity seen in the region continues as earthquake series. These earthquake series are earthquake forms which are usually observed at fault zones that have lots of minor faults and also such forms were observed in different regions in our country in past years. Earthquake series can continue for days and months at such fault zones [3].

Seismic data acquisition and processing

During the sea trial survey, approximately 370 km of multi-channel seismic reflection data were acquired in August-2005 (Fig. 1). To produce and collect the seismic data the GI Gun (Generator-Injector Air gun) and 48 channel digital seismic streamer were used, respectively. Data processing flow was applied as follows:

Data load, geometry load, band pass filter, water bottom time pick, water bottom top mute, bottom mute, true amplitude recovery, decon before stack, stack, velocity analysis, radon velocity filter, time migration. The multiples due to the shallow seafloor and basement reflector were eliminated as much as possible by radon velocity filter techniques.



Fig. 1. The study area and seismic profiles.

Conclusions

The seismic data were collected during a sea trial survey, just two months before the Sigacik earthquake series which occurred between 17 and 21 October 2005. The epicenters of the earthquake series present at the same area with our seismic profiles. The Miocene age basement can easily be determined on seismic sections and the basement outcrops to the sea bottom. Earthquake series probably occurred on shear zone. One of the most important strike-slip faults occurred by means of this shear zone is the Tuzla Fault Zone and the component of this fault zone can be seen on

seismic sections. Multibeam Echosounder Survey and Side Scan Survey have been planned to make a detailed map of active faults.

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STATUS OF THE IHO-IOC IBCM-II 0.1' BATHYMETRIC GRID FOR THE MEDITERRANEAN

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Abstract

This note gives the status of the effort by the IHO-IOC IBCM program (International Bathymetric Chart of the Mediterranean - and Black - Seas) to produce a new digital bathymetric and topographic grid at 0.1' spacing. The new compilation will consist of the 0.1' SRTM data on land, clipped at a coastline derived from navigational charts, and merged with shoal-biased hydrographic soundings on the shelves and slopes, and presumably with the multibeam data for the deeper basins already acquired for 45% of the Mediterranean. *Keywords : Bathymetry, Black Sea, Coastal Waters, Topography, Swath Mapping.*

The International Bathymetric Chart of the Mediterranean (IBCM) is the oldest of the IHO-IOC regional bathymetric mapping projects. Over the past three decades it has produced charts at 1:1 million scale of the bathymetry of the Mediterranean and Black Seas as well as geological/geophysical overlay sheets of the Bouguer Gravity (IBCM-G), Seismicity (IBCM-S), Magnetics (IBCM-M), Plio-Quaternary isopachs and structural contours (IBCM-PQ), and Recent Unconsolidated Bottom Sediments (IBCM-SED). Each of these chart series now has a published explanatory brochure, available as pdf files. All the published maps, some 70 sheets at 1:1 million, and seven sheets at 1:5 million, have now been scanned and are available digitally at different resolutions.

Over the past decade, work has continued on a digital IBCM-II bathymetric compilation on a 0.1' grid. Data at 0.05' from the 2000 Shuttle Radar Topographic Mission (SRTM) is available for the land areas around and in the Mediterranean and Black Seas. Well over a million soundings have been extracted from more than 1500 navigational charts for the Mediterranean and Black Seas. In recent years multibeam swath surveys have been carried out in the deep basins and on some of the slopes and shelves, and now cover some 45% of the Mediterranean, and a smaller percentage of the Black Sea.

The task now is to clip the terrestrial SRTM data with digitized coastlines for the 46,000 km of coast in the Mediterranean, and merge these onshore grids with grids to be built up from the shoal-biased soundings of the inshore navigational charts, together with digitized shelf contours. Existing spot soundings and contoured 'postage stamp surveys' will be used to extend out to areas covered by seamless multibeam coverage. The grids from earlier piecemeal coverage will be replaced with multibeam grids wherever it becomes avalable.

This Sisyphysian work has been ongoing in Israel since the Seventh IBCM Editorial Board meeting in Kaliningrad in 1999, and it will continue in parallel with the recent efforts to have 100% multibeam coverage for the Mediterranean and Red Sea areas offshore of Israel, and in the Dead Sea.

Postcards are available from the first author, printed with the various bathymetric, geological, and geophysical compilations.

Reference

IBCM printed sheets at scales of 1:1 million and 1:5 million are available for purchase from: GeoPubs, 4 Summerdale, Billericay, Essex, CM12 9EL, England, Phone +44 1277 632454, Fax +44 1277 632454, and E-mail: sales@geopubs.co.uk.

CAPTURING A SALT GIANT - RISER DRILLING PERSPECTIVES FOR THE LEVANTINE BASIN

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Abstract

Riser-drilling of the Messinian evaporites is crucial to test the following hypothesis: Young salt giants are intrinsically highly dynamic in terms of structural, chemical and biogenic evolution, even without any external tectonic trigger. On a regional scale, we propose that the basinal Messinian evaporites represent the key archive for understanding of rapid environmental changes of the pan-Mediterranean realm in the Messinian.

Keywords : Evaporites, Levantine Basin, Messinian.

Salt giants are a global phenomenon and both indicators and generators for significant environmental changes. Salt layers of some kilometres thickness strongly affect the structural, chemical and biological evolution of sedimentary basins. Fluid inclusions within the salt represent ice-corelike microbial habitats of so far unknown importance. The world's most significant hydrocarbon traps are related to salt structures. Quantitative understanding of salt dynamics and associated fluid flow is further necessary in order to assess the geohazard exploration and production risk. Because evaporites may cause mass wasting and sink holes, they are an important source of geohazards. However, in spite of their global occurrence and general importance within the Earth system there is a significant lack in our knowledge about the early evolution of all salt giants on Earth.

The petroleum industry regularly drills through thick evaporite successions in the Gulf of Mexico, the North Sea and the South Atlantic, but always in positions where the evaporites have been massively remobilised by protracted phases of salt tectonics. There is no complete record of any major evaporite basin in a relatively young and undeformed state. Drilling through the complete Messinian succession represents perhaps the only opportunity to understand the stratigraphy, biosphere and fluid dynamics of a global salt giant in a state close to its original depositional configuration, because the present state of Earth system does not form salt giants. This is a novel concept for scientific drilling in sedimentary basins beyond the IOPD Initial Science Plan and one of the last scientific frontier challenges in sedimentary basin research.

In a global context, drilling a young salt giant is a unique chance to advance our understanding of gravity tectonics on basin evolution in the presence of a mobile layer. The specific role of a thick salt layer on basinal fluid dynamics and its interrelation with the deep biosphere adds further to the potential scientific implications of a future proposal. A single and preferable continuous core from the seafloor down to beneath the evaporitic layers will calibrate the extensive 2D-and 3D-reflection seismic data sets from the geometrically well defined Levantine Basin [1-2].

A complete core of the Messinian evaporites would open an outstanding archive of environmental changes since the Messinian. The discovery that the Mediterranean experienced a catastrophic desiccation phase during the Messinian has since proven to be one of the major achievements of the DSDP program. In the 35 years after completion of that leg, over 1000 papers have been published on the Messinian Salinity Crisis. In spite of all this research activity, one fact remains: we have no complete calibration of the stratigraphy of the most complete record of the MSC, because no scientific drilling has been able to venture into deep water and drill through the thickest succession of the deep basin. A huge amount of descriptive and analytical work has been conducted on the sequences preserved in marginal basins, producing elaborate and often conflicting correlation schemes aimed at a pan-Mediterranean synthesis based on these marginal stratigraphies. It has been estimated that 95/100 of the total volume of the Messinian evaporites is now preserved in the deep basins, and the lack of knowledge of deep basinal stratigraphy is thus fundamental to the entire field. Finally, unraveling the Pan-Mediterranean environment during the Messinian desiccation period is also a possible prospect on the future, since the closure of the gateway to the Atlantic is expected get closed due to the African-Eurasian convergence in some million years.

Riser-drilling of the Messinian evaporites in the Levantine Basin is crucial to test our hypothesis that in contrast to generally accepted models, emerging salt giants are intrinsically highly dynamic in terms of structural, chemical and biogenic evolution, even without any external tectonic trigger. On a regional scale, we hypothesise that the basinal Messinian evaporites represent the key archive for understanding of rapid environmental changes of the pan-Mediterranean realm in the Messinian.

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TOWARD A RISK ASSESSMENT OF THE SANTORINI-AMORGOS VOLCANIC COMPLEX

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Abstract

The Santorini-Amorgos Volcanic Complex has been investigated in spring 2006 by means of profiling geophysical data. More than 1500 km of multichannel seismic and magnetic data as well as 2500 km of gravity data have been collected. The data allow the identification of active tectonics; the budgeting of pyroclastic deposits around Santorini and the Columbo volcano as well as in the SAZ; the interpretation of individual eruption events of the Columbo and Santorini volcanoes; and the detection of fluid migration paths and reservoirs associated with magmatic intrusions.

Keywords : Aegean Sea, Volcanology, Seismics.

Active tectonic processes along the African-Eurasian collision zone are associated with catastrophic events including earthquakes, major volcanic eruptions, and tsunamis. Understanding how these processes can affect the eastern Mediterranean is of increasing scientific and public interest. The region includes a frequently crossed international sea traffic corridor and dense population centers. Furthermore, most of the small volcanic islands in the Aegean are major tourist attractions that contribute significantly to the wealth of this region. One of these Aegean islands is Santorini, which is a major explosive volcano and possibly one of the most dangerous volcanoes in Europe. During the past 150 million years, Santorini has had 12 major eruptions, and several of them ejected large columns of ash and debris high into the atmosphere. It is widely believed that the eruption of Santorini about 3600 years before present (B.P.) destroyed the Minoan civilization of Crete. In addition to the volcanic island, there are several submarine volcanic seamounts in the Aegean Sea. One of them, the Columbo seamount, is about eight kilometers northeast of Santorini, and recently has attracted attention due to the high earthquake activity of the Hellenic subduction zone. This activity is concentrated in an area northeast of Santorini, within the so-called Santorini-Amorgos zone.

According to previous findings, the Santorini-Amorgos zone (SAZ) marks a major structural boundary in a dextral transtensional regime that subdivides the Hellenic volcanic arc into a seismically and volcanically quiet western and an active eastern part. The highest earthquake activity has been observed beneath the submarine Columbo volcano and northeast of it along the Santorini-Amorgos Ridge, which terminates south of the island of Amorgos [1].

The activity close to the Columbo seamount is considered to be linked directly to a magma reservoir and to be influenced by the migration of magma and fluids toward the surface. Earthquakes northeast of the volcano also may result from magma and associated fluid migration toward the surface, according to some suggestions. The Santorini-Columbo volcanic complex includes one caldera at Santorini and one crater at Columbo. The caldera of Santorini is formed by four deep basins (from 290 to 390 meters deep). The Columbo volcano has a well-defined crater with a single basin (depth 500 meters). Until now, only a single underwater eruption has been reported for the Columbo volcano in 1650 A.D. [2]. However, evidence for previously undiscovered activity in Colombo's was expected on the seafloor surrounding the seamount.

The general scientific objectives of the already completed first phase of the so-called Inspecting Columbo project included the investigation of shallow expressions of deep-rooted tectonic or magmatic intrusions, which may result in active faulting or fluid migration, respectively [3]. During the research cruise, the Santorini-Columbo complex as well as the SAZ were mapped in detail by means of multichannel reflection seismics as well as magnetic (1500 kilometers each) and gravity (2500 kilometers) profiling. For the active seismics, a bubble free airgun with about 100hertz main frequency served as the seismic source. In the sediment basins, the signal penetrated to a depth of more than one kilometer beneath the seafloor. Data were received by two seismic sensor cables (streamers) of 600- and 150-meter length, respectively. The seismic data will help with (1) the identification f active tectonics; (2) the budgeting of pyroclastic deposits around Santoriniand the Columbo volcano as well as in the SAZ: (3) the interpretation of individual eruption events of the Columbo and Santorini volcanoes; and (4) the detection of fluid migration paths and reservoirs associated with magmatic intrusions. The gravity and magnetic data will help to correlate shallow tectonic signals with deeper magmatic intrusions, and therefore determine the distinction between main faults above an intrusion or side branches.

Seismic cross-sections of the Santorini-Amorgos Ridge where the earthquake activity is highest indicate that its sediment cover is highly and actively faulted. The presence of magnetic anomalies at the ridge's southeastern escarpment suggests that the earthquake activity and the active faulting are caused by magmatic processes. Initial modeling results suggest that the magnetic source body, such as a magma chamber, lies at a depth of five kilometers. This is consistent with previously published epicenter depths of a few kilometers. Seismic lines across the Columbo volcano elucidate the primary building blocks of the volcano. Two conelike volcanoclastic deposits show that the Columbo volcano evolved from atleast two eruptions. A bright spot about 200 meters beneath the calderaprovides evidence for gassy and/or fluid charged sediments. The strong magneticanomaly (450 nanoteslas) above the caldera can be assumed to be caused by a magma chamber beneath the caldera. In addition, a depth for the magnetic body has been estimated at five kilometers. Southeast of the volcano, along theso-called Kameni line, an elongated dike intrusion, named the Poseidon Ridge, has been discovered about 100 meters beneath the seafloor. The ridge, six kilometers wide and more than 10 kilometers long, is characterized by a small magnetic anomaly of about 40 nanoteslas. An active extensional fault can be seen on the seafloor. A second extensional fault lineament is present northwestof Columbo, where initial faults already pierce the seafloor. Both of these examples prove that the Santorini-Amorgos zone is tectonically active and deserves constant monitoring.

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SEDIMENTATION RATES IN THE INNER PART OF İZMİR BAY

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Abstract

Sedimentation rates were determined for the inner part of Izmir Bay, close to a heavily industrialized Turkish coast of Aegean Sea. The highest sedimentation rates were found at 0.278 cm y-1 in station 8 and the lowest at 0.104 cm y-1 in station 9 in the shallower area of the bay.

Keywords : Aegean Sea, Sedimentation.

Izmir bay (Fig.1) is located on the western coast of Turkey and surrounded by a densely populated community. The bay has been divided into three sections (outer, middle and inner) according to physical characteristic of the different water masses.

The inner bay is small (57 km^2) and shallow (max. depth 15 m). A 13 m deep sill (Yenikale Strait) separates the middle bay from the inner bay. Aegean Sea waters enter the inner bay through the narrow Mordogan strait. The water depth in the outer bay is about 70 m and decreases towards the inner bay, the coast of which is intensely industrialized compared to the middle and outer parts of the bay.



Fig. 1. Sampling locations in Izmir Bay.

Core samples were collected from different stations in the inner bay using core sampler during January-June 2004. Sediment cores were subsampled at 4 cm intervals using plastic tools and each layer was oven-dried to constant weight at 80^oC, disaggregated and passed thought a 250 μ m sieve. The water content of samples was determined by weight loss after oven drying: water content (W in %)=(water weight/wet sediment weight x 100). The analyses of ²¹⁰Pb were determined by alpha spectroscopy of its daughter ²¹⁰Po according to the methodology described by Flynn (1968).



Fig. 2. Profiles of ²¹⁰Pb vs. depth in sediment cores.

For 3 stations (station numbers 8, 9 and 10 in Fig.1) the ²¹⁰Pb profile distributions were obtained in exponential form as expected so that it was possible to determine sedimentation rates (Fig.2). Various numbers of cores taken from each station at different times were analyzed and sedimentation rates were found to vary in the range of 0.104 cm y⁻¹-0.278 cm y⁻¹. Relatively high average sedimentation rates as 0.210 cm y⁻¹ and 0.184 cm y⁻¹ were observed at the stations number 8 and 10 respectively that are closer to the coast.

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PALAEOCLIMATIC RECORDS OF A DEEP SEA CORE FROM THE ANAXIMANDER AREA

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Abstract

The hemipelagic sediments from a gravity core retrieved from the Anaximander Mountains, Eastern Mediterranean were analysed for isotope, palynological and micropaleontological composition. The multiproxy data records provided the palaeoclimatic and palaeoceanographic evolution of the studied area during the late stageof Last Glacial period and Holocene. *Keywords : Dinoflagellates, Eastern Mediterranean, Foraminifera.*

Introduction. The Mud Volcanoes (MV) in the Anaximander Mountains (Mts) Eastern Mediterranean were sampled during the cruises of the' Anaximander' project with the *RV Aegaeo* in May 2003 and October 2004. The target of the project, funded by EU, is the examination of the Gas Hydrates (GH) and the associated deep biosphere occurring at the area [1]. The aim of the present work is to present the results from the micropalaeontological and the palynological studies of the hemipelagic sediments sampled from the gravity core AN11GC1 collected from Kula Mud Volcano in order to interpret the palaeoenvironmental conditions in Anaximander area.

Materials. The core AN11GC1 (lon.35° 43' 712, lat.30° 27' 589, water depth 1644m and 200cm length) retrieved in Kula MV. Twenty-six samples were used fo rpalynological analysis (pollen, terrestrial spores and dinoflagellatecysts), for microfauna analysis, for the determination of the oxygen and carbon isotopes on the tests of the planktonic foraminifera *Globigerinoides ruber*. The dating of the events was based on two AMS 14 C dates and a tephra chronology.

Results-Discussion. The core AN11GC1 consists of eight lithological units. Sapropel S1 occurred between 23 and 29cm. Two lithological units (29-71cm and157-200cm) consist of mud with abundance of clasts Both these units indicate reworked sediments and enhanced activity of the related mud volcano. Almost during the former interval the microfauna associations were absent. A fine grey ash layer is present between 102 and 109cm and is correlated with the Y2 ash layer (Cape Riva eruption of Santorini).

The downcore variation of the δ^{18} O in core AN11GC2 together with the downcore variation in abundance of the three main group of the planktonic foraminifera are shown in Fig.1. Group A consists of the warm planktonic species *Gs. ruber*, *Globigerinoides spp*, *Globigerinella spp* and *Or. universa*. Group B consists of the cold species *Gr. scitula*, *T. quinqueloba*, *N. pachyderma* (*d*), *N. dutertrei*, *G. glutinata* and *G. bulloides*. The Group C consists of *Gr. inflata*, *Gr. crassaformis* and *Gr. truncatulinoides* and is associated with cool and deep mixed waters in the Mediterranean [2].



Fig. 1. Downcore variation of isotope and micropalaeontology data. The lithological sequence of AN11GC1 is presented.

Between 200 and 85 cm the heavy δ^{18} O values together with the dominance in the planktonic associations of the Groups B and C suggest the prevalence of cold climatic conditions during the last glacial period. The most severe conditions prevailed around 90cm suggesting that this interval corresponds to Last Glacial Maximum. At the same time the increased abundance of the N on Alboreal Pollen (presented in Figure 2) dominated by Artemisia suggests increase in aridity. The microfauna and microflora deduction for this period is in agreement with similar results from sediments of the eastern Mediterranean [2, 3]. Noticeable is the increased participation of Group C during the deposition of the reworked sediments between 200 and 140cm and the peak in the planktonic and benthonic productivity curves at130cm which mark the end of the lihtological unit. Between 85and 35cm the deglaciation is characterized by the high presence of Artemisia and the low presence of Quercus. The climate in the pollen source area was arid, cold in winter, briefly warm in summer and substained the vegetation. Throughout the deglaciation from 18 to 11 kyrs, the aridity progressively increases but it is interrupted by a more humid event (presence of Quercus). Maximum aridity occurs around 70cm and probably corresponds to Younger Dryas chronozone (12-10.5 kyrs) [2, 3] interrupting the regional expansion of deciduous trees.

During the upper 35cm of the core the light δ^{18} O values accompanied with increased abundance of Group A suggest the permanent climatic amelioration during the Holocene. The most depleted δ^{18} O values occur during the deposition of S1 and are attributed to the establishment of warm and low salinity waters. In the pollen records the Holocene is characterized by warm mixed and temperate deciduous forest association [3]. During the deposition of sapropel S1 the records of palynomorphs are characterized by high increases of *Quercus*, accompagnied by the increased abundance of *Spiniferites, Lingulodinium machaerophorum* and *Operculodinium centrocarpum*. The above indicate an increase in humidity and pollen productivity and a reduction in surface water salinity during the deposition of S1 [2,3]. In the planktonic data records the end of S1 is marked by the increase of Group C suggesting winter water mixing and recovering of the watercolumn circulation.



Fig. 2. Downcore variation of organic carbon percentage and palynological data.

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BATHYMETRIC CHANGES OF THE BOTTOM RELIEF IN THE GULF OF ALEXANDROUPOLIS (NE AEGEAN SEA) BETWEEN 1960-2004, IN RELATION TO ITS HARBOUR EXPANSION

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Abstract

The aim of this study is to examine the bathymetric changes taking place in the bottom relief of the area surrounding the harbour of Alexandroupolis, after its recent expansion. Qualitative and quantitative changes of the bottom relief have been based upon the comparison of the bathymetric maps of 1960 and 2004, with the use of GIS. The results show that most of the area is characterised by sediment accumulation (average rates up to 4mm/yr), whilst their origin has been related to the nearby R. Evros sediment fluxes, wave activity and offshore patterns of water circulation.

Keywords : Aegean Sea, Bathymetry, Sediments.

Introduction

The harbour of Alexandroupolis was first constructed in 1870, used as a small piscatorial shelter. After a series of reconstructions and expansions it is now functioning as a big commercial harbour, having a major significance for northern Greece. Following harbour works, remarkable bathymetric changes have occurred associated with extraction and deposition of dredged material and/or the modification of nearshore hydro- and sediment dynamics, caused by the seaward prolongation of harbour piers. The scope of this investigation is to assess qualitatively and quantitatively the above mentioned seabed morphological changes.

Study area

The harbour of Alexandroupolis is located in the homonymous Gulf which belongs to the inner continental shelf of the NE Aegean (Samothraki Plateau). The relief of the seabed is smooth with very low gradients (<1%), which extend several kilometres offshore. The seabed consists of fine-grained sediment, whilst offshore there are relict sand deposits. To the east, the river Evros (drainage basin=52.500km²) debouches, discharging some $3,2x10^6$ t/yr (Pehlivanoglou, 1989). The gulf is exposed to waves caused predominately by S and SW winds, while coastal sediment transport has a dominant east to west direction, especially for the region to the east of the harbour (Pehlivanoglou, 1989). Wave heights induced by average wind speeds (4-5 B) are in the order of 1,3 m, reaching values of 5 m during storms (Athanasoulis & Skarsoulis, 1992); these wave heights are expected to break in water depths of about 2,5m and 6.5 m, respectively. Furthermore, the above mentioned wind-induced waves are capable to resuspend the surficial bottom sediments (Karditsa, 2006). This highly energetic and sediment rich marine environment not only has caused serious problems by infilling the harbour basin, but has also changed bathymetry in association with harbour works (dredging, pier extension etc).

Methodology

The study of the bathymetric changes of the gulf, focused on the neighbouring area of the harbour, was based on the comparison of bathymetry charts (scale 1:10.000) produced and published by the Hydrographic Service at 1960 and 2004. Digitized ground models were built according to these maps, which were subsequently compared by abstracting the digitised bathymetric surface of 2004 from that of 1960, with the use of GIS (ArcMap 8.3) function, named "cut and fill".

Results and Discussion

Following the conclusion of harbour works (in 2004) the dredged harbour basin and the associated navigation channel present depths between 6 m and 7 m. In the contrary, the comparison of the bathymetric charts of 1960 and 2004 show that the nearby off-harbour area is characterised by deposition (figure 1). According to calculations, the depth inside the harbour has decreased on average by approximately 1.7m since 1960 whilst the water depths outside the harbour have increased about 0.9m.

Sediment accumulation is obviously related to the seaward prolongation of harbour piers (e.g. the W pier, directed to the ESE, has today a length of 1.5 km) that has modified nearshore hydrodynamics and associated sediment dynamics and transport pathways.



Fig. 1. Bathymetric changes, after the comparison of the bathymetric charts of 1960 and 2004. (1): Position of bathymetric profiles (figure 2).

In addition, the comparison between the bathymetric profiles of 1960 and 2004 (figure 2), to the west of the harbour, shows a general accretion and two distinctive bathymetric changes at about 3m and 6m of water depth. The depth of occurrence of these two underwater terraces coinciding with the calculated depths of wave breaking, under most frequent and extreme wave conditions, indicate the importance of the local wave regime.



Fig. 2. Cross-shore (N-S) bathymetric profiles for the 1960 and 2004.

In conclusion, the observed bathymetric changes have been attributed to and/or partially caused by the expansion of the harbour, while the shallowness of the inner shelf and its fine-grained composition along with the sediment influx of the R. Evros, some other smaller torrents, and the wave regime (breaking zone of storm waves very close to the harbour) make the position of the harbour rather unsuitable, at least from a sedimentological point of view.

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BENTHIC AND PLANKTIC FORAMINIFERAL ASSEMBLAGES OF THE SEDIMENTS DEPOSITED DURING THE LAST 25 KY IN THE MARMARA SEA

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Abstract

Benthic and planktic foraminiferal fauna were identified in six cores from the deep basins of the Marmara Sea. We determined seven local biostratigraphic zones based on quantitative distribution patterns of foraminifers and species diversity. These zones reflect the changing environmental conditions in the Marmara Sea, from lacustrine to marine, during the last 25 ky BP. *Keywords : Foraminifera, Sapropel, Sea Of Marmara.*

The Marmara Sea is a land-locked sea between the peninsulas Thrace and Anatolia and constitutes an oceanographical link between the two large semi-enclosed basins; the Mediterranean and Black Seas. It is connected to the brackish (18-22 ppt) Black Sea via the Istanbul Strait (Bosporus) and to the normal marine water (37.5-38.5 ppt) of the Mediterranean Sea via the Canakkale Strait (Dardanelles) with permanent two-layered water stratification [1] at about 25 m water depth.

The sea floor of the Marmara Sea presents a complicated morphological system, including shelves, slopes, ridges and deep basins [2]. The four basins, namely Cinarcik (1270 m), Silivri (820 m), Central (1268 m) and Tekirdag (1133 m) are separated by ridges, occurring at water depths between 360 and 650 m. During a cruise of the Research Vessel *Sismik-1* in 1998 and M44/1 cruise of the Research Vessel *Meteor* in 1999, six cores were collected from the Central and Cinarcik basins of the Marmara Sea, in changing water depths from 703 to 1203 m (Table 1).

Tab. 1. The locations, water depths and lengths of the studied cores.

Core number	Latitude (N)	Longitude (E)	Water depth (m)	Core length (cm)
32MC	40°45.612	27°44.942	711	48
DM18	40°49.8452	27°52.6262	895	424
DM22	40°48.6212	27°58.3712	1203	422
KL40	40°47.122	27°46.312	703	901
KL89	40°45.42	28°46.362	1156	622
KL97	40°51.212	28°46.532	1094	540

In this study, Micropaleontological and geochemical analyses were carried out in the cores. Benthic foraminiferal fauna observed in the cores displays high diversity compared to planktic fauna. A total of 99 species of benthic foraminifera and 11 species of planktic foraminifera were identified. Benthic foraminiferal species are represented by predominantly calcareous forms. Planktic foraminifers are abundant in spite of the low diversity. A sapropelic layer deposited at about 10.3-6.2 ky BP and having >1.5 % Corg contents were found in some of the cores. Micropaleontological examination of the cores provided to distinguish seven local biostratigraphical zones, reflecting distinct changes in paleoenvironmental conditions before, during and after the sapropelic deposition. These zones can be summarized into three main sections; Pre-sapropelic (Pr1-2 zones), Sapropelic (Sap1-2 zones), and Post-sapropelic (Po1-2-3 zones) sediments. The lake stage of the Marmara Sea, when it was isolated from both the Black and Mediterranean Seas, was determined at the basal section of the cores (Pr1 zone), and characterized by the absence of foraminifers. First colonization of benthic and planktic foraminifers at about 11-10.4 ky BP indicated the starting of marine conditions, after the entrance of Mediterranean waters through the Canakkale Strait (Pr2 zone). Benthic foraminiferal assemblages of the sapropelic sediments showed that the sapropelic deposition started under anoxic-close to anoxic bottom water conditions (Sap1 zone) and continued in dysoxic-suboxic conditions (Sap2 zone). Foraminiferal distribution allowed to determine three zones within the post-sapropelic sediments, possibly indicating relative changes in the Marmara Sea during the Late Holocene.

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MODES OF TECTONICS IN GOKCEADA ISLAND, NORTHERN AEGEAN SEA: IMPLICATIONS FOR THE NORTH ANATOLIAN FAULT

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Abstract

Gokceada (formerly Imbros) Island lies in the northern Aegean Sea in close proximity of the Saroz Tough along the seismically active North Anatolian Fault (NAF). Fault segments including those in NE-SW orientation parallel to the NAF truncate the sequence in the island that comprises 2 km thick Tertiary sedimentary strata and the underlying metamorphics. Evidence of many morphological, coastal and geological/tectonic features suggests a component of reverse dip-slip within extensional tectonic setting of the strike-slip North Anatolian Fault (NAF). Tectonics along the NAF does include both modes of dip-slip along with strike-slip movements. *Keywords : Aegean Sea, Geomorphology, Sea Level, Tectonics.*

Gokceada (formerly Imbros) is one of the few islands in the northern Aegean Sea. The island is situated in close proximity of the North Anatolian Fault (NAF), that occupies a NE-SW orientation off-shore to the west along a rugged bathymetry and a deep channel known as the Saroz Trough [1] (Fig. 1). The NAF, accommodating the westerly movement of the Anatolian Plate, extends through northern Turkey into depressions of the NW Turkey such as the Marmara Sea and the Gulf of Saroz.



Fig. 1. Seismo-tectonic features of Turkey and GokceadaIsland. Dashed contours top of the Middle Eocene age unit in metersbelow sea level [2].

In the Gulf of Saroz, the NAF is considered to exhibit an extensional character attributed to releasing fault bend geometry, and the region is considered to have been undergoing a subsidence in association with the development of the fault. Gokceada Island is a terrain in the northern Aegean Sea that allows this fault system and its tectonic characteristics to be investigated in relation to morphological and coastal features.

Gokceada has a high and rough topography along its western shore that diminishes towards the north and east with a depression in the middle. The peaks reach up to 673 m in the western half of the island and the island has a water division line in a NE orientation asymmetrically proximal to the western coast. The island possesses a variety of morphological and coastal features such as paleo-coastal notches, hanging valleys, waterfalls, springs and travertine formation [3] (Fig. 2a). Along the northern coast near Mavi Cove, a distinct paleoshore structure is seen at an elevation of 12 m on a steep slope. This paleo-coastal notch has a width of 6 m and length of 200 m (Fig.2b) and it occurs in stiff volcano-clastics on the steep cliff. There are also occurrences of prominent water-falls in the northern half of the island. One of these is located at the northern side of the village of Derekoy with a height of 35 m.

Morphological features of Gokceada are evidences of active tectonics. A history of uplift in this transtensional tectonic setting of the NAF is evident in uplifted wave-cut notches, uplifted terraces, hanging valleys and water falls. The paleo-shoreline at northwest of the island in stiff volcanics (andesite) at the foot of a steep cliff is of importance.

Further strong support for tectonic uplift is evident by the exposure of the basement rocks along the western coast of the island. There, the exposure of the metamorphics occurs at the base of Tertiary strata that have a thick-

ness more than 2000 m in the SW Thracian basin (Fig. 1). Considering these rocks presently lie at a water depth of more than 1000 m in the Saroz Trough, we could suggest a few kilometers of vertical displacement must have occurred for the metamorphics to acquire their position on the island. This uplift may be attributed to the collusion tectonics in the early Tertiary along the intra-Pontid ocean. However, the occurrence of basement rocks under a very thick sedimentary cover of the Thrace basin, their total absence on the surface in the Thrace, but their exclusive occurrences along the North Anatolian suggest an alternative setting of strike-slip transpressional fault as a significant parameter in this process. In Gokceada, the northern Aegean Sea, the uplift is affiliated with interaction of faults in a strike-slip fault system and supported by the fault geometry, displacement of the units, and fault lineations. This is consistent with the thrust and normal-slip components observed in the seismic events of the region [4].



Fig. 2. a) Principal morphotectonic features of the island; b) Paleowavecut notch occurs at 12 m elevation in the north of the island.

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ASSESSMENT OF THE SEDIMENTARY SYSTEM OF THE BLACK SEA SINCE THE LAST GLACIAL MAXIMUM

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Abstract

ASSEMBLAGE was an integrated pan-European study of the northwestern Black Sea sedimentary system from the continental shelf to the deep sea. The Black Sea being a unique feature characterised by the only particularly wide shelf in the northwestern sector is the drainage basin of some major European rivers. The Black Sea is also characterised by high sedimentation rates presenting favourable conditions for paleoclimatic studies. The project itself has increased the knowledge of the Southern European Ocean Margin and facilitate access to and use of the Black Sea seafloor and exploration and exploration of its resources, and preservation of its environment. This was achieved through the examination of existing and collected geomorphologic, geophysical, stratigraphic, sedimentological data permitting progress in deciphering the past climatic and environmental changes of the Black Sea.

Keywords : Black Sea, Sedimentation, Sea Level, Stratigraphy.

ASSEMBLAGE was a European collaborative project focused on the assessment of the North-western Black Sea sedimentary systems from the continental shelf and slope down to the deep-sea zone. The Black Sea is one of the largest marginal seas ¹ and one of the largest receiving basins for important European rivers (Danube, Dniepr, Dniestr). ASSEMBLAGE project proposes a preliminary Quaternary stratigraphy for this region.

ASSEMBLAGE project has realised a complex marine research programme in the Black Sea using modern scientific equipment and technology and high expertise by unifying the efforts of scientists from Western Europe and Central-Eastern Europe. As the Black Sea is characterised by high sedimentation rate, this water body presents favourable conditions for paleoclimatic studies, in particular its preferential location being in the immediate vicinity of the ice-cap during the last Glacial period.

ASSEMBLAGE marine research programme objectives were to contribute to have a complete sedimentary record of the past climatic changes over least 20,000 yr in this region and to compare it to the Global record. This has been achieved as an integrated approach of the Black Sea sedimentary system through the examination, the processing and the interpretation of first existing data and secondly of geomorphologic, geophysical, stratigraphic, sedimentological, paleomagnetic and geochemical data acquired during the ASSEMBLAGE project.

aims to advance at the optimum achievable level the assessment of the Black Sea sedimentary system. This has been done through integrated studies on the sedimentary processes and sequences since the last Quaternary period of the Southern European Ocean Margins. The Black Sea represented a unique laboratory in the world and the project was therefore a case study for a better understanding of sedimentary processes in semi-enclosed anoxic basins. The project results now form a basis for extrapolation to other sedimentary systems as well as other closed basin in Europe and elsewhere in the world.

The specific scientific ASSEMBLAGE project outcomes realised are the following:

(1) geomorphologic and stratigraphic studies from the shelf to the deep sea. ASSEMBLAGE project has greatly contributed to the study of the thickness distribution and the analysis of the internal geometry of important depocentres dated from the last 20,000 years of shelf deposits. This geomorphologic studies allowed to determine ages and extension of the connected Danube-Dniept/Dniestr deepâĂŚsea fans. This was correlated to the study of the hydrates potential of this region. To achieve these results ASSEMBLAGE project has used seafloor surveying systems (multibeam, high-resolution seismic such as CHIRP-sonar profilers equipment). The 1-m resolution of swath mapping sonars combined with very-high-resolution seismic profiles enabled to recognise relict shorefaces formed by successive water level fluctuation, deep-sea fan extension and seeps localisation;

Dufresne", a series of long cores were retrieved from the North-western shelf and the deep-sea fans of that cover the Late Pleistocene lacustrine phase and the Holocene marine phase of the Black Sea. Stable isotopes, pollens, molluscs, foraminifers, diatoms, and clay mineralogy of these cores were analysed and the history of climate change at a cm core-resolution was deduced for some specific chosen cores using precise proxies. In hydrates recognised areas, combination of microbiological studies were also carried out with the tools of molecular biology and organic geochemistry;

(3) modelling of the paleo-evolution of the Black Sea level during the Lateglacial-Holocene transition was approached and new estimates for that period based on the analysis of water budget were also provided. Hydrological conditions in the Black Sea catchment area were reconstructed using water balance equation, available data, and constraints based on simple theory relating the runoff ratio with climatic characteristics. In order to estimate the impact of the aridity of climate two alternative scenarios were considered: (3.1) climate change under constant in time gradient in precipitation and evaporation over land and sea, and (3.2) climate change accounting for changes in the horizontal distribution of precipitation and evaporation. Hydrological data were compiled from available present-day data and paleo-observations. A number of sensitivity experiments were carried out revealing that the hydrological conditions in the Black Sea watershed should have evolved towards a very arid climate (similar to the present-day climate in the Caspian Sea area) in order to initiate a drop of sea level of -100 m below the sill depth of the Bosporus Straits, as speculated in some recent research. Estimates of sea level changes reveal a qualitative agreement with the coast-line evolution inferred from paleoobservations;

(4) building out a comprehensive database and a GIS for the sedimentary systems of the North-western Black Sea as a support of any interpretation and modelling of such sedimentary systems for in-land sea basins. The database and the GIS offer a scientific base for scientists and decision-makers in taking decisions concerning the Black Sea environment and especially the coastal sea and coastal zone protection and rehabilitation and by;

(5) All these information are easily accessible through ASSEMBLAGE web site (http://www.ifremer.fr/assemblage) for informing the scientific world and the mass media about the work carried out in the frame of the project as well as for demonstrating the main scientific results obtained.

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(2) during ASSEMBLAGE first cruise carried out onboard the RV "Marion

HIGH RESOLUTION DELTA¹⁸O AND DELTA¹³C PROFILES IN BIVALVE SHELLS FROM EAST MEDITERRANEAN COLD SEEPS

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Abstract

Cold seeps ecosystems from deep sea environments are characterized by venting of methane-rich fluids. High resolution isotopic studies on bivalve shells from Mediterranean cold seeps provide informations on changes of environmental parameters as venting activity during the growth of the animals.

Keywords : Bivalves, Carbon, Eastern Mediterranean, Oxygen.

Methane-rich fluids venting at cold seeps from deep sea environments fuel an intense biological activity where anaerobic oxidation of methane by *archaea* and *eubacteria* provide the energy necessary to sustain life of invertebrates. Methane contained in fluids is characterized by low delta ¹³C values (-40 to -110 parts per mil V-PDB for biogenic methane and -35 to -60 parts per mil V-PDB for thermogenic methane) [1].

Previous studies on bivalve shells from hydrothermal vents and cold seeps [2,3] have shown that delta¹³C and delta¹⁸O values reflect environmental conditions experienced during their life (venting system variability, temperature, water composition, methaneflux...).

The aims of this study were to determine which signals are recorded by bivalve shells from Mediterranean cold seeps and what are their significance in terms of variability of environmental parameters as well as on the metabolism activity.

This study focuses on eight specimens of *Myrtea aff. amorpha*, bivalve *Lucinidae*. The shells were collected dead, by submersible dives during MEDINAUT cruise in November 1998 (Kazan Volcano at 1706 m) and during NAUTINIL cruise in September 2003 (Pockmarks area at 1600 m and Amon volcano at 1100 m), in Eastern Mediterranean. The carbonate mineralogy of Lucineshells is aragonite (96 %) and calcite (4 %).

The isotopic compositions of carbonate shells exhibit characteristic values depending on the site location: in Amon volcano: 2.1 <delta¹⁸O parts per mil V-PDB <2.2 and 1.4 <delta¹³C parts per mil V-PDB <2.1; Pockmarks area: 1.8 <delta¹⁸O parts per mil V-PDB <2.5 and -1.8 <delta¹³C parts per mil V-PDB <2.2; Kazan volcano 2.1 <delta¹⁸O parts per mil V-PDB <3.4 and -10.2 <delta¹³Cparts per mil V-PDB <1.9. Moreover, the stable isotope compositions display a large dispersion in shells from a same location: delta¹⁸O vary by about 1.3 parts per mil V-PDB whereas delta¹³C vary up to 12 parts per mil V-PDB.

High resolution delta¹⁸O and delta¹³C profiles of bivalve shells consist in doing successive micro-sampling ($\approx 100 \ \mu g$) of calcium carbonate following the growth increment direction.

Isotopic profiles of the two shells from Amon volcano show similar delta¹⁸O and delta¹³C values. They both vary by about 1.5 parts per mil. Moreover, in these two shells, delta¹⁸O and delta¹³C values decrease with age. The two shells collected from the active pockmarks zone show two different delta¹³C profiles. One shell records a variation of delta¹³C values by about 9 parts per mil whereas the other shell displays moderate delta¹³C variations by about 1.3 parts per mil. As shells were collected dead, it is possible that they didn't experience the same events.

The four shells collected from Kazan mud volcano also present different isotopic profiles. Three of them show small but significant variations 1 to 2 parts per mil for delta¹³C and 1 parts per mil for delta¹⁸O values. The fourth shell exhibits carbon isotopic profile with an important change of delta¹³C values along his life (from -10 parts per mil to 0 parts per mil).

In conclusion, this is the first high resolution isotopic study carried out on bivalve shells of Mediterranean cold seeps. Bivalves shells from cold seeps are exposed to venting fluids containing methane with low delta¹³C values which probably explains the pulses of delta¹³C values recorded in shells. In addition, metabolism processes seem to influence delta¹³C evolution with age. Variations of the oxygen isotopic compositions of bivalve shells might also be explained by metabolism processes, although local temperature variability could be due to higher heat flow.

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LONG-TERM DEVELOPMENT AND CURRENT STATUS OF THE BARCELONA CONTINENTAL SHELF

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Abstract

The seafloor and subseafloor of the Barcelona continental shelf (NW Mediterranean Sea) records its Late Quaternary history and the imprint of the factors controlling this sediment-dispersal system. Two main morphosedimentary domains have been recognized: (i) a relict, sediment depleted area, and (ii) a modern, river-influenced area. Both domains are affected by a variety of anthropogenic impacts such as the enlargement works of the Port of Barcelona, sewage pipes, dredging, anchoring and trawling. *Keywords : Continental Shelf, Geomorphology, Sea Level, Swath Mapping, Western Mediterranean.*

The Barcelona continental shelf, off the city of Barcelona (NE Spain), is a relatively narrow canyon-bounded shelf in the northwestern Mediterranean Sea [1]. Two medium-size rivers (Besos and Llobregat) and several ephemeral rivulets flow into this margin. A detailed geomorphologic study based on multibeam bathymetry and backscatter data, high resolution seismic profiles, and surface sediment samples allowed mapping and interpreting the main distinctive seafloor features on the Barcelona shelf. Two main domains have been identified in the Barcelona shelf: (i) a relict area mostly lacking recent sedimentary coverage, and (ii) a modern area influenced by recent rivers discharge (Fig. 1). Both areas show the imprint of various human impacts.

A large part of the study area is sediment-depleted where relict (Late Pleistocene-Holocene) morphosedimentary features such as beach ridges and beachrocks crop out (Fig. 1). These paleo-coastal indicators form two different sets that follow N090 and N030 orientations. Their morphosedimentary arrangement is interpreted as a 45° shift of the seashore direction between MIS 4 and MIS 2. Multibeam and seismic reflection data allowed mapping a complete set of NE-SW seafloor normal faults in the Barcelona sediment-depleted area (Fig. 1). The faults resulted from reactivation of the deep Neogene extensional structures of the margin [2].



Fig. 1. A) Swath bathymetry shaded relief map of the Barcelona continental shelf and onland orthophotomap. White lines correspond to river courses. Numbers mark some examples of the interpreted seafloor features. 1: Faults. 2: Beachrocks. 3: Relict coastal sand bodies. 4: Large submarine step. 5: Finest sediments depositional areas. 6: Wavy prodelta front. B) Stretch showing the general zonation of the Barcelona shelf. a: Severely anthropogenically impacted area. b: Modern, river-influenced shelf domain. C: Relict, sediment depleted shelf domain. Map projection is UTM 31N WGS84.

Modern sedimentary features reveal that the Llobregat River is the main sediment source of the Barcelona prodeltaic shelf. The Llobregat and Besos adjacent prodeltas are the main Holocene depocenters in the study area. However, the continental shelf reaches its minimum width off the Llobregat River mouth as most of the sediment inputs are deviated southward by the dominant coastal circulation. The wavy nature of the Llobregat prodelta front (Fig. 1) may result either from hyperpycnal and bottom currents or from soft sediment destabilization [3].

Anthropogenic impacts are widespread on the Barcelona inner and middle shelf, especially along the Besos-Llobregat coastal stretch (Fig. 1). Coastal infrastructures already have a major impact on sediment dispersal patterns, that will likely increase in the near future. The Port of Barcelona directly affects a large part of the Llobregat prodelta and has the potential to disrupt the natural paths of sediment transport. The seafloor sediment cover is largely reworked by dredging, anchoring, and trawling activities. Fluvial water and solid discharge are equally affected by the anthropogenic pressure.

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DISSOLUTION OF MESSINIAN EVAPORITES AND ITS EFFECT ON THE SLUMPING OF PLIO-QUATERNARY SEDIMENTS ALONG THE LEVANT MARGIN, EASTERN MEDITERRANEAN

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Abstract

Series of reverse faults in the upper part of the sedimentary sequence in the Levant Basin deform only the Plio-Quaternary series and the upper part of the Messinian evaporites. The faults suggest that the Messinian salt flows basinwards, carrying along the overlying sediments. The flow pulled the salt away from the edge of the Levant Basin, where it pinches out and the overlying sediments slumped. Seawater penetrated along the normal detachment faults of these slumps, dissolved the salt, and enhanced the collapse of the overlying Plio-Quaternary sequence.

Keywords : Messinian, Salinity.

Reverse faults that dip to the SE, that were discovered in seismic surveys of the Levant Basin off Israel presented evidence of basinwards flow of the Messinian salt. The faults offset the upper part of the Messinian evaporites and the Plio-Quaternary sequence while the lower part was not deformed. The basinward flow of the Messinian salt was probably initiated by the subsidence of the Levant Basin due to sedimentary load. The faults suggest the structural evolution of a series of complex and enigmatic structural features in the subsurface at the base of the continental slope of the Levant, which were described by Neev [1] off Israel and by Tapponnier et al. [2] off Lebanon. Neev [1] presumed that the structures are a part of a global shear zone, and Tapponnier et al. [2] correlated the feature with possible eastward subduction. Comprehensive and systematic multichannel seismic surveys (e.g. [3]) enabled us to shed new light on these structures.

Already the early explorations of the eastern Mediterranean found out that the lower part of the continental slope of the Levant is characterized by extensive slumps and landslides, and Plio-Quaternary sedimentary strata that overlie enigmatic structural features of Messinian evaporites proved unstable. Complex structural features of the Messinian series were traced along a strip 20 km wide that stretches along some 250 km parallel to the coast of Israel and Lebanon. Although these structures have been known for more than 30 years, their origin was considered unresolved.

Recent discovery of numerous reverse faults that offset only the Messinian evaporites and the overlying strata in the Levant Basin seems to illuminate the process that formed the enigmatic structures. We show that the complex structures are associated with the wedging out of the Messinian evaporites. The initial deposition of the Messinian evaporitic sequence took place in a hypersaline lake that covered the deeper parts of the Mediterranean Sea, where the configuration of the bottom of the lake is represented by seismic reflector N. The top of the evaporitic sequence, reflector M, was deposited in the proximity of the lake level. The shoaling of that lake is represented by the wedging out of the evaporites and the merging of reflectors M and N, which can be discerned at reflection time of 2.5 seconds, or 2 km. It seems that slight basinal subsidence during the late Pliocene due to sedimentary loading initiated westwards flow of the Messinian salt, as indicated by numerous southeastwards-dipping reverse faults. This flow tapered off at the eastern edge of the salt deposit, where the flow of the salt was compensated by subsidence of the overlying strata. This subsidence generated geotechnical faulting that enabled the penetration of water into the evaporitic layer and partially dissolved it. The dissolution removed additional portions of the evaporites, and left behind irregular relicts of the evaporitic layer, further enhancing the subsidence of the overlying strata. Thus the dissolution of the edge of the salt layer dropped the basis of the Plio-Quaternary series further and led to its slumping and collapse along the distal slope.

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NEW EVIDENCE FOR ABRUPT FLOODING OF THE BLACK SEA IN THE EARLY HOLOCENE

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Abstract

Recent study of the distal continental shelf of the Black Sea off western Turkey obtained sediment cores where layers bearing shells of recent marine fauna were underlain by strata containing brackish water fauna. Preliminary, uncalibrated and apparent ¹⁴C dating suggest that the age of the base of the marine layer is circa 7,000 years while the top of the brackish layer, some 2 cm below, is ca. 28,000 carbon years. It seems that when the marine invasion took place, the level of the Black Sea was approximately 100 m below its present level. *Keywords : Black Sea, Sea Level, Sediments.*

Conflicting interpretations of geological, geochemical and geophysical data regarding the variable water composition of the Black Sea and its changing water level during the latest Pleistocene and the early Holocene were presented during the last 12 years in the scientific literature. While it is generally agreed that a fresh-brackish water lake existed in the Black Sea basin after the Last Glacial Maximum, when global sealevel was approximately 125 m lower than its present level, there is disagreement on the rate in which the Black Sea changed to obtain its present marine environment. In an effort to shed some light on the debate, a geological and geophysical marine investigation was carried out along the distal continental shelf off the northern edge of the Bosporus Strait in the southern Black Sea in summer 2005 on board R/V Mediterranean Explorer. The study was carried out at depth of 100-120 m. at 3 areas of 4X6 km, and a network of high-resolution chirp profiling, spaced 150 m apart, were used to image the seafloor, the shallow unconformities and the geological structures. Based on these chirp profiles gravity cored were obtained in the studied areas. The chirp survey confirmed previous observations of a regional depositional unconformity in the upper part of the sedimentary sequence along the distal continental shelf. Earlier studies that encountered these features in their broadly-spaced profiles attributed them to coastal ridges. Aksu et al. [1] suggested that these coastal ridges indicate the slow ascent of the water level of the Euxenic Lake, the water body that preceded the present Black Sea.

Preliminary paleontological observations of the sediment cores displayed the unconformity encountered in the seismic profiles. The fossil fauna show evidence of brackish water fauna below the unconformity and marine shells above it. Uncalibrated measurements of ¹⁴C attribute an apparent age of ca. 25,000 years to the layer right below the unconformity and ca. 7,000 years to the layer above it. These findings suggest that there was a depositional break before sediment deposition under marine conditions started, and that the unconformity indicates subaerial erosion. Since the present depth of the Bosporus Strait is 33 m, the Mediterranean water breaching the Strait dropped to the brackish lake some 60 m below. Consequently we suggest that the glacial lake that prevailed in the Black Sea after the LGM desiccated in the early Holocene, like many other continental lakes, and when the Mediterranean water breached the Bosporus Strait a large waterfall of more that 60 m was formed, and the Black Sea was filled abruptly. Such a violent event has probably left its mark on human mythology [2].

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AN INTEGRATED ANALYSIS OF THE NILE CONTINENTAL MARGIN: FROM THE MOHO TO BEGGIATOA SP

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Abstract

Less than 10 years ago the Egyptian continental margin off Nile delta was an almost unknown margin segment, only investigated, along its uppermost continental slope and shelf, by oil/gas companies, and crossed in its deepest part by sparse data. In the frame of the French margin program the marine team of Geosciences-Azur has initiated, in late 1998, a systematic study of this area with the aims to better image and understand the various tectonic, sedimentary, geochemical and environmental processes which have shaped this margin segment and are still operating on the sea floor.

Keywords : Continental Slope, Nile, Eastern Mediterranean.

An initial survey, Prismed 2, in 1998, provided the first detailed swath bathymetric maps based on data recorded by an EM12D swath system, of the Nile deep sea fan, huge sedimentary construction which results from the deposition, trough Plio-quaternary times, of thick clastics transported by the Nile, the world's longest river [1-2]. After Prismed 2, 8 successive marine geophysical/geological/biological cruises have been carried out between 2000 and 2006.

In 2000 Fanil cruise operating an EM300 swath system, was chiefly devoted to investigations of active sedimentary processes (turbidites, unstabilities), salt gravity tectonics, and allowed to discover many fluid-releasing features such as pockmarks, gas chimneys, and at the foot of the continental slope tens of mud cone and mud calderas. The data completed the systematic morphological mapping of the Nile margin [3-5].

In 2002, a MCS survey, Medisis, has recorded using a long offset digital streamer (4.5 km) and an array of 10 air guns, about 2000 km of regional lines; these data have imaged the deep geological structures of different morphological provinces up to depth of 25 km [6]. Interpretation of the data and modelling of gravity anomalies, support that the deep fan is built on a stretched continental crust covered by an excess of 12 km of sediment, including thick Messinian evaporites which may locally reach up to 3 km in thickness.

In 2004 Simed cruise has completed the sytematic swath bathymetry, gravity and magnetic mappings of large areas of the margin now almost entirely covered from water depth between 600 meters to the deep abyssal plain (circa 3100 meters). The same year a short cruise, Vanil, recovered 11 giant Calypso cores for a total sedimentary section up to 350 meters completing a set of 60 Kullenberg cores previously obtained.

In 2003 the first step of the ESF Euromargins Mediflux program cooperation between German, Dutch and French institutes, has lead to the Nautinil cruise using the scientific submersible le Nautile. 19 deep dives were performed on several fluid vents to investigate their activities and study their impacts on the deep sea geological and biological environments. Spectacular observations and sampling of active vents where brines and fluids are mixed were made on a deep mud caldera (3000 m water depth), upper slope gas bubbling chimneys were sampled and a few pockmarks were visited. In 2004 the Dutch Mimes survey provided near bottom sonar records on gas chimneys and some of the pockmarks, and demonstrated the presence of active gas plumes in the sea water. Bionil, conducted on the German RV Meteor has chiefly been devoted to in situ geochemical, microbiological and biological sampling using an ROV on targets mapped in details using an AUV equipped with a swath bathymetry system.

We present here the main results of the different surveys, made in an interdisciplinary approach, on the Nile continental margin.

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COMPOSITION OF HYDROCARBON GAS VENTING AT EASTERN MEDITERRANEAN MUD EXPULSION STRUCTURES AND THEIR DEEP ORIGIN

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Abstract

Mud volcanoes (MV's) are structures that can be found on land and on the seafloor at passive and continental margins. Eruptions are triggered by overpressure occurring at depth and resulting from decomposition of organic matter. Gas, fluids, and sediments are then mobilized and migrate along the sedimentary column, building mud domes [1,2]. Here, we present results of gas, carbon and hydrogen isotopic composition of migrating hydrocarbons as well as some essential elemental and isotope pore water data in order to highlight the processes involved, and to assess the origin of gases and water. Results will be presented from water and sediment samples collected at N.Alex and ISIS mud volcanoes during the NAUTINIL (Sept. 2003), and the MIMES cruise (May 2004) to the Nile deep-sea fan. *Keywords : Eastern Mediterranean, Geochemistry, Nile, Mud Volcanoes, Passive Margins.*

At all mud structures investigated, enhanced concentrations of hydrocarbon gases, namely methane, ethane, and propane, have been observed in the water column. These gas plumes can extend up to several hundreds meter above the seafloor and at shallow sites such as at North Alex MV, in the central part of the Nile fan (Fig. 1) [3,4]. Moreover, these gas plumes are associated with enhanced light scattering, which can be associated to the release of gas bubbles and/or sedimentary particles.

The original signature of the gases can be found in the deepest core samples. The gas content presents various wetness ratio $[\Sigma(C_2-C_6)/(\Sigma(C_1-C_6))]$, a parameter giving indications on the origin of the methane (bacterial vs. thermogenic). In association with the carbon and hydrogen isotopic composition of the hydrocarbons, these ratios indicate that at all mud volcanoes, methane is a mixture of bacterial and thermogenic origin, with a thermogenic contribution up to 65% in the eastern part of the Nile fan.



Fig. 1. Methane concentration and light scattering at North Alex mud volcano, central Nile fan.

At Isis MV, a camembert-like mud structure in the eastern Nile fan, large quantities of hydrocarbons appear to be recently released into the overlying water column. Commonly, the methane flux into the water column is controlled by anaerobic oxidation of methane (AOM) occurring in the sediment. During AOM, the anoxic methane oxidation and sulphate reduction, light methane is preferentially oxidized, leading to residual methane enriched in ¹³C and ²H.methane. This process is clearly visible at Isis MV at about 50 cm below the seafloor, where methane is enriched in ¹³C and ²H.methane. But interestingly, beside AOM, oxidation of heavier hydrocarbons also occurs. Indeed, propane and *n*-butane are also enriched in ¹³C and this enrichment occurs at the same depth as for AOM. Those hydrocarbons seem therefore to be efficient electron donors for sulfate reducing bacteria. Moreover, relatively to methane, propane and *n*-butane seems also to be preferentially oxidized, as suggested by the larger ¹³C enrichment observed in the AOM zone. Further analysis and

investigations are needed to better assess the processes occurring at gas seep related sites and will be one of the aims of the Bionil expedition in November 2006.

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ACTIVE TECTONIC ALONG THE NORTHERN MARGIN OF LIGURIAN SEA : EVIDENCES FROM SWATH BATHYMETRY AND HIGH-RESOLUTION SEISMIC

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Abstract

During the Malisar-1 cruise, a new structural map was established from detailed bathymetric survey and an extensive set of high-resolution seismic reflection or mud-penetrator profiles along the northern Ligurian margin between $7^{\circ}25W$ and $9^{\circ}10W$ of longitude. The preliminary results shows evidences of tectonic activity in the prolongation of active faults identified onshore, as well as along the major epicentral zones offshore, specially on the toe of the margin, in good accordance with the concentrations of present (1962-2002) seismicity. *Keywords : Bathymetry, Seismics, Ligurian Sea.*

The present seismicity along the northern margin of Ligurian Sea is moderate, but permanent, and several big earthquake (M>6) have been recorded in modern times (M=6.5, 1887, M=6, 1963; Larroque et al., 2001). Most of the epicenter have been localized offshore, on the margin, and could not be easily related to the known active or potentially active fault identified onshore. One of the major goal of the Malisar-1 cruise (swath bathymetry, high resolution seismic reflection, mud-penetrator) was to collect evidences of recent deformation offshore along the margin, at different scales. The preliminary results shows evidences of tectonic activity in the prolongation of active faults identified onshore, as well as along the major epicentral zones offshore, specially on the toe of the margin, in good accordance with the concentrations of present (1962-2002) seismicity.

- In the Western part of our study area (west of $8^{\circ}15^{\circ}$), the continental slope of the northern Ligurian margin presents a sharp and contrasted morphology, with numerous deep rectilinear canyons crosscutting the slope. Frequent oblique structures across these canyons could explain some of the great gravity sliding. The tectonic morphology of the toe of the slope is specially interesting, for example close to the canyon of Taggia : active or recent fault have been identified along this limit, geographically related to the concentration of epicenters (magnitude >5) of a 1985-1986 crisis. (Figure 1 : profile MR06-1, mud-penetrator). These faults could be interpreted as normal and possibly strike-slip faults. However, we have to take into account the significative presence of Messinian salt below this region, that could represents an important bias for the tectonic interpretation of the identified deformations.



Fig. 1. Mud-penetrator profile MR06-1, at the base of the continental slope off Ventimiglia. West is at the left of the image, line oriented $N80^{\circ}W$. Note the metric offset of the last horizons, below a 5m thick debris-flows.

- In the Eastern part of our study area (E of 8°15'), the continental slope is characterized by the presence of a massive NE-SW elongated promontory, off Albenga and Savona. The geographic pattern of the submarine canyons with a systematic eastward or northeastward deviation suggests that this promontory is recently uplifted. The base of the promontory is strongly deformed in the eastern part of the area, and crosscutted bt major, rectilinear N60° faults (Fig.2 : bathymetric map of the northern Ligurian margin). This recent, possibly active deformation is recorded in the sedimentation as imaged in our high-resolution seismic profiles ans appear to have occurred mostly during the Plio-Quaternary time.



Fig. 2. Bathymetric map (shaded relief) of the North Ligurian margin between $7^{\circ}25W$ and $9^{\circ}10W$ of longitude. Note the major N60° rectilinear fault at the base of the deformed margin.

This data together allow us to propose a better tectonic framework to analyze the distribution of seismicity of this area.

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MORPHOLOGICAL EVIDENCES OF RECENT SUBMARINE LANDSLIDES ON THE LIGURIAN MARGIN (NORTH-WESTERN MEDITERRANEAN): FIRST RESULTS FROM THE MALISAR CRUISE

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Abstract

The MALISAR cruise acquired in august 2006 new high-resolution data, including EM300 bathymetry and backscatter imagery, 3-5 kHz and seismic-reflection profiles, on the Ligurian margin, between Nice (France) and Genova (Italy). These data revealed the presence of numerous small- and large-scale failures related to high sediment supply coming from the Var and Paillon rivers or related to the presence of active faults.

Keywords : Ligurian Sea, Continental Slope.

Submarine landslides are the one of the major mechanism of sediment remobilisation and transfer from the slope to deep-sea environment [1-3]. Their main triggering mechanisms are usually earthquakes, fluid seepages or anthropogenic activity [4]. Submarine landslides occur preferentially in areas that present conditions prone to failure: sediment underconsolidation, high-slope gradient, high sedimentation rates, variability in the texture and physic-mechanical state of the sediment strata. When landslides occur in shallow water depth, they can also have a strong impact on coastal environments by generating tsunamis [5-6].

The Ligurian Basin experienced recently such a mass-wasting event: on October 16^{th} 1979, a failure involving about 8 x 10^6 m³ of material occurred in shallow-water depth during infilling operations related to the construction of the new Nice harbour [7]. Since 1975, at least 25 x 10^6 m³ of aggregates were deposited on the narrow shelf, at a water depth ranging from 10 to 15 m, to increase the surface of the airport in a seaward direction. The failure affected both under-consolidated silty-clayey deposits of the upper continental slope and some of the landfill aggregates. Eight minutes after the failure occurred, three successive waves, 2-3 m height, were generated and broke along the coastline between Nice and Antibes.

The Ligurian Basin has been frequently affected by earthquakes (four historical earthquakes in 1564, 1644, 1817 and 1887), and tsunamis (1564, 1817, 1887, 1979). Based on the 1979-event experience, earthquakes might have generated tsunamogenic failures on the Ligurian slope in the past.

To analyse the distribution of failures on the slope, and to study their triggering mechanisms and their relationship with tsunamis, the MALISAR cruise (august 2006) acquired EM300 multibeam bathymetry in the area between Nice and Genova, from about 100 m to 2500 m water depth, as well as 3-5 kHz profiles, and 24- or 72-multichannel seismic profiles. The dataset reveals numerous fresh scarps and mass-transport deposits involving several km³ of sediment. The second part of the cruise will take place in 2007, and will collect SAR (side-scan sonar) and AUV data, as well as cores over the whole area.

Offshore the Nice city (France), mass-wasting events mainly affect the upper part of the slope, in areas close to the Var and Paillon river mouths, where volume of fresh sediment delivered by rivers is the highest. Small-scale failures (<100 m wide) are mainly located near the shelf break; they are the most abundant type of failures and are restricted to the uppermost layers (up to 10 m) of slope sediment. Larger-scale failures (up to 400 m wide) are located deeper on the slope and they affect deposits over greater thickness (up to 40-50 m). Smaller failures mainly result from the underconsolidation state of slope sediment during periods of high sedimentation rate, while the triggering of larger failures probably requires an external constraint such as an earthquake-induced acceleration of the seafloor.

Between Nice (France) and Imperia (Italy), failures are several kilometres wide and affect slope deposits over 100 to 300 m. They are located near the base of the slope, between 1300 and 2000 m of water depth. One of the most impressive scarp is located in the epicentral area of the 1887 earthquake. The location of failures is controlled by the presence of nu-

merous active faults related to the salt tectonic affecting the basin or of deeper crustal origin.

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MINERALOGY OF RECENT BRYOZOANS (*PENTAPORA FASCIALIS*) FROM DIFFERENT ENVIRONMENTS IN THE ADRIATIC SEA

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Abstract

Pentapora fascialis bryozoans, collected from 3 different sites in the Adriatic sea, were investigated by x-ray diffraction and scanning electron microscopy. Their skeletons consist of calcite and aragonite, in differing percentages. Compositional variation reflects possible differences in habitational environment.

Keywords : Adriatic Sea, Bryozoa, Mineralogy.

Pentapora fascialis [Pallas 1766] is the largest and most conspicuous calcified bryozoan in the Adriatic Sea. It is common in current-swept coarse bottoms. Colonies are mostly red, erect, rigid and heavily calcified (Fig. 1).

Three different samples of bryozoan *P. fascialis* were collected at three different localities in the North, Central and South Adriatic: in the Velebit Channel (Zdralova cove) from 10 to 20 m depth, on Jabuka shoal from 40 to 50 m depth and at Korcula Island (Lucnjak Islet) from 20 to 35 m depth. The samples were collected by scuba diving and dredging between August 2001 and April 2004.

Colonies of collected bryozoans are different in shape and size, but there is no visible difference in the structure and morphology of zooids from different colonies.

Along the coast of the Velebit Channel in the North Adriatic, large colonies of *P. fascialis* were particularly abundant. There, *P. fascialis* colonies grow only in the vicinity of submarine freshwater springs on sandy-detritic bottom, between 1 m and 35 m depth. Those colonies are always widebranched and are, without any doubt, the biggest colonies ever found in the Adriatic, up to 200 cm in diameter [1].

On Jabuka shoal, in the Central Adriatic, only small and narrow-branched colonies (10 to 20 cm in diameter) were observed, within the depth range from 20 m to 50 m.

But large colonies of *P. fascialis* were also observed in the South on Korcula Island where the location was narrow passage between small islands Badija and Lucnjak characterized by constant and very strong currents. There, large and numerous colonies of *P. fascialis* (50 to 80 cm in diameter) grew in both forms, as wide- and narrow-branched colonies. Every sample was cleaned from organic matter and investigated by X-ray powder diffraction combined by scanning electron microscopy.



Fig. 1. Colony of Pentapora fascialis from the Adriatc sea.

All three samples show that their skeletons are built of a mixture of calcite and aragonite. The sample from the vicinity of Jabuka shoal contains the highest percentage of aragonite while two other samples show very similar and lower aragonite to calcite ratios. The reason for these differences probably derive from differences in the habitat environment or from specific differences in organic production.

Unit cell parameters for calcite show that the purest end member calcite is formed in bryozoans from the Jabuka shoal colony (a = 4.945(2) and c = 16.92(2) A), while unit cell dimensions of the other two samples Zdralova (a = 4.941(3) and c = 16.83(2) A) and Korčula (a = 4.943(1) and c = 16.851(9) A) indicating significant substitution of calcium for magnesium.

These differences in mineralogical composition of recent skeletons of bryozoans can be most probably attributed to different physical-chemical conditions pertaining to their habitat environment. The differences may also originate from the geological environment, since the Jabuka shoal is built of igneous rocks which are not very common in Adriatic Sea.

The differences in temperature and salinity probably caused different forms and sizes of colonies.

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GEOPHYSICAL INVESTIGATIONS AT BOSPHORUS OUTLET

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Abstract

Ongoing arguments about the origin of the reconnection of Black Sea and Mediterranean Sea with the rising sea level after the last glacial period raised scientific interest at Black Sea and Marmara Sea. The opening of Bosphorus played an important role on the present day sea level of Black Sea. There are many scenarios about the history of Bosphorus. Relative sea level changes in Black Sea are affected by Bosphorus Strait passage, exchanges in fresh water supply and neotectonic factors so it is important to investigate the connection point of Bosphorus and Black Sea both geologically and geophysically.

Keywords : Bathymetry, Continental Slope, Mud Volcanoes, Bosphorus.

In recent studies, it is assumed that a rapid flood could occurred in Holocene [1]; [2]. In 1997 Pitman and Ryan suggested that the Black Sea became a giant fresh water lake during the last glacial maximum, with water level standing at -150 m, and that during the post-glacial sea level rise at 7.15 ka and Mediterranean Sea breached the strait of Bosphorus catastrophically re-filling the Black Sea basin [3]. This hypothesis is contradicted by Aksu et al , who suggested that it was instead the Black Sea that first breached the Bosporus and overflowed into the Marmara sea during early Holocene [4]. The most prominent physical evidence of the controversial Outflow hypothesis is the existence of 9-10 ky aged delta lobe at southern exit of Bosporus in Marmara Sea [5].

In August 2002 on board R/V Le Suroit a survey provided bathymetric data (Figure 1) using EM 300 multibeam echosounder and 3.5 kHz Triton Elics Chirp Sonar data. The purpose of the survey was the investigation of the effects of Bosporus strait, changes in fresh water supply and neo-tectonic factors on sediments depending on relative sea-level changes. Acoustic imaging of sea floor allowed to identify continental shelf incision and continuation of the Bosporus strait to the Black Sea. A tributary canyon system, composed of many feeder canyons merging with one or two main canyons, was revealed. Two or more recent canyon heads can be traced landward on the shelf which are trending in W-E direction probably following tectonic direction.

A prominent retrogressive submarine canyon dissects the continental slope together with numerous smaller canyons and gullies, giving the impression that it was once linked to the Bosphorus (Figure 1). Two or more recent canyon heads can be traced landward on the shelf. Erosional surfaces at the upper parts of the canyon walls indicate recent activity. Retrogressive erosion on the steeper V-shaped sections of canyon head cause landward expansion of the canyon head. The canyon heads are directed west-east and the paths of canyons are probably guided by local tectonic structures. Chirp Sub-bottom Profiler profiles demonstrate paleochannels which indicate that the canyon heads were located in an area of high sediment supply during the last low levelstand of Black Sea. In the northwestern part of the study area profiles show some interesting features which have been interpreted before as mud volcanoes [5]. They exist only on the western shelf at 100 m waterdepths. Gas and fluid-related features observed on the shelf, include acoustic turbidity, acoustic columns. First 6m of the piston core, that was taken from the northwestern part of the same canyon area during Assemblage survey on board R/V Marion Dufrense was totally deformed by gas existence. Besides, gas and fluid-related features observed on the shelf.

Also TTR 15 cruise in June provided 5.1 kHz Sub Bottom Profiler data and 9.5 kHz Long Range Sonar data (Okean) acquired at northwestern toe of the canyon system of the previous study. An unnamed new mud volcano was discovered. And for the first time at Bosporus outlet gas hydrates were recovered in the cores. High backscattering lineaments indicate the canyon axes which are the continuation of the canyon system in the previous study. In addition, some high backscattering zones are interpreted as recent mud breccia. Also mud breccia recovered in the cores indicate that the feature is a mudvolcano.



Fig. 1. 12 kHz Multibeam Echosounder data showing 3D bathymetric map of continental slope.

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HIGH RESOLUTION BATHYMETRY OF THE MEDITERRANEAN OFF NORTHERN ISRAEL

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Abstract

A new poster, based upon high resolution multibeam sonar surveys, shows the bathymetry of the Mediterranean continental shelf and slope off northern Israel. The image reveals in detail many features of the offshore. On land, hill shading of an orthophoto image allows visual continuity between the terrestrial and submarine morphology. The posterscale is 1:50,000. *Keywords : Bathymetry, Continental Margin, Eastern Mediterranean, Levantine Basin, Swath Mapping.*

The bathymetry of the Mediterranean off northern Israel is shown in this poster at 1:50,000 scale. The offshore is based upon over 850million soundings from multibeam sonars. Water depths from about 8 m toover 900 m result were mapped by the Israel National Bathymetric Survey, a joint undertaking of the Geological Survey of Israel (GSI), the Israel Oceanographic & Limnological Research Ltd. (IOLR), and the Survey of Israel (SOI). The survey was carried out between 2001 and 2006 by the IOLR's 48' vessel R/V Etziona using a Kongsberg Simrad EM1002 multibeam sonar. The EM1002 has 111 2° beams operating at 96 kHz spread over an arc of up to 150°, giving maximum swath coverage of up to 7.4 times the water depth. The survey involved some 4,218 km of track.

Further offshore F.S. Meteor Cruise 52/2 in 2002 obtained partial coverage in deeper waters with an Atlas Hydrosweep system operating 60 beams at 12 kHz over a 90° arc. Additional data was available in detailed (5 m) contour maps of the landing of the SEA ME WE 2 fiberoptic cable extending from Ayia Napa, Cyprus, to Nahariya in Israel. Ifremer's vessel N.O. L'Atalante surveyed this route in 1992 with a Simrad EM12D system. Other holes were interpolated using soundings from the 1970s reconnaissance work of the GSI. The vertical exaggeration of the gridded bathymetric data is 6 times.

On land Global Mapper software used the Survey of Israel's 4 m Digital Terrain Model (DTM) to shade their 1 m orthophoto. The illumination is from the northwest (N315°E) at 45° altitude with a vertical exaggeration of 2. Image scale is 1:50,000 on the Universal Transverse Mercator (UTM) Projection (Zone 36), withWGS-84 datum.

The image shows the sweep of the northern Israel coast from HaHotrim in the south to Rosh Haniqra in the north. The low-lying Zevulun Valley and its extension, Haifa Bay, separate the western promontory of Mount Carmel, cut by numerous ravines, from the Coastal Plain of the western Galilee. This coastal plain is crossed by a number of rivers whose continuations can be seen in the offshore.

The continental margin off northern Israel shows the interplay between past global sea-level changes, long-shore sedimentation, and tectonics. The coastline is paralleled by a number of carbonate-cemented quartzsandstone (kurkar) ridges. In the north these rise above sea-level and form eight small islands. In deeper waters there are several raised platforms, some exhibiting curving dune-like bedforms, perhaps of current or eolian origin. The shelf-break occurs at around 100 m depth, and beyond this many canyons carry sediment out to the deep sea. The prominent Carmel Nose is an extension of Mount Carmel across the shelf. The Western Galilee is cut by a number of E-W trending faults. Offshore these define a series of raised and sunken blocks, and appear to provide preferential courses for the rivers as they breach the kurkar ridge system. A number of straight or curvilinear trends appear to result from tectonic activity, and may be related to normal faulting. Opposite Haifa Bay, in water depths of 30 m, a broken-up area called the "Brittle Sheet" was mapped, and may also have a tectonic origin. In the far north, the steep Akhziv Canyon cuts deep into the continental margin. The entire shelf and slope is marked by numerous shallow pits and slightly raised mounds.

ACOUSTIC BACKSCATTER AT 95 KHZ FROM THE SEAFLOOR OFF NORTHERN ISRAEL

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Abstract

A new poster shows the acoustic backscatter as determined by innovative analysis of the returns from high resolution multibeam mapping of the Mediterranean continental shelf and slope off northern Israel. The backscatter received by a Simrad EM1002 sonar system was reanalyzed using the new Geocoder software developed at the Center for Coastal and Ocean Mapping (CCOM) at the University of New Hampshire in the USA. The poster is at 1:50,000 scale on a UTM projection. This poster appears on the backside of a laminated poster showing the bathymetric results.

Keywords : Acoustics, Swath Mapping, Continental Margin, Levantine Basin, Bathymetry.

A new poster prepared for mass distribution presents an image of the acoustic backscatter of the Mediterranean continental shelf and slope off northern Israel.

Technical Details

Offshore: This grayscale image of the seafloor is based upon the acoustic backscatter at 95 kHz obtained with a Kongsberg-Simrad EM1002 multibeam sonar system. On each swath, the EM1002 measures around 4,000 samples of the backscattered acoustic energy returning from the 111 2 degree beams impinging on the seafloor. Thus the 840 million soundings in the bathymetric survey represent about 7.5 million swaths, with over 40 billion backscatter samples.

The Geocoder software package (Fonseca and Calder, 2006), introduced at a two-day workshop (23-24 August 2006) at the Center for Coastal and Ocean Mapping at the University of New Hampshire (CCOM-UNH) in Durham, NH, USA, was used to process these measurements to produce a uniform representation of the acoustic backscatter in reproducible decibels (db).

Geocoder corrects the original backscatter time series registered by the sonar for angle, varying gains, and beam pattern. It filters out speckle and corrects for slant range. Every backscatter sample is geocoded using several algorithms, which apply anti-aliasing, mosaicking, and blending between swaths. The final mosaic exhibits low noise, few artifacts, reduced seams between parallel acquisition lines and reduced clutter in the near-nadir region, while still preserving regional data continuity and local seafloor features. The mosaic resolution here is 5 m, tied to the underlying bathymetric grid. Resolutions as high as 25 cm are possible inshore. Lighter regions represent higher backscatter. The original mosaic image has been contrast-stretched using Adobe PhotoShop, but this is reflected in the accompanying decibel scale.

Land: The Survey of Israel's 1:50,000 scale topocadastral map sheets are reproduced on land in Hebrew. They are texturized with the Survey's 4 m digital terrain model (DTM) using Global Mapper software with the sun in the northwest (N315E) at 45 degrees altitude and a vertical exaggeration of 2.

Map Projection: The image is at scale 1:50,000 on the Universal Transverse Mercator (UTM) Projection (Zone 36), on the WGS-84 datum.

Acoustic Characterization of the Offshore:

Kurkar ridges: The kurkar ridges show the higher backscatter. This is a result of their relative hardness, as well as the roughness of the biological growth that blankets them. Of note are the meanders and inter ridge areas with lower backscatter, representing channel bed deposits, softer sediments, and generally smoother seafloor.

Sedimentary facies: Areas of higher backscatter in deeper waters beyond the kurkar ridges on the shelf south and west of the Carmel may be related to the higher percentage of coarser sand within the sediments. Opposite the Zebulun Valley and beyond the ridges within Haifa Bay the backscatter is lower, likely related to the finer silt and mud fraction. Farther north, higher backscatter appears to be related to the slightly uplifted platform.

Dune-like bedforms on the outer shelf: The areas of dune-like bedforms and the northernmost Shaal Ridge have slightly higher backscatter, possibly related to induration and roughness.

Brittle Sheet Area: Within the so-called broken 'Brittle Sheet' area 8 km

NNW of the Carmel Cape, high backscatter is associated with the lows, and low with the upraised blocks. The topography here is around 2-3 m. Note the distinct NNE trending demarcation between high backscatter on the west and lower backscatter on the east.

Bulls' Eyes: Northwest of the Brittle Sheet area, within a triangular zone, more than 100 circles of high backscatter are visible. These are from 30 to 120 m in diameter; a few are associated with a subdued crater-like topography. These may be areas of gas or fluid seepage.

Man's activities: Opposite Haifa Port at depths of 10-12 m, just south of the kurkar ridges, brighter areas stand out. These are likely dumpsites of material dredged from the port. East of the Brittle Sheet area, a mottled zone may show much older material dumped during major port expansions. Parallel low contrast brush-like strokes farther to the west may indicate the marks of fisherman's bottom trawls.

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FOSSIL CARBONATE CHIMNEYS DISCOVERED IN LOWER PLEISTOCENE MARINE SEDIMENTS OF SOUTHERN PELOPONESE, GREECE

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Abstract

Herewith we report the first discovery and sampling of a field of fossil, non volcanic, carbonate chimneys at the coasts of Neapolis, Lakonia region in South Peloponese, Greece. Several hundreds of weathered but still erosion-resisting, pipe like chimneys, up to 2.5m high, rise vertically through marine Lower Pleistocene sediments. X-ray diffraction and X-ray fluorescence analyses yielded calcite composition for the chimneys tubes and siliceous composition for the orifices infill. Although the origin of the chimneys is not yet clear, we strongly suggest that they are associated with methane related cold seepages in the extensional basins of the Hellenic Forearc. *Keywords : Hellenic Arc, Mud Volcanoes.*

Introduction

Cold seepages and related features (mud volcanoes, gas chimneys, authigenic sedimentation) have been reported and studied from modern submarine environments worldwide and the Mediterranean region particularly. Onshore active mud volcanoes occur in the northern Apennines while ancient seep/vent formations of various ages are known from the Appenines, the Moroccan Rif Belt, Algeria and the Middle Atlas[1]. Herewith we report the discovery of a vast field of carbonate chimneys and related structures, possibly associated with fluid seepages of non volcanic origin, in marine Pleistocene deposits of Southern Peloponese, Greece. The field is located along the shoreline of Agia Marina bay at the southern coast of Maleas Peninsula, south west of Neapolis town.

Field Observations and Laboratory Analyses

Marine pelites of Lower Pleistocene age form the low coastal area of the Agia Marina bay and are being locally overlain by biogenic carbonate formations or stromatolites. The Quaternary deposits may be as thick as 250-300m and cover unconformably alpine deformed, Triassic-Jurassic limestones [2]. On flat wave-cut terraces, developed parallel to the bedding planes of the pelites at 1-2m above the sea-level, pipe-like, upright standing, up to 2.5m high and 1m in diameter chimneys show a wide range of morphological types (cylindrical, conical, mushroom-like and mounded) and form a spectacular field, which covers an area of about 200x2000m or more (Fig.1& 2). Similar morphological types of chimneys have been reported from the Gulf of Cadiz [3]. Local people call Agia Marina field petrified forest but the positive structures are of carbonate composition and there is no evidence supporting this characterization. The chimneys are composed of hard but weathered, several cm thick, whitish, carbonate tube. The central orifice of the chimneys is filled up with dark grey, argillaceous material with numerous whitish, mm-thin, carbonate veins. Concentration of fossil biogenic communities composed of cm-large bivalves, echinoids and worm tubes occur together with the chimnevs.



Fig. 1. View of cylindrical chimneys in Lower Pleistocene pelites of Agia Marina, Greece



Fig. 2. Close view of conical carbonate chimney in the Agia Marina field.

The latter are commonly aligned on vertical E-W or NE-SW trending fractures sealed also by carbonate material and mm-thick veins, indicating that tectonic elements may have controlled the development of the chimneys and have been used as conduits for the upward fluid flow. Samples were taken from the least weathered chimneys and veins which seal the fractures. The bulk mineralogy was determined using X-ray diffraction (XRD) on powdered samples. The bulk rock chemical composition and major and trace elements were analyzed by X-ray fluorescence. The tube of the chimneys and the thin veins are mainly composed of calcite with subordinate quartz, while the significantly weathered fill of the orifices displays siliceous composition and muddy character.

Discussion

The impressive Agia Marina field of carbonate chimneys provides insights into the geodynamic regime of the sedimentary basins developed along the Hellenic Forearc in Lower Pleistocene. It implies new considerations on the importance of cold seepages and eventually the role of possible mud volcanism in post-alpine basins of the Hellenic Orogenic Arc.

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THE SPANISH CONTINENTAL SELF AND UPPER CONTINENTAL SLOPE CARTOGRAPHY

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Abstract

It is being carried out a systematic study of the Spanish Continental Shelf and Slope seafloor characteristics (ESPACE project) with multibeam (EM-3000D), very high resolution seismic profiles (TOPAS), sediment samples and video-TV record. The work methodology and standards have been designed from a Geographic Information System (G.I.S.) point of view, to help the management and interpretation of data. The main result has been the first Systematic Cartographic Series about this area with very high resolution information. This Cartographic Series consists of 171 sheets at 1:50.000, with land and marine information. Each sheet is made up of 3 series: a) description of the marine environment, b) management of the marine environment and c) 3D models and geomorphology. At this moment have been published 7 sheets at SE of Spain. This work presents the first cartographic results of ESPACE project, that help to know and to characterize the geomorphological, lithological features, etc. as well as to help marine activities in this area. *Keywords : Swath Mapping, Geomorphology, Alboran Sea*.

Since 1999 the Instituto Español de Oceanografía (IEO) and Secretaría General de Pesca Marítima (SGPM) has been carried a systematic study of the Spanish Continental Shelf-and-Slope seafloor characteristics with the ESPACE project [1], with the objective of having appropriate information with high precision to carry out a good management of this area that has a great economic importance, as well as to know possible natural risk zones and the recent variation with human activities or climatic change.

Between 2000 and 2005 the SE and part of NE Continental shelf and upper continental slope of Spain has been explored at 100 %, from -8 m to 140 to 160, with multibeam echosounder (EM3000 dual) to collect the bathymetric and backscatter data, as well as with seismic of high-resolution (TOPAS PS-040) and has been collected sediment samples, photo and T.V. submarine, to investigate the stratigraphy, geomorphology, thickness of the recent sedimentary deposits, phanerogames meadows, etc. A specific methodology [2] has been designed from the collecting, organization and management of the data to the incorporation in a Geographic Information System (G.I.S.) [3], being defined the name of the files in each moment the acceptable tolerances in the treatment and the output formats adapted for its integration in the G.I.S.

Main results

a) The design of a high resolution cartographic marine project, from the point of view of their administration and handling with GIS, it has implied to define a detailed work methodology and standards from the planning of the marine survey, to data acquisition, processing, management, organization and presentation.

b) The development of a working methodology that allows comparing phenomena and characteristics in the time and the space.

c) Generation of a high quality and standardized database of the seafloor of the Spanish continental shelf and slope, organized in the Marine G.I.S. (S.G.P.M. - I.E.O.)

d) To elaborate a thematic cartography about the Spanish continental shelf and upper slope, in which are integrated the characteristics of the terrestrial and marine environment. This cartography plan consists of 171 sheets, in WGS84 reference system and UTM projection, each one presents 3 series: Serie A. (Descriptive of the marine environment, scale 1:50.000). This map shows 2 meters-equidistant isobaths, textural classification of the seabed and a schematic bionomic cartography. On land show the recent quaternary deposits classified by sedimentary environment, topography equidistant 100 meters, beaches, hydrography, administrative limits, the situation of lighthouses, highway and urban nucleus (Figure 1).

Serie B. (Management of the marinates environment, scale 1:50.000), This map show 5 meters equidistant isobaths, to aggregated textural classification of the seabed, seagrass meadows classified by species, fishing areas, Marinate you Reserve, LICS (Comunitary Interest Sites), Natural protected Sites, artificial reefs, devices of traffic separation, anthropogenic elements (jetties, pipelines, cables, dredged areas, shipwreck, etc.). The situation of lighthouses and beaches, land topography equidistant 100 meters, the recent quaternary deposits classified by sedimentary environment, hydrography, highway, administrative limits and urban nucleus are shown. Serie C. (Models and geomorphology), it presents 3 maps to scale 1:100.000, geomorphology, model of illumination or 2.5D and slopes, and 4 figures of 3D- view.

e) This cartography will help at all sectors with interests in these areas and allow to have an element of great help for the integral management of the coastal area and continental shelf and show the variety of the relief, the superficial geology, different types of sediments, and sedimentary bedforms generated, etc..





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SEAFLOOR MAPPING AND ACOUSTIC GEOPHYSICAL DATA OF A SHALLOW LIKELY MUD-VOLCANOES PROVINCE OFFSHORE SICILY (EASTERN SICILY CHANNEL - HYBLEAN- MALTA PLATEAU)

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Abstract

A detailed acoustic geophysical survey has been performed on R/V Universitatis, covering a part of the Hyblean-Malta plateau few miles offshore south-eastern Sicily, during the first cruise within the framework of the National Prin project MESC (Mud volcanoes Ecosystem study - Sicily Channel). The survey was carried out to map several shallow seafloor features with acoustical proprieties such that they could be interpreted to be Mud Volcanoes (MVs). Their morphologies, peculiar arrangement on the seafloor and geological setting are here presented.

Keywords : Acoustics, Mud Volcanoes, Continental Shelf.

MVs are the morphological expression of a process initiated deep in the sedimentary succession and resulting in the emission of gas, water and sediment on the earth's surface or the seafloor [1, 2]. Research on MVs in Mediterranean sea had focused mainly along the Mediterranean Ridge accretionary complex in deep sea water [3, 4], while our study investigates a relative flat area at shallower depth (between -140m and -170m) hosting numerous recently discovered [5] high backscattering seafloor features settled on the Hyblean-Malta plateau. The survey track lines were performed by different types of geophysical devices (100-500 kHz side-scan-sconar, 50 kHz multibeam echosounder, 2-9 kHz chirp sonar, 27-200 kHz echosounder and a multi-tip sparker) providing a detailed topography and a wide range of acoustical proprieties of the explored area.



Fig. 1. Multibeam map of a part of the study area, with some details from side scan sonar (A, B) and echosounder data (C) showing the backscattering proprieties and the different morphologies of the investigated seafloor features.

The investigated seafloor features revealed different morphologies, in particular they are few meter high (no more than 10m) and are arranged on the seafloor in two main different styles: 1) several conical features of 50 - 200m in diameter, preferentially aligned along the isobaths 2) numerous close-set small cones up to 10m in diameter, settled within well defined, flat, elongated areas (the largest one reaches 2000m in its long axis and 500m in its short axis) rising up to 10m form the seafloor. Furthermore, their raw acoustic reflection data (mainly from the singlebeam echosounder) show evidence of (gas?) plumes rising into the water column. Their morphologies, their strong acoustic scattering and their possible gas plumes are foremost distinctive proprieties that liken them to MVs.

Their easy accessibility, in comparison with deep-sea MVs, makes them an excellent natural laboratory to study in detail the ecosystem response to such geological phenomena. Their detailed acoustic mapping allows the planning of a focused future sampling, aimed to the collection of valuable geochemical, sedimentological and biological data.

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CRITICAL RESEARCH PARAMETERS AMONG HALOKINETIC PROCESSES ORGANIZING THE CILICIAN SALT-SEDIMENT SYSTEM, THE NORTHEASTERN MEDITERRANEAN

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Abstract

The dynamic evolution of the Cilician-Adana salt-sediment system and structural development is affected by salt tectonism and halokinetic regimes. Gravitationally unstable and asymmetric uneven overloading of frictional-plastic delta sediment progradation (Plio-Quaternary) above a viscous salt substrate (Upper Messinian salt) in the basin resulted in halokinesis and delta progradation-controlled prominent structures. Analyzing and parameterization of salt dynamics such as regional destabilization of salt, upward mass transport, dissolution, mobilization, migration, withdrawing, evacuation of salt, emplacement mechanisms of diapir growth, delta deformation pattern in the basin, and the resultant architecture of salt-sediment body styles are vital to understanding the history of salt structure formation, its geodynamic effects on structural evolution of the basin. Some quantifications of the dynamics controlling viscous-plastic regime of salt at the Cilicia back-arc region improved seismic data interpretations on basin analysis, and lead to critical research parameters among halokinetic processes.

Keywords : Diapirs, Evaporites, Messinian, Seismics.

The dynamics of salt tectonics in the Cilicia-Adana Basin has been recently investigated using seismic reflection profiling of a viscous substrate underlying a frictional-plastic sedimentary overburden of laterally varying thickness by ([1], [2]), geologically by [3]and seismic stratigraphically by [4]. Seismic reflection data collected by Graham Evans during the years of 1974-1977 and briefly reported by [2] illustrated a wide range of halokinetic structures and their evolutionary stages such as salt pillows and diapirs, salt dissolution structures, collapse-solution depressions, rim synclines, peripheral sinks, mini depocenters, secondary basins driven by salt-related thin-skinned tectonic processes.

The Cilicia Basin is tectonically unstable, due to halokinesis, back-arc sedimentary region with considerable evaporite deposits, and hence, dynamic modeling of delta sedimentation above a viscous salt layer in the basin consists of critical research parameters. Clues to the regime of halokinetic processes are found in these measurable parameters of the Cilicia basin. Based on a critical appraisal of the seismic survey and dynamic geology of salt systems, some parameters are also estimated for each of modern salt tectonic zones in the world. This work represents only a small part of research concept within salt-sediment dynamics and indicates the next investigations of margin tilting, basement and salt layer geometry, sediment-salt rheology, the hydrostatic pressure in the submarine environment, localized stress-strain fields, fluid overpressure within the sediments, isostatic effects, thermo-mechanical structure, low density mass transport, subsequent convectional properties of diapirism and evaporates. The conceptual and observational basics of all these important parameters can effectively influence the stability of regional halokinetic regime, delta overburden deformation, thus organizing a complete framework of salt-sediment system dynamics in the basin as follows;

Geomechanical Analysis; basement geometry and basal slope, the Plio-Quaternary delta overburden and upper Messinian salt layer geometry, salt withdrawal compensation (SWC), salt-sediment overburden rheology (friction, cohesion, strain softening etc.,).

Sedimentation and Sediment Physics; compensatory sediment loading (CSL), differential sediment thickness, delta progradation and its deformational effect on salt-sediment body architecture, the velocity and input ratios of episodic sedimentation, mini-depocenters, and physical properties of sediments.

Chronization and Distortion in Folding Styles; syn-/diachronized folding of salt-sediment body styles and time relationships between sediment influx and the main salt stock (mother salt) as feed back process.

Thermo-mechanical and Hydrological factors; thermal evolution of halokinetic structures, salt-pore water convectional process, deformation-fluid flow interaction, salt upwelling rates (low density mass transport), salt dissolution-karstification and correlative basin dating with other salt basins and hydrocarbon maturation.

Buoyancy Factor and Deformation Styles; brittle or viscous deformation of buoyant diapirs (the controversial problem of buoyant salt diapirism),

viscosity contrast, differential stresses (stress state-strain rates), and creeping or faulting. Buoyancy levels (positive, negative, neutral) of diapirs, subsurface erosion and removing of topographic relief induced by diapir swells.

Abnormal Pore Water Pressure; pore water overpressure fluctuations both in salt deposits and also sediments, spatial and temporal variations in fluid overpressures, the strong effect of diapirism as pressure seals (or trap/confinement mechanism) on basinal stress, strain and strength relations and local mapping of differential high strain fields in the basin.

Hydrodynamics; high density-salinity brine pools on the sea bottom and their residence, indicating deep water current system and saline conditions (stagnant or unstagnant).

Regional Tectonism; superimposed and contrasting regimes of thin and thick-skinned tectonism. *Isostasy;* flexural isostatic compensation (e.g., Adana flexural delta platform system), and rapid graben subsidence as a regional response to extensional block faulting or vertical differential movements in the basin. *Eustasy;* effects on delta sequence stratigraphy, facies analysis and tectono-/sedimento-eustatic relations between fluctuating sea level and upward diapir growth-lateral salt flow.

As petroleum exploration becomes increasingly focused on the Mediterranean deepwater evaporite basins, insight into these parameters driving salt-sediment dynamics will be useful in constraining the timing of salt development and also the implications this has for overburden deformation, salt-sediment distribution patterns and hydrocarbon maturation.

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THE SEISMICITY AND ACTIVE FAULTING AROUND THE GULF OF GöKOVA IN THE SOUTHWESTERN TURKEY

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Abstract

The Gökova region is a part of the western Anatolia-eastern Aegean Sea area, which is under the N-S regional extensional tectonic system. This tectonic framework of western Anatolia comprises E-W and WNW-ESE oriented grabens, associated with the regional north-south extension of the Aegean plate. These active faults are generating numerous great earthquakes for many thousand years. Epicentral distribution of the earthquakes extending in the Gökova region shows a relatively high seismic activity in the northern part of the Gulf. Younger active faulting, which was never mentioned before in literature except Uluğ et al. (2005), called Gökova Transfer Fault trends NE-SW direction in the central part of the Gökova Basin and records sinistral strike-slip motion broadly parallel to the convergence direction of the Aegean-Anatolian and African plates.

Keywords : Aegean Sea, Seismics, Tectonics.

Introduction

The Gulf of Gökova lies in a very important region by the reasons of the seismicity and morphotectonic features in Türkiye (see Fig. 1). The Gulf is located in one of the geologically most active parts of southeast Aegean Sea - southwest Anatolia that includes the major rifts and grabens. The Gulf of Gökova is bordered by Datça Peninsula to the south, the island of Kos to the west and Bodrum Peninsula to the north. The Gökova region is a part of the western Anatolia - eastern Aegean Sea area which is under an N-S regional extensional tectonic system [2]. The imprints of this extensional regime are clearly seen in the geology and geomorphology of western Anatolia.



Fig. 1. Seismotectonic map of Gökova Region.

Results

High resolution seismic reflection data from the Gulf of Gökova (southeast Aegean Sea) were interpreted in this study and suggested the late Quaternary tectonic subsidence in the northeastern slope of the basinis about 0.3-0.4 m/1000 yr and is probably related to basement graben structures [3]. The Gulf of Gökova is opened mainly by the E-W-oriented, buried Datça Fault located at the south and its antithetic faults located at the north. The Datça Fault might have begun to work in the Latest Miocene-Pliocene. In terms of local rather than regional effects, its activity has been decelerated, possibly since the Pleistocene. The continuing extension in the area may have initiated a second phase of faulting, e.g., WNW-ESE-oriented sub grabens in the central gulf and major WSW-ENE normal faulting at the northwest margin.

Overall fault pattern of Gulf of Gökova shows an important difference between the western and eastern parts of the basin. It is proposed that central trough and a submarine canyon are the part of a probable NE directed left lateral strike slip zone, called Gökova Transfer Fault (GTF) [3]. WNW-ESE trending central trough and E-W directed Datça fault correspond to an-apparent left-lateral offset of the continental slope edge. Left lateral offset is also clearly visible in Lower Miocene rock and this is probably the continuation of NE directed GTF on land. A recent proposal is that a series of earthquakes was produced by GTF zone.

This fault pattern convenient to seismic reflection profiles indicating the major faults can explain the occurrence of great historical earthquakes creating destruction on many ancient cities. Gökova Basin has been tectonically subsiding as a result of fault shift inside this fault zone. The seismic risk of Gökova Gulf in the northern part is higher than in the southern part and this active basin associated with strong earthquakes may continue producing widespread destruction and coastal subsidence.

By now, about 70 serious earthquakes in the southwestern Anatolia occurred beginning at 2100 BC. Some of these earthquakes occurred between Kos and Rhodes Islands. Likewise, earthquakes may have been responsible for the final abandonment of the Cnidus city lying in a seismically active area [1]. Over 25 earthquakes causing damage occurred in the area between 1400 and 1990; in addition,1493 earthquake destroyed Bodrum town. It was assumed that earthquake activity of the Gulf of Gökova and surrounding region occur on the E-Woriented faults. On the contrary, earthquake activity began at 03/04/2006 developed NE-SW oriented Gökova Transfer Fault zone and not on the E-W direction fault system.

The continuous tectonic movement of the southeastern Aegean Sea and its surrounding area was always important and it is necessary to keep on research on the subject to determine characteristics of the area.

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RIVER SEDIMENTS AS A TRAP FOR METAL POLLUTANTS

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Abstract

The efficiency of river sediments to scavenge heavy metals released from industrial waste (slag) was tested in this work. Sediments and water were sampled from the River Deûle canal (northern France). The concentrations of Pb, Cd, Zn and Cu measured in river sediments were 10 to few hundreds times higher than the background values. Slag particles were composed mostly of Al, Fe, Ca, Mn, Zn, Pb, Cd, Cu and Cr and in contact with river water they released high concentrations of Pb, Cu and Cr. When sediments were added to the river water - slag mixture, the remobilization of those metals was not so expressed. As it were, in spite of the high metal pollution level, sediments have shown the ability to adsorb metals released from slag under the conditions provided. *Keywords : Sediments, Metals, Pollution.*

Introduction

Metallurgical industries in northern France produce thousands tons of metals yearly and consequently, large amounts of potentially dangerous wastes. This material, improperly stored, can spread to the environment and affect the quality of the water, soil and air, and endanger the health of the population. In such cases, the role of sediments in removing toxic metals from water is of great importance.

Experimental

Sediments and water used in experiments were sampled from the river canal, about 2 km downstream from the lead and zinc smelter, and slag was obtained from industrial waste depot. Prior to experimental work, sediments were dried under laminar flow and river water was filtered through a 0.45 μ membrane. The total concentration of metals in sediments, water and slag was measured with ICP-AES or ICP-MS.

Three sets of remobilization experiments were then performed: 40 g of (i) sediment, (ii) slag and (iii) slag/sediment mixture was dispersed in 4 dm³ of river water. The rate of metal release was checked in different time intervals during 48-hour experiments. For that purpose, 10 ml of suspension was taken from the bulk suspension and concentration of metals was measured.

Results and conclusion

The total analysis of metals in sediments, water and slag revealed high concentrations of lead, cadmium, zinc and copper. The concentrations of Pb, Cd, Zn and Cu measured in river sediments were 300, 800, 50 and 15 times higher, respectively, than the background values (1). The concentrations in water were also much higher than the world average (2), while slag contained 59, 22, 0.64 and 0.005 g kg⁻¹ of Zn, Pb, Cu and Cd, respectively.



Fig. 1. Pb remobilization from slag, sediments and slag-sediments mixture.

The results of remobilization experiments showed that slag, in contact with river water, released high concentrations of Pb, Zn and Cu. Compared to the concentrations of metals released from slag, concentrations desorbed from sediments were not very high. On the contrary, sediments adsorbed some of the metals initially present in river water. When slag and sediment were mixed together, the concentrations of metals measured (*i.e.* released) were higher than those released from sediments only, but much lower than those released from slag. The results obtained (Fig. 1.) presents the case of lead) indicated that sediments, although highly polluted, seemed to be capable of adsorbing metals released from slag.

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Comité 2

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Physique et climat de l'océan

Président : Jordi Font

DOES THE MID-MEDITERRANEAN JET EXIST?

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Abstract

The Atlantic water circulation in the eastern Mediterranean is still debated. Using a high horizontal resolution (\sim 5 km) numerical model, we found that mesoscale eddies control significantly the general circulation in the basin. Two main behaviours of the Atlantic water eastward paths in the Levantine basins are observed. One consists on a permanent alongslope current and the other one is a recurrent mid-basin current.

Keywords : Eastern Mediterranean, Ionian Sea, Levantine Basin, Mesoscale Phenomena, Circulation Models.

Introduction

In the eastern Mediterranean Sea, a large-scale cyclonic circulation [1] was widely accepted until 1980s. Then a new circulation scheme showed permanent features of cyclonic/anticyclonic gyres separated by the Mid-Mediterranean Jet (MMJ) mainly carrying the Atlantic Water (AW) [2]. At the same time, Millot [3] claimed the similarity of AW pathway in the western and the eastern Mediterranean basins. Recently, analysis of IR-AVHRR images [4] shows a cyclonic alongslope circulation dominated by recurrent mesoscale eddies and thus that denied the MMJ existence. In this study, we analyse the surface circulation from a high resolution numerical model outputs [5].



Fig. 1. Levantine Basin 2-days mean Temperature/Velocity fields integrated over the upper 50 m depth a. on October year 20 and b. on December year 21 of MED16-07 simulation.

Results

The simulated patterns suggest that the model reproduces successfully all the main general circulation characteristics in the eastern Mediterranean basin as described in the literature. Model outputs exhibit recurrent mesoscale eddies which propagate eastward except in the southern Ionian near the Libyan coasts, where they propagate westward [5]. Depending on the position and development of these eddies, different circulation regimes were observed. In the Levantine basin, the simulation shows a permanent alongslope AW current. Offshore AW advection (Fig.1a) driven by the growing of the Egyptian eddies (EEs) produces a strong jet similar to the MMJ, but it is not the continuity of the Atlantic Ionian Stream (AIS). Fig.1b shows that the Ierapetra Anticyclone generates the retroflexion of the Asia Minor Current forming a Central Levantine basin Current which also looks like MMJ, but mainly transports the Levantine Surface Water.

Conclusion

The eddy signatures are in agreement with observations of [2] and [4] that leads us to be confident in the model results. The model in all the cases reproduces a permanent alongslope cyclonic current but a recurrent MMJ. The simulated MMJ is not the continuity of the AIS and is not always associated to the AW as proposed by the POEM group [2].

Acknowledgements

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LONG LIFE FOR THE EASTERN MEDITERRANEAN MESOSCALE EDDIES

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Abstract

The three-dimensional structure of the eastern Mediterranean mesoscale eddies was studied using a combination of a high horizontal resolution numerical model (\sim 5 km) outputs, in-situ and satellite data. Most of these eddies show good similarity between model results and observations. The structure, formation, development and propagation of each feature were studied separately and the results were then compared. Westward propagation in the southern Ionian Sea and eastward propagation in the southern Levantine Basin were observed with lifetime of more than two years.

Keywords : Eastern Mediterranean, Ionian Sea, Levantine Basin, Mesoscale Phenomena, Circulation Models.

Introduction

The POEM program [1] was the first to highlight many stationary and permanent mesoscale eddies in the eastern Mediterranean Sea (EMed). Recently, the propagation of these eddies was well documented using SST-VHRR imagery [2]. For the first time authors observe the southward propagation of the Ierapetra eddy and the eastward propagation of eddies in the southern Ionian Sea (S-IS) and southern Levantine Basin (S-LB). Our analysis of a 24-year simulation [3] focuses on the mesoscale activity in four key areas of the EMed (Pelops, Ierapetra, S-IS and S-LB) (Fig.1a, b).



Fig. 1. a. IS eddy trajectories: Pelops Anticyclone (PA), Libyan Eddies (LEs), b. LB eddy trajectories: Ierapetra Anticyclone (IPA) and, Egyptian eddies (EEs).

Results and discussion

Ionian Sea: We call the S-IB eddies (below 35° N) Libyan Eddies (LEs). The LEs have a diameter of 75-150 km and a vertical extension of 1000 meters. Maximum swirl speeds reach ~80 cm/s and their propagation speeds are of ~1-2 km/day. Surprisingly and contrary to what we previously believed, the LEs are generated in the south-eastern part of IS and they propagate westward (Fig1.a) [Recently observed by EGYPT program, personal comm.]. LEs lifetime can reach 2 years [3]. Pelops Anticyclone (PA) displays the smallest diameter of 50-75 km and the deepest vertical extension of 2000 m in good agreement with the literature. The PA is generated in summer or autumn, which supports the consideration

of wind-induced eddy. Depending on its generation position, it propagates northward or westward and its lifetime varies from 3 to18 months.

Levantine basin: The most striking feature, which the model reproduces, is Ierapetra Anticyclone (IPA) of 75-150 km diameter and vertical extension of 1000 m. It seems to be generated by the Etesian winds in late summer. IPA lifetime is ranged from 4 to 11 month. Its propagation paths (Fig1b) are in good agreement with SST-AVHRR observations [2]. We call the S-LB eddies Egyptian Eddies (EEs). The EEs can reach 250 km of diameter and swirl speeds of about 50-100 cm/s. Their vertical signatures are limited to the upper 700 m depth. Tracking EEs shows eastward propagation (Fig1b) with speeds of 1-2 km/day and lifetime ranged from few months to about one year.

Conclusion

The model resolution allowed us a detailed investigation of the mesoscale eddies in the EMed. The eddy characteristic analysis reveals a good similarity between the model results, the SST (AVHRR) images and in situ measurements.

Acknowledgements

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THE HYDRODYNAMICS OF THE STRAIT OF MESSINA: TIDALLY-INDUCED DYNAMICS AND STRATIFICATION EFFECTS

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Abstract

For the first time, a very high resolution numerical model has been used to investigate the three-dimensional structure of the hydrodynamics of the Strait of Messina. In particular, the role of climatologic as well as anomalous stratifications in the generation and evolution of tidally induced currents is investigated.

Keywords : Strait Of Messina, Circulation Models, Stratification, Tides.

A very high resolution, 3D numerical model based on curvilinear, boundary-fitted coordinates is used to investigate in detail the threedimensional structure of the hydrodynamics in the Strait of Messina for different climatic scenarios. Firstly, superficial as well as internal currents are investigated and compared to observed features for a stratification within the strait similar to that observed climatologically in the area. In particular, the generation and propagation of tidally induced internal disturbances and the vertical structure of submesoscale whirls are discussed. Secondly, tidally induced surface and subsurface water jets are studied for a stratification characterized by a reverse in the horizontal gradients of temperature and salinity along the strait, which resembles an observed anomalous stratification. The strait of Messina separates the Italian Peninsula from the Italian island of Sicily. It is a narrow channel (its smallest cross-sectional area is 0.3 km²) connecting the Tyrrhenian and the Ionian seas. In the approaches to the Strait of Messina very strong tidal phenomena take place [1]. This is due to the fact that, although tidal elevations are in general small in the Mediterranean, a very strong gradient of tidal displacement is present along the Strait of Messina as the semidiurnal tide north and south of it are approximately in phase opposition [1].



Fig. 1. Model domain.

Mainly through the interaction of the predominantly semidiurnal tide with bathymetric features within the Strait, large, sometimes jet-like disturbances are produced in the stratified fluid, which may evolve into trains of southward as well as northward propagating internal solitary waves [2, 3]. There is, however, a large asymmetry between northward and southward propagating, tidally induced disturbances, which is mainly due to the morphological asymmetry of the Strait, and to the structure of the local vertical stratification [3]. In order to investigate realistically the behavior of such tidally induced phenomena, we implemented a 3D numerical model. A boundary value problem was considered for the three dimensional equations describing the dynamics of the local density field and turbulence characteristics in curvilinear coordinates and in sigma-coordinate in the vertical, fitted to the geometry of the Strait of Messina.



Fig. 2. Evolution of the main interface for 6 selected times within a semidiurnal period.

The numerical method used is based on composite schemes for split operators. The schemes allow one to control numerical viscosity and solution smoothness in regions of steep gradients. The Strait of Messina is discretized in 33x83 cells on the horizontal and 40 vertical levels. The maximum resolution (55 m) is achieved at the Strait sill, the minimum one (670 m) at the southern open boundary (Figure 1). The model is forced at the two open boundaries imposing there the semidiurnal tidal displacement. In Figure 2 the evolution of the main interface as a function of the semidiurnal time is depicted for a climatologic stratification. Note that the model is able to capture the development of hydraulic disturbances at the Strait sill, which evolve in propagating internal waves. Associated with these disturbances are near-surface and intermediate water iets: in particular, with the given stratification a near-surface jet is produced which transports Tyrrhenian surface water toward the Ionian sea, and an intermediate jet arises that transports Ionian water toward the Tyrrhenian sea. Assuming, instead, an anomalous stratification characterized by a near-surface reverse in the horizontal gradients of temperature and salinity along the strait, a near-surface jet emerges thath transports Ionian water toward the Tyrrhenian sea, whilst an intermediate jet transports Tyrrhenian water toward the Ionian sea. This anomalous tidally induced dynamics is characterized by features which correspond to features observed in the strait of Messina [3] in a period characterized by a large inflow of Atlantic Water in the southern approaches to the Strait of Messina caused by an anomalous path of the Atlantic-Ionian Stream.

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SURFACE CIRCULATION AND WATER MASSES PROPERTIES IN THE SICILY CHANNEL IN 2005-2006

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Abstract

An investigation, including repeated CTD casts (more than 90 profiles), seasonal deployments of surface drifters (31 units) and satellite SST images, was carried out between September 2005 and fall 2006 in the Sicily Channel. Preliminary results, particularly those concerning the spatial and temporal variability of the AW and its dynamics, are presented. *Keywords : Temperature, Salinity, Remote Sensing, Circulation, Sicilian Channel.*

Introduction

It is well known that the Sicily Channel general circulation consists of a two layer system: the surface layer with Atlantic Water (AW) flowing eastward into the Eastern Mediterranean basin, and the subsurface layer of Levantine Intermediate Water (LIW) outflowing westward into the Western Mediterranean basin. The AW circulation is characterized by a substantial mesoscale variability [1]. Recently [2] have described qualitatively the general circulation of the area characterized by a main path of the AW as Atlantic Ionian Stream (AIS) which is strongest and most widely spread in summer. In winter this current is weaker and presents a different meandering while on the other side of the Channel the Atlantic Tunisian Current (ATC) becomes more energetic [3]. In general, the ATC has not been very well studied because of the scarcity of data in the Tunisian side. As a part of the EGYPT/EGITTO project, seasonal experiments were carried out in the Sicily channel, and particularly in the Tunisian side, in order to study the surface circulation features. A comparison between in situ sea surface temperature (SST), satellite-derived SST images and Lagrangian drifter trajectories between September 2005 and October 2006 is presented.

Data and Methods

The present work is based on a total of 90 CTD casts (Fig.1), measured with high spatial resolution during 4 cruises (November 2005, May, August and October 2006) carried out onboard the R/v Hannibal, 31 surface drifters equipped with a drogue centred at 15 m depth released between Cap Bon (Tunisia) and Mazzara del Vallo (Sicily, Italy) during 5 deployment episodes (September 2005, November 2005, February 2006, May 2006 and October 2006). The timing of these deployments, from research vessels (R/V Hannibal, R/V Urania) and ships of opportunity (Medmar fand GNV ferries) was chosen to explore the seasonal variability of the surface currents in the area. Daily SST composite images of the Sicily Channel were created using AVHRR data collected by a TeraScan satellite System located at OGS (Trieste, Italy).



Fig. 1. The location of CTD measurements and drifter deployments in the Sicily Channel from September 2005 to October 2006.

Results

The distribution of temperature and salinity shows the presence of AW close to the Tunisian coast with absolute minimum of salinity equal to 37.1. The temperature is characterized at the surface by a larger variability due to the atmospheric forcing but we can identify the permanent presence of cold water at 150 m depth (Fig.2) close to the Tunisian slope [4], which is the signature of the Winter Intermediate Water (WIW) identified by [5]. The comparison between the spatial distributions of temperature, salinity

and density in 50 m depth obtained in August and October 2006 shows a strong north-south gradient, which confirms that the AW features change greatly all along the Tunisian coast and between the seasons. The analysis of hydrographic data, satellite SST, and Lagrangian drifter trajectories between September 2005 and October 2006 shows that the surface circulation in the Sicily Channel is under the influence of strong variability, and that the path of the AW current follows several cyclonic structures. Indeed, the instability of the surface current at the entrance of the Sicily Channel is confirmed. The AW path presents different scenarios. This variability is not only explained in terms of the atmospheric forcing and the complexity of the bathymetry, but also by the path of the LIW. Indeed we were able to demonstrate interference between the two water masses, very influenced by wind forcing in this area [6]. This preliminary analysis of combined data confirms the existence of the ATC flowing along the Tunisian coast, and shows a change in its hydrological characteristic along the coast.



Fig. 2. θ -S diagram from the August 2006 hydrographic data.

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INTERANNUAL VARIABILITY OF DEEP WATER FORMATION IN THE GULF OF LION

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Abstract

We are presenting a study of the interannual variability of the oceanic winter convection in the Gulf of Lion in the western Mediterranean Sea with a high resolution oceanic numerical model (5 km) forced by ECMWF analysis (50 km). The experiment concerns the period 1998-2007. The results were compared to recent climatology based on observations. Time and space variability have been quantified in relation with the local atmospheric forcing.

Keywords : Gulf Of Lions, Water Convection.

Introduction

In the western Mediterranean Sea, the Western Mediterranean Deep Water (WMDW) forms in the Gulf of Lion in winter. Using a high resolution numerical Mediterranean model [1] forced by ECMWF analysis (50 km), the interannual variability of the convection was studied from 1998 to 2007. The convection occurs in the region centered on 42° N and 5° E in agreement with the observations [2]. The three phases described in [3] for the deep water formation processes are well noticed in the experiment:

- the doming structure and an initial cooling of the surface waters down to 200 m in fall,

- another cooling of surface waters down to the upper part of the Levantine Intermediate Waters at 400-500 m at the beginning of winter, which is followed by a violent mixing down to deep layers at the end of February or at the beginning of March and that is represented by several chimneys whose diameter is of several kilometers,

- the restratification starting at the beginning or middle of March.

The WMDW temperature is generally higher by 0.1-0.2°C in our experiment than in the literature based on observations [2, 3]. Timeseries of the maximum depth reached by the convection illustrate the high interannual variability in the model with values ranging between 600 m and 1300 m.

Winter convection

For each winter, maps representing the area where the vertical mixing has been at least once deeper than 450 m, have been displayed. The results are in good agreement with those reported in [4] from data analysis. The mean spatial coverage of this area ranges between S_{depth} =4,000 km² and S_{depth} =21,000 km² in good agreement with the observations reported in [4]. Time-series of the area where the vertical mixing was deeper than 450 m during each 5-day interval (inside each S_{depth}) were calculated to characterize the intermittency of the preconditioned and deep convection processes during each winter. The results show two different regimes corresponding to:

- Regime 1: only one convective event with a large spatial coverage (75% of S_{depth}) and a short duration (20 days to one month) -which was the case in winters 1999 and 2003 -,

- Regime 2: several convective events with a lower spatial coverage (25% of S_{depth}) but occurring successively during a longer period (2 to 3 months) - which was the case in winter 2000-.

Then we have correlated the 5-day mean spatial coverage to the 5-day mean atmospheric forcing for each winter. It appears that regime 1 seems to be triggered by local heat loss larger than 750 Wm^{-2} associated with strong winds, while regime 2 is triggered by local heat loss of the order of 400 Wm^{-2} associated with moderate winds.

Conclusions

According to this numerical study, the strong mixing phase of the convection during winter depends on several regimes mainly triggered by the local atmospheric forcing. We present the results for the1998-2007 period, the later three years being rich in in situ measurements, which helps the model validation.

Acknowledgment

This work was supported by the Mercator project. Atmospheric forcing was provided by ECMWF. Computations were made at the French IDRIS centre from CNRS.

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ANALYSIS OF TWO MESOSCALE EDDIES IN THE SOUTHERN IONIAN AND CRETAN BASINS IN 2006

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Abstract

During the EGYPT-1 campaign in April 2006, two mesoscale eddies, a Libyan eddy and the Ierapetra 2005, have been sampled in detail mainly with CTD casts. The goal of this study is to compare these hydrographic measurements with results of two simulations done with high resolution models developed in the framework of the Mercator project. Focus is on the generation, the vertical water mass distribution, and the drift of these eddies.

Keywords : Levantine Basin, Ionian Sea, Mesoscale Phenomena, Circulation Experiments, -missing-, .

Introduction

During the EGYPT-1 campaign in April 2006, two mesoscale eddies have been sampled by CTD casts (\sim 10 km apart): (1) a Libyan eddy (LE) included in a transect from the Libyan to the Cretan shelves and (2) the Ierapetra remaining from the summer 2005 (I-2005). Two simulations are compared with in situ measurements. One simulation was done with the operational Mercator model running with assimilation [www.mercatorocean.fr] and another simulation was done with a similar model running without data assimilation [1]. A preliminary comparison of the general circulation in April 2006 is made. And then the characteristics of the observed and modelled eddies are investigated.

Observations versus models

As observed in situ in April 2006, the surface layer of the sampled LE is mainly composed of recent Atlantic Water (AW) that has been transported along-slope there from the West. Recent AW signature with a different origin than those of the sampled LE, was not observed on the section from the Libyan to Cretan shelves, highlighting thus the absence of the Mid Mediterranean Jet (MMJ). The sampled LE had a large signature at depth (>1000 m), a diameter of about 100 km and it was centred near 33.5°N-23.5°E. Simulations show LE with a vertical distribution of water masses in agreement with in situ data. But in April 2006, modelled LE was not at the position of the observed LE. The observed LE was later tracked during its westward drift at least from April to October 2006. Such a long westward drift for LEs had not been observed yet. But according to a recent modelling work [2], LEs could be generated in the south-eastern part of the Ionian basin near 19°E-21°E and could propagate westwards along the 1000-2000 m isobaths with a speed of \sim 1-2km/day and a lifetime ranging from few months to more than 2 years.

According to measurements, the I-2005 had a diameter of 150 km and a vertical extent larger than 1000 m. It was centred near $33.5^{\circ}N-26^{\circ}E$ that is well south of its summer position. It finally merged with the I-2006 being created in early summer. This behaviour was already observed [3] but was not so well reproduced by the simulations [2].

Conclusion

This study of the circulation and the hydrology of the southern Ionian and Cretan basins in 2006 helps validating models. These first results assist the circulation schemes provided by models and observations that show a circulation along the slope, and the absence of MMJ.

Acknowledgments

The EGYPT program is supported by French funding from INSU, PATOM, GMMC, CORIOLIS, and Région Provence Alpes Côte d'Azur. Modelling work was supported by the Mercator project and atmospheric forcing was made available by the ECMWF. Computations were made at the French IDRIS from the CNRS.

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DYNAMICS OF THE CILICIAN BASIN CIRCULATION

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Abstract

Data driven simulations in the Cilician Basin based upon observations during May-August 2005 and a coupled 3-d physical model have been carried out. The circulation features of the Cilician Basin and connected bays were investigated. Circulation features of the region are complex with elements of sub-basin scale gyres, meso-scale eddies and jets. Quantitative and qualitative comparisons of the model fields with ADCP measured currents are given.

Keywords : Circulation, Circulation Models, Levantine Basin.

The Cilician Basin coastal system occupies the northeastern part of the eastern Mediterranean Levantine Basin between Cyprus and Turkey. The system includes the wide continental shelf of the Mersin and Iskenderun Bays.

Three oceanographic surveys with mesoscale grid resolution were conducted in the Cilician Basin during May-August 2005 to investigate the circulation features of the basin. The data set collected during the cruise consists of temperature and salinity profiles at stations and ADCP measured currents throughout the cruises.

Data driven simulations in the Cilician Basin based upon above observations and coupled 3-d physical and biochemical models have been carried out to understand the dynamics of the circulation in the region. The model was initialized with the data obtained during May 18-26, 2005 and run till August. The data obtained during summer cruises were assimilated into the model.

The physical dynamical model employed here is the 4-d primitive equation (PE) model of Harvard Ocean Prediction System, which is based on the GFDL integration algorithm. The model grid covers the entire Cilician Basin at a resolution of 3 km with 25 terrain-following levels in the vertical.



Fig. 1. Model initialization

A cyclonic circulation in the Eastern Mediterranean has long been proposed as the dominant mean current system. Accordingly, the steady surface current follows the coast of Israel, Lebanon and Syria and turns west to follow along the southern Turkish coast.

While mean currents appear to have a relatively simple pattern, the actual time-dependent currents in any part of the eastern Mediterranean are far more complex, and this complex pattern is impressed on the coastal regions. The current systems with elements of sub-basin scale gyres, meso-scale eddies, jets and oscillatory features have a determining role in the transport of materials in the sea. The shallow and wide shelf region adjacent to the Gulf of Iskenderun implies local characteristics of currents, and mixing and exchange mechanisms of the Gulf waters, which impact its biochemical structure and variability.

ADCP measurements carried out during the cruises indicate the existence of a jet with 60 cm/s velocities with the core located at the 200 m depth contour in the Mersin Bay. This jet separates coastal and open sea waters and its spatial variability affects the replenishment of the coastal waters of the Mersin Bay. The model simulated circulation features are consistent with ADCP measured currents both quantitatively and qualitatively.

The interactions between northeastern Mediterranean shelf area and the open waters drive the circulation within the Iskenderun Bay. The strong local wind in Iskenderun region is also effective on the short term variability of the Iskenderun Bay circulation.



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Fig. 2. Model 14 days forecast

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SHALLOW WATER ENVIRONMENTAL PROFILER IN TRAWL-RESISTANT REAL-TIME CONFIGURATION (SEPTR) USED FOR FRONTAL DYNAMICS RESEARCH

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Abstract

During both a winter and summer period of 2006, SEPTR moorings were used for real-time monitoring of velocity, temperature, salinity, waves, and optics in a dynamic frontal zone of the central Adriatic Sea. From the trawl-resistant barnacle like shaped SEPTR housings, velocities were measured acoustically. Other water column parameters were measured four times a day through a CTD profiler that was released to the surface and winched back into the protective mooring housing. Thus all variables of dynamic significance were monitored synoptically across a heavily fished coastal frontal zone.

Keywords : Fronts, Adriatic Sea, Instruments And Techniques.

A Cooperative Agreement was established between the NATO Undersea Research Centre (NURC) and the U.S. Naval Research Laboratory (NRL) to establish the feasibility of carrying out real-time environmental assessments over longer time periods in shallow seas where commercial fishing is often intense. The work under this agreement built upon NRL/NURC past success of improving trawl-resistant bottom mounts for Acoustic Doppler Current Profilers (ADCP) [1] and NURC work on prototype systems for bottom-mounted profiling systems [2]. The result was five production units of Shallow water Environmental Profiler in Trawlresistant Real-time configuration moorings (SEPTRs) that were tested and used during the winter and summer experiments of the Dynamics of the Adriatic in Real-Time (DART) international collaborative project. The moorings were used to study the frontal dynamics of the Western Adriatic Current (WAC) in the Gulf of Manfredonia area of the Adriatic Sea. Throughout three cruises, the moorings measured profiles of velocity, temperature, salinity, chlorophyll concentration, and backscattering at two wavelengths. The velocity profiles were acoustically measured every 15 minutes while other parameters were measured every six hours during CTD casts taken by a profiler that was released in the water column and winched back into the protective mooring housing after the brief measurement period. During these casts, an option was sometimes used to pause near the surface and also measure the surface wave spectrum and significant wave height. When at the surface, the profilers attempted to send all data back to a land-station via the Global-Star satellite system. During the summer cruises of DART, three SEPTRs deployed across the WAC demonstrated the importance of synoptically measuring both the thermohaline and velocity structure to gain understanding of frontal dynamics.



Fig. 1. Temperature and velocity measurements for 18-August 2006 from three SEPTRs deployed across the WAC. White arrows indicate 6-hour averages of ADCP measured velocities where upward is flow into the page, downward is flow out of the page, and horizontal is along-section flow. Shading indicates the profiler measured temperatures.

Figure 1 shows an example of SEPTR measured dynamic variables for a particular day. The profilers measured a relatively simple, but strong and consistent offshore rise in thermocline depth during this time. However,

the measured velocities reveal multi-level structures with significant time dependence (tidal and inertial) and an interesting upper-layer flow at the inshore mooring directed along the section towards the oscillating WAC flow seen further offshore. Further analysis will be done using these direct measurements to understand the relative importance of geostrophic, advective, and other forces in determining the WAC frontal structure.

Acknowledgments

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MEDITERRANEAN CLIMATE VARIABILITY AND PREDICTABILITY (MEDCLIVAR): AN ESF NETWORKING PROGRAMME

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Abstract

MedCLIVAR is an international programme which aims at coordinating and promoting the study of the Mediterranean climate. Med-CLIVAR's scientific priorities are: description of climate past evolution, assessment of climate variability, understanding the mechanisms responsible for it, identifying trends and providing climate prediction in relation to future emission scenarios. *Keywords : Global Change, Models, Circulation, Air-sea Interactions, Paleoceanography.*

The Mediterranean climate is characterized by the Mediterranean Sea, which represents a relatively large mass of water, and its peculiar geographical location: at mid latitude, on the west side of a large continental area, surrounded by three continents with high mountains ridges, and with a restricted exchange with the Atlantic ocean. In general the climate exhibits hot and dry summers, and mild and rainy winter seasons. However, within such a small spatial scale there are large climate contrasts as the area includes Alpin regions in the north, with permanent glaciers and relatively high precipitation rates, and subtropical semiarid regions in the south where the extended Atlas mountains ridge also play a major role. Moreover the Mediterranean is a transition zone between midlatitude climate regimes, located at the border of the midlatitude storm track, and the tropical climate, located under the descending branch of the Hadley cell [1].



Fig. 1. Multi Global Model Ensemble average change in precipitation for the four seasons, 2071-2100 minus 1961-1990, A2 scenario. Units are % of 1961-1990 value. DJF is December-January-February, MAM is March-April-May, JJA is June-July-August, SON is September-October-November (Courtesy of F.Giorgi)

These characteristics make the Mediterranean region potentially very sensitive to climate change. Indeed, simulations of future climate scenarios tend to agree that a higher emission level could produce a temperature increase larger than the global average value, further reduce summer precipitations and increase the interannual variability of both temperature and precipitation. Progress in understanding of the Mediterranean climate has important environmental, societal and economical implications. The Mediterranean region is characterized by large cultural, economical, political, demographic gradients in a situation already under environmental stress (heat waves, highly variable precipitation, limited water resources, drought, floods), where lack of readiness and adequate adaptation strategies could result in critical situations, in particular in connection with the occurrence of extremes and inadequate evaluation of climate change impacts [2].

The European Science Fundation MedCLIVAR Programme aims at assisting scientists in developing coordinated research projects; favouring the exchange of information and expertise; establishing a network of European, Middle-East and North African institutes and scientists actively involved in regional climate studies; providing a source of information to assist governments and local authorities in decision-making; and providing material and documentation to the public to inform them on climate issues. The ESF MedCLIVAR will pursue these goals through:

- Annual workshops

- Summer schools

- Exchange grants, to offer MedCLIVAR scientists the opportunity to spend up to 5 months in a host institution to exchange information, share data and develop common work on the Mediterranean climate.

For the latest information on this Research Networking Programme, consult the MedCLIVAR websites: www.esf.org/medclivar and www.medclivar.eu

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SLOW ABYSSAL CLOCKWISE ROTATING EDDIES IN THE IONIAN SEA

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Abstract

The dynamical characteristics of the deep currents flowing over the KM4 site $(36^{\circ} 30^{\circ})$; $15^{\circ}50^{\circ}E$) measured, from July 2001 to March 2003, through two Aanderaa RCM 7-8 current meters set at 2700 m and 3050 m depth (230 m from the bottom) are here investigated. The presence of 8 large scale slow barotropic vortices, clockwise rotating, is discussed. *Keywords : Abyssal, Ionian Sea, Currents.*

From the year 1999, within the NEMO project, a current meter chain has been deployed at the KM4 site (at 36°30'N; 15°50'E, Ionian sea, Central Mediterranean Sea, Fig 1) about 130 km south-east of Cape Passero, the meridional tip of the Island of Sicily. This site is on a rather flat plane 3280 m deep, at 50 km from the oriental Sicilian sharp shelf break. The velocity, temperature and density outputs from two Aanderaa RCM 7-8 current meters, set at 2700 m and 3050 m depth (the latter at \sim 230 m from the sea-bottom) have been analysed. The characteristics of the KM4 site are: i) the mean measured salinities are consistent with those of the Aegean water; ii) the deep sea current is mainly "barotropic", with an average current of \sim 1.89 cm/s towards north-north-west; iii) strong inertial and tidal signals are present; iv) the baroclinic signal is concentrated around the inertial range. Its energies are ~ 5 % of those of the "barotropic" velocities; v) 9 mesoscale large signals, crossing the site during the measurements period, have been detected. Among them, one is a crossing front and 8 are large scale clockwise rotating vortices (Fig.2). Their crossing-time 10 < T < 30 days and their chord (diameter, if the center of the vortex crossed the current meter chain) 20<D<45 km can be estimated: the crossing times of maxima velocities of these vortices is $\approx T/2$. But other smaller signals appear as vortices sideways crossing the KM4 site.



Fig. 1. Geographical position of the KM4 moorings and time-averaged vectors for both depths

From the termohaline characteristics of the water column we estimate the internal Rossby radius R ~ 7 km, the Rossby number ~ 3×10^{-2} , the Burger number ~ 0.4-0.7, the Brünt-Vaisala frequency ~ 3×10^{-3} s⁻¹, the Richardson number Ri ~ 60. In synthesis the abyssal KM4 flow is geostrophic, there is no evidence of turbulence, and *L* is about 3/2 the Rossby radius of deformation. A spectral and a rotary analyses show three "barotropic" kinetic energy peaks at periods of $\approx 19.8 \pm 2$ days, 15.2 ± 1 days, and $\approx 29.5 \pm 4$ days. Over the entire spectral band, as that of the mesoscale vortices, the rotary coefficient is always large and <0, so the idea of persistent clockwise motion of these vortices has been investigated, as due to: *a*) a local wind blowing over the site; *b*) a basin resonance

with the wind, c) a 'cyclogenesis' process [1, 2] generated along the dense current down-flow, after the dense Aegean water crosses the Antikithira strait and enters in the Ionian Sea [3]. Against hypotheses a) and b) there are the lack of anticlockwise vortices and the positive rotary coefficient of the winds at the peaks frequency range. The last hypothesis c) appears to be the most reliable at the moment. At the light of these partial considerations, only further measurements can verify these hypotheses.



Fig. 2. Stick diagram of the "barotropic" low-pass filtered current in the half-month running average frame

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DENSE WATER SINKING IN THE BARI CANYON (SOUTHERN ADRIATIC SEA)

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Abstract

In order to study the role of the Bari canyon system as pathway for sediment and water coming from the Northern Adriatic, three moorings consisting of sediment traps and current meters, were deployed near the bottom, at 600 m depth, for one year. Two moorings were deployed within the canyon (B and C) and one on the adjacent open slope (A). Principal Component Analysis (PCA) on current data indicates that for moorings A and C the major variance occurs in the along- and the across-slope (along canyon axis) direction, respectively; while for mooring B the variance was almost equally between both components. A very good correlation between the major variance component and temperature was found showing 3-day and 10-day fluctuations mainly during the convection and spreading phase. *Keywords : Adriatic Sea, Continental Slope, Currents, Sediment Transport.*

The Bari canyon is a morphological structure that incises the western Adriatic shelf in the southern basin, 600 km away from the main freshwater input to the Adriatic. It is generally assumed to play an important role in dense water sinking [1] and sediment transfer to the deep Southern Adriatic basin, although no direct observations are presently available to explain water dynamics and sediment transport associated with the canyon system. In order to study the water characteristics, dynamics, and vertical particle fluxes within the Bari canyon, three mooring lines equipped with sediment traps, current meters and temperature recorders were deployed near the bottom for one year (March 2004 - March 2005). One mooring (A) was deployed as reference on the open slope ~10 km north of the canyon, the other two were deployed within the canyon (B in the northern branch and C in the southern branch), at a distance of 4.3 km from each other (Figure 1).



Fig. 1. Detailed multibeam (MB) bathymetry of the Bari canyon, mooring locations and main current directions

From the Principal Component Analysis (PCA) of the current components it resulted that at mooring A 89% of the variance is associated with the along-slope component with an average direction of ${\sim}145^\circ,$ and in mooring C to the across-slope component, with a prevalent direction of $\sim 80^{\circ}$, along the axis of the southern branch of the canyon. Differently, currents at mooring B showed two main directions: one southward, parallel to the isobaths (~170°), and the other along the canyon axis (~110°) with the variance divided in 60% and 40%, respectively. Velocity components (higher than 15 cm $\rm s^{-1})$ indicate that those along the canyon axis occur only during the mixing and convection period associated with a temperature of 13.1°C, while those southward were measured during the whole year with a mean temperature of 13.5°C. Vertical particle fluxes collected inside the canyon were higher than those of the open slope, and peak values were recorded in correspondence to temperature minima. Time series of current and temperature were smoothed by applying a 25-hour low-pass filter and correlated with the temperature measured at each site (Figure 2).



Fig. 2. Monthly moving correlation between a) along-slope current component and potential temperature, b) across-slope (down canyon axis) current and potential temperature in the three mooring sites

The highest correlation ($r^2 = -0.60$) was found during the late winter-early spring (post-convection) period for the along-slope component in mooring A, in contrast to what was found in mooring B and C, where the highest values were found for the across-slope component showing a 3-day fluctuation frequency. This fluctuation was confirmed by a spectral analysis of the raw data of the same period, which showed also high energy in the 10-day oscillation. All observations in the Bari canyon system are consistent with the presence of a vein of North Adriatic Dense Water (NAdDW) flowing southward, intermittently, along the Adriatic shelf and sinking in the southern Adriatic basin, both along the open slope and, in an enhanced way, through the Bari canyon.

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MOON IN SUPPORT OF THE STATE OF MARINE ENVIRONMENT ASSESSMENT

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Abstract

The main elements of the Mediterranean Operational Oceanography Network-MOON forecasting system were implemented as part of several EU projects and national funding. MOON was established in 2005 for the further development of ocean forecast products in the basin, and represents the EuroGOOS system in the Mediterranean Sea. The MOON observations, forecasts, and analyses are available in real time on the MOON web site: (www.moon-oceanforecasting.eu). MOON is producing a monthly bulletin that contains the observation collected in previous month, the air-sea fluxes, the anomalies and the climatic indices computed by the modelling system. On the basis of this product MOON community is developing a customized monthly bulletin of the ocean state together with UNEP/MAP in support of state of marine environment assessment.

Keywords : Circulation, Temperature, Salinity, Eutrophication, Ocean Colours.

MOON is based upon the demonstration of the real time functioning of an integrated system composed of: a) the Near Real Time Observing system; b) a numerical forecasting system at basin scale and for sub-regional and shelf areas; c) a product dissemination/exploitation system. The latest updates of the system considers a model at 6.5 km horizontal resolution, daily 10 days forecasts, weekly analyses with assimilation of all available data, both from 2 satellites (SST, SLA) and in situ (XBT, ARGO). Sub-regional (ADRICOSM-Adriatic Sea, ALERMO-Levantine and Aegean, ESEOO-West Mediterranean, NW-MED-West Mediterranean, POSEIDON-Aegean Sea, Sicily Channel) and coastal forecasts (CYCOFOS-East Levantine, Gulf of Lyon, Israel coasts, ROSARIO_Malta Shelf) up to 2-1 km resolution, in several open ocean and shelf areas are produced as part of MOON.

The MOON observations and the forecast and analysis data are available in real time on the MOON web site: (www.moon-oceanforecasting.eu). The user community is composed of governmental and military agencies, environmental protection agencies, research institutes, and private companies. MOON has developed and is implementing biogeochemical models coupled to the forecasting system for future predictions of algal blooms in different shelf areas. End-users applications involve oil spill forecasting, real time observing and modelling system for commercial species fish management.

The MOON Marine Core Services derived by the observing system components and running operationally progressively since summer 2004 are: 1) a SOOP-VOS system composed of 9 tracks with 12 nautical miles' resolution and full profile transmission [2]; 2) an altimeter RT data analysis system using four available altimeter sensors for sea surface elevation anomalies, RT analysis of AVHRR with the production of daily SST fields and RT Scatterometer wind analyses blended with NWP products; 3) 23 MedARGO floats deployed at 350 m parking depth, 700 m profiles and 5 days cycle (every 5 cycles a 2000 m profile is collected); 5) a moored buoy network (M3A) (E1-M3A and POSEIDON network in the south Aegean Sea, W1-M3A in the Ligurian Sea, Cyprus Buoy in the Levantine, W2-M3A in the Catalan Shelf and ESEOO buoys network in the Spanish coast). The RT data dissemination network works properly on a daily time scale.

The MOON MCS derived by the forecasting system component are composed of:

1) 10-day basin scale forecasts done with an OGCM at 6.5 km resolution and 71 levels. The forecasts is produced in real time on daily basis [1]

3) 5-days regional forecasts at 3 km resolution in 6 sub-regions nested in the basin scale model: Western Mediterranean (ESEOO), North-Western Mediterranean, Sicilian Strait, Adriatic Sea (ADRICOSM), Aegean Sea (POSEIDON) and Levantine-Aegean Sea (ALERMO). 5-days shelf (1,5 km resolution) forecasts nested in the sub-regional models (Gulf of Lion, Malta Shelf (ROSARIO), Cyprus Coastal Ocean Model (CYCOFOS), Southern Eastern Levantine Shelf). In additino the ESEOO Sea level forecasting system (Nivmar) is available

4) operational weather LAM forecast at 10 km resolution used to force the sub-regional nested models (SKIRON);

5) three-dimensional ecosystem model composed of a general Biochemical Flux Model-BFM coupled to the Adriatic Sea, Eastern Levantine and Aegean Sea , and Mediterranean Sea models. The BFM is a new code for open ocean and coastal biochemistry based upon a biomass and functional group representation of the marine food web;

The MOON Marine Downstream Services consist of end-user applications such as the oil spill drift model CYCOFOS, the Fishery Observing System - FOS for fish catches observation in support of sustainable fishery management and the User Visualization Tools for MCS model output visualization and for particles drifting to be used for Search and Rescue operation and for oil spill drift forecasting.

In addition MOON, on the basis of the above mentioned Marine Core Services, is producing a monthly bulletin that contains the observation collected in previous month, the air-sea fluxes, the anomalies and the climatic indices computed by the modelling system. On the basis of this product MOON community is developing a customized monthly bulletin of the ocean state together with UNEP/MAP in support of state of marine environment assessment. This customized bulletin is actually under development for UNEP/MAP and will contain the observing system data for the previous month, including chlorophyll data from MODIS satellite, True color data for dust event detection and CASE I/CASE II waters evaluation), maps of the mean ocean circulation, dedicated, high resolution, data for pilot areas where Eutrophication is under evaluation, and ocean state indicators such as: Sea Level fluctuation in different sub-portions of the basin; Upwelling indexes for relevant sites in the Mediterranean Sea; Eutrophication and Anoxia indexes; Anomaly fields correlated with NAO; Flushing rates/residence time Ocean heat storage.

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MEDITERRANEAN ECOSYSTEM MODELLING: WHERE ARE WE GOING TO?

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Abstract

In recent years many Mediterranean ecosystem models have been published, but they were basically local of process-oriented. Now the Mediterranean modelling community is moving towards more challenging goals that both science and society are asking for. The new frontiers for ecosystem modelling set by operational oceanography include short term forecast and long term simulations. An overview of state-of -the-art and future perspectives on these fields is presented in the light of ongoing projects and strategic guidelines for marine research.

Keywords : Models, Food Webs.

Mediterranean Sea is an ideal basin to implement (and to challenge) pelagic ecosystem models because of its physiography, the presence of key oceanic processes, the variety of habitats and living communities. In the past, a number of articles on Mediterranean ecosystem models have been published but they used largely one-dimensional, sub-regional or process- oriented models. Now the Mediterranean community seems ready to respond to the request of environmental information for policy makers, the monitoring and prediction of environmental and climate changes.

In operational oceanography, GMES (Global Monitoring for Environment and Security), a partnership of the European Commission and the European Space Agency, asks for the demonstration of short term forecast of marine ecosystems to monitoring the environment, preventing and managing natural or industrial catastrophes. EU-funded Integrated Projects MFS (Mediterranean Forecasting System) and now MERSEA (http://www.mersea.eu.org/) and ECOOP develop and coordinate a sustainable pan-European system that include the prediction of biogeochemical and ecosystem parameters for some European regional seas including the Mediterranean. This philosophy include a nesting strategy in order to downscale the resolution and biological detail in selected coastal areas where the major practical applications are present. In this context, a demonstration of short term forecast is going to be produced using an innovative off-line coupling between INGV OPA 16° resolution operational forecasting system for Med Sea (http://www.bo.ingv.it/mfs/) and OGS/OPA transport module embedding the Biogeochemical Flux Model (http://www.bo.ingv.it/bfm/) [1]. This approach exploits the benefits of state-of-the-art dynamical prognosis including extensive data assimilation up-scaled to lower horizontal spatial resolution $(1/16^{\circ} \text{ to } 1/8^{\circ})$ to keep off-line dynamics files and computational load at affordable level for the forecast. The OGS/OPA transport model does not include at the moment any direct data assimilation techniques already applied in experimental way in some Mediterranean simulations [2, 3]. Instead, the spatial estimates for the diffusive absorption coefficient obtained from SeaWiFS 490nm band is going to be implemented.

Further developments in data assimilation for biological variables are expected in the near future and will be the basis for a better integration and exploitation of the information coming from satellite sensors in the visible band.

Since large part of biogeochemical modules presently are run in datafree conditions, they have the potential to be applied also in a long term integration for hindcasting and for scenario analyses under different forcing and anthropic pressure. SESAME, an EU FP VI co-financed project started in November 2006, has as general scientific objective to assess and predict changes in Mediterranean ecosystem through extensive usage of mathematical modelling in order to provide ecosystem key variables for the assessment of climatic impact on key goods and services provided by the Mediterranean. The proposed numerical design includes again decadal hindcasts and scenarios for the whole Mediterranean using similar numerical tools as those used for the short term forecasts, or set up during MFS in a nesting structure. IPCC scenario A1B will be used for testing the biogeochemical cycles modifications with full 3D biogeochemical models with different resolution, physical modules and domains. The improvement in model complexity and parametrization will be beneficial also for the short term forecast applications.

Regarding the assessment of the predicting capabilities, even the most advanced biogeochemical forcasting systems have often low skill score. Ecosystem models are still in their infancy and their uncertainties are higher than physical variables and care must be taken not to release products prematurely, before full confidence can be stated.

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MODEL OF GIBRALTAR'S SHORT PERIOD OSCILLATIONS

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Abstract

Tide gauge records from different harbours in the Strait of Gibraltar area show events of short period oscillations (SPOs), with periods ranging from some minutes to tens of minutes, that persist from several hours to one-two days. The numerical model developed to investigate these oscillations shows that they correspond with harbour resonances, which are excited by the normal modes of the Strait of Gibraltar (regional domain): coupled model of normal modes.

Keywords : Air-sea Interactions, Coastal Models, Strait Of Gibraltar, Sea Level, Waves.

The exchange of Mediterranean and Atlantic waters through the Strait of Gibraltar is a complex phenomenon which responds to physical forcing of different temporal and spatial scales [1]. The shortest time-scale actually found in the Strait of Gibraltar corresponds to the SPOs (Short Period Oscillations), of few minutes of period, and that are known to affect the sea level within the harbours in the Strait area (see tide gauge record at Figure 1). They are an interesting and striking phenomenon by themselves, despite the fact that observations do not support any dynamical relation of the short period oscillations with the water exchange in the Strait.

The amplitude of these SPOs ranges from 1 cm to 10 cm, that is, they are one or two order of magnitude below the predominant tidal signal (around 0.5 m). It is also noticeable that the SPOs are more frequently observed in summer, pointing to a certain seasonal variability. Spectral analysis show relevant peaks between 7 and 30 minutes, and highlight a clear relation between the geographical location and the typical excited frequencies in a set of 4 bands, named here as A (\sim 7-8 min, typical of Tarifa harbour), B (\sim 11-14 min, Algeciras and Ceuta), C (\sim 17-21 min, Algeciras), and D (\sim 23-27 min, less clear than the rest) bands.



Fig. 1. Upper plot: tide gauge record in Tarifa from 21 to 31 of May, 1999. SPOs of large amplitude are present the 30 and 31 of May although they are observed from 25 of May. Lower panel shows the tide gauge record in Algeciras from 11 to 30 of June, 1999. The thick line remarks the observations on June 28, when SPOs of considerable amplitude were registered.

The selective frequency response at the different harbours, suggest that observed SPOs are a very local phenomenon, basically an excitation of the normal modes of the different harbours. The resonant modes have been calculated using a model that solves the two-dimensional periodic linear barotropic equations of continuity and moment (depth averaged-shallow water equations), without friction nor rotation [2, 3]. Boundary conditions are: 1) no flow in the solid boundary, 2) no oscillation in the harbour's mouth (open boundary) [4]. The proposed harbour resonance explanation for the SPOs is quite satisfactory for the A frequency band at Tarifa and the B band at Ceuta and Algeciras. However, C and D band at Algeciras, are not properly modelled.

Despite the fact of a different frequency response at Tarifa than at the other two ports, we have found that the SPOs appear often simultaneously at the three ports. A straightforward calculation shows that half-wave stationary oscillations between North and South coasts (L \sim 15km) would produce SPOs of O(10min) for a bottom depth of H \sim 400m, in the same range that

the observed and modeled SPOs. The most probable mechanism would be some type of atmospheric disturbances that would excite sea level oscillations (at least) all over the Strait (at regional scale), which themselves would produce sea level co-oscillations within the harbours whenever the fundamental periods of both systems match (resonant mechanism).

The possible normal modes of oscillation in the regional domain have been constructed applying the former barotropic port's model to the geometry of the Strait with opened contours located at different distances [5]. The model found a set of normal modes: the higher periods ones (T>18min) fit with observed modes of the bay of Algeciras (generating SPOs in the bands C and D) whereas the lower periods (<14min) fit with normal oscillations modes of the Strait. These, in turn, are subdivided in normal oscillations of the broadest Eastern part (T>10min) and normal oscillations of the section of minimal width (T<10min), just in the frequency range capable to excite harbours SPOs at B and A bands, respectively.

The similar frequency ranges of the regional and local normal modes is the key factor in the process. A coupled model of regional SPOs-port resonances produces a profit that depends on model's friction. For reasonable values, the amplification factor ranges between 5 and 10. This is sufficient to justify the observations if the regional SPOs are O(1cm), which only happens if these in turn are generated by periodic pressure disturbances or synthetic atmospheric disturbances with energetic content in the high frequency.

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VERIFICATION OF A COUPLED AIR-SEA MODEL OVER THE ADRIATIC SEA USING SATELLITE DATA

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Abstract

A verification of the EBU-POM coupled model forecast is done by using satellite observations of SST (Aqua Modis) and surface winds (QuikSCAT) over the Adriatic Sea. The verification is done over a period of 17 days during which a strong Bora event occurred for several days. The idea was to test the model capabilities to perform simulation of such an extreme event as a Bora wind. This can be also an indirect test for atmospheric turbulent fluxes parameterizations which are one of the crucial components in the air-sea interaction modeling *Keywords : Air-sea Interactions, Adriatic Sea*.

EBU-POM is a two-way coupled model [1], with Eta/NCEP [2] limited area model as its atmospheric part, and Princeton Ocean Model [3] as its ocean part. In the present case the ocean model had the same setup as AREG/INGV [4] Adriatic model, but without river runoff parameterization. The centre of the atmospheric model was at 16E, 42.5N and the horizontal resolution was 0.09 degrees.

Integration was seventeen days long without any interruptions, starting at 00UTC 11th February 2003. Strong Bora wind was present over the Adriatic during 17th, 18th and 19th. As initial conditions for the ocean part of the model we used temperature, salinity and velocity fields from the first day of AREG model simulations. These simulations are operationally produced by INGV-Bologna and they are ftp available through the ADRICOSM-EXT project activities. As initial and boundary conditions for atmosphere we used analyses of the ECMWF global model. Satellite observed SST and surface winds were provided by CNR.ISAC Rome. Exchange of these satellite data are also part of ADRICOSM-EXT activities. For verification of the model we used standard methods of evaluation such as BIAS, RMSE and correlation scores.

First we present SST verification scores. Fig.1 shows the area averaged values of the two RMSE scores (for day time and night time observations) from 11th to 27th February. The mean RMSE value, for the whole period of integration, is very close to 1 for both day/night observations. We must keep in mind that area averaged RMSE is mean value over the area where satellite observations were available, i.e. area free of clouds. High RMSE is almost always connected with small number of observations (cloudy days), especially when those observations are located close to the coast. We can also see that values of RMSE don't have tendency to increase during integration, so we can conclude that SST forecast kept the same quality for the whole period.



Fig. 1. Night (upper panel) and day (lover panel) daily values of area averaged RMSE for SST forecast in the period 11th -27th Feb. 2003.

Bora is a strong north-east wind that mainly affects the north-west part of the Adriatic Sea. So, for wind verification we are only concerned with the area north of 43N. The verification period was from 15th to 20th February, during which the Bora event was present. Fig. 2 shows model vs. satellite mean wind seed (upper panel) and mean wind direction (lower panel) for this area. For every day there are two observations, at 6 am and at 6 pm local time. Problems with the scatterometer measurements are not connected with clouds but with rain and also with wind speeds lower than 3m/s. All points with any rain probability and all points with low speed were excluded. We find very strong dependencies between these two parameters and the verification scores. For clear sky situations, correlation coefficients between model and observed wind speed have high values, around 0.8, while for rainy days coefficients were much lower, around 0.4. This is the reason why we have a big difference between observed and simulated wind speed for 16th February at 6 am. During that day rain occurred over almost all the Adriatic. For other days differences were not so large. The mean bias for the whole period was -0.8.



Fig. 2. Model vs. observation values of area averaged wind speed (upper panel) and wind direction (lower panel) for the period 15th -20th Feb. 2003

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A REAPPRAISAL OF THE EXTREME SEA LEVELS ALONG THE CROATIAN ADRIATIC COAST

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Abstract

Sea-level time series from 1955 to 2004 relevant to the northern (Rovinj), middle (Split-harbour) and southern (Dubrovnik) part of the Croatian Adriatic coast have been analysed to make estimates of return sea levels for 100-years return period. This was done by fitting observed annual sea level maxima and minima to an assumed parametric "Generalised Extreme Value" (GEV) distribution function with three parameters. A little discrepancy in the predicted return sea levels estimates for 100-years return period exists in comparison with previous studies, due to different methodologies used in the analysis and diverse length of the time series data. *Keywords : Adriatic Sea, Tides, Sea Level.*

One of the most valuable applications of long-term sea level records is the estimation of risks of coastal flooding. Typical questions associated to the problem are: What is the probability that a sea wall of a certain height is overtopped during one year? What is the height of a sea wall that should be built so that it is overtopped with a probability 1/N in a particular year (N - year return levels)? Therefore, estimates of the sea level heights with an expected return period of 50, 100 or more years are of a great importance.

Along the Croatian Adriatic coast long series (50-years) of sea level measurements exist at three sites under the authority of the Hydrographic Institute of Republic of Croatia (HIRC). These stations are Rovinj, Splitharbour and Dubrovnik, enabling us to make a reappraisal of the height of extreme sea levels measured from 1955 to 2004. Although previous studies exist [1, 2], it is known that the return sea level estimates obtained for 100-years return period may vary due to a number of mechanisms that affect the components of sea level and because of different methodologies used in the analysis. These can contribute to changes in extremes [3]. Therefore, if possible, the longest sea level series should be used in determining the extreme sea levels expected within any given period. This requires that a chosen distribution is fitted to available sea level data and then extrapolated to the desired exceedance probability. However, there are a large number of different approaches discussed widely in the literature [4, 5, 6].

In this presentation, sea level data from HIRC tide gauge stations that are working continuously since 1955 are used in the analysis. The coordinates of these stations are: Rovinj ($\Phi = 45^{\circ} 05.0$ ' N, $\lambda = 13^{\circ} 37.7$ ' E), Split-harbour ($\Phi = 43^{\circ} 30.4$ ' N, $\lambda = 16^{\circ} 26.5$ ' E) and Dubrovnik $(\Phi = 42^{\circ} 39.5' \text{ N}, \lambda = 18^{\circ} 03.8' \text{ E})$, representing northern, middle and southern part of the east coast of the Adriatic respectively. Extreme sea levels, annual maxima and minima are derived from sea level records [7]. In the analysis we applied the best known, simplest, and most widely used method of analysis of extreme sea levels. It is the annual maxima method considering the case where there is no trend and where the series of annual maxima and minima are stationary [4]. In brief, the analysis estimates the asymptotic distribution of sea level maxima through fitting to a "Generalised Extreme Value" (GEV) distribution to the ranked annual extremes, and uses this frequency distribution to estimate, by extrapolation, the return levels and the associated return periods. We processed the data by applying the Extremes Toolkit (extRemes) designed to facilitate the use of extreme value theory in applications oriented toward weather and climate problems [8].

One hundred years return values based on sea level data from three tide gauge stations were analysed as shown in Fig 1. Return periods and return levels of annual extreme sea levels show a consistent spatial distribution with the maximum values found in the north Adriatic Sea (Rovinj). Model GEV maxima return levels of 100-years return period above local "Mean Sea Level" (MSL) are as follows: 1.28 ± 0.18 m in Rovinj (1.28 m observed), 0.93 ± 0.20 m in Split (0.88 m observed) and 0.69 ± 0.04 m in Dubrovnik (0.68 m observed). Model GEV minima return levels of 100-years return period below local "Mean Sea Level" (MSL) are as follows: 0.94 ± 0.09 m in Rovinj (0.91 m observed), 0.63 ± 0.20 m in Split (0.60 m observed) and 0.58 ± 0.09 m in Dubrovnik (0.52 m observed). Comparison with previous works ([1], [2]) shows a small discrepancy of a few centimetres in the predicted return levels for 100-years return period, because of different methodologies used and due to diverse length of annual maxima and minima time series.



Fig. 1. Return sea level plots for Rovinj, Split-harbour and Dubrovnik calculated from associated GEV distribution (solid line) with 95% confidence interval approximately. Left panel shows maxima sea level data above local MSL while right panel shows minima sea level data below local MSL. Return period are in years and return level are in meters.

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DESIGN AND REALIZATION OF AN INEXPENSIVE TRANSMITTANCE AND FLUORESCENCE METER: INITIAL REPORTING

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Abstract

We describe here the design, laboratory implementation and performance of an inexpensive yet reliable beam attenuation meter for coastal ocean measurements. In its final operational form it is anticipated to be capable of measuring backscattering and fluorescence as well. Given that these parameters are indicators of coastal ecosystem health, low cost optical instruments become valuable tools for activities such as coastal engineering, fish-farming and water quality monitoring in recreation areas.

Keywords : Monitoring, Instruments And Techniques, Coastal Management.

Introduction

The use of optical instruments for monitoring the state of coastal waters has emerged as a common practice during the last decade [1]. It is achieved by measuring specific inherent optical properties, such as scattering, absorption, beam attenuation and fluorescence. Backscattering and beam attenuation are resuspension proxies, while absorption and fluorescence are CDOM and chlorophyll indicators. In the project reported here, the main goal is to build a cheap but reliable optical instrument using widely available off the shelf components. It will be capable of measuring beam attenuation, backscattering, and fluorescence. The instrument in its final field version, will aim towards groups involved in activities such as coastal engineering, water pollution monitoring in recreation areas and fish-farming. At this stage the beam attenuation (transmittance) mode has been implemented in the laboratory and we present here the first results.

Design and implementation

The configuration for the beam attenuation mode incorporates a GaAlAs ultra-bright LED emitting 3000 mcd at 660 nm where gelbstoff absorption is negligible. The emerging 20° light cone is focused via an f=+20 mm biconvex to a \sim 1 mm pinhole for conditioning, and a collimated beam with a diameter of 15 mm is shaped with the aid of an f=+50 mm lens. The beam travels through an attenuation path 130 mm long and then is refocused to a silicon photodiode which has an active area of 1.75 mm and is fitted with a dichroic red filter. The LED is driven by a current modulated at 1 KHz and electronically maintained to guarantee stability of light intensity. The reverse biased photodiode is wired to a trans-impedance mode operational amplifier and after that, the signal is further amplified and filtered by a narrow second order band-pass filter. The effect of any changes in ambient light intensity is eliminated by this stage of selective gain. This signal is then passed through a low-power, precision, true rms-to-dc converter. The output of the system provides a voltage which is linearly dependent on the intensity of the incident modulated radiation. The digital subsystem is responsible for the task of digitizing the dc output voltage of the analogue subsystem. All the circuitry is powered by a single battery by implementing a virtual ground technique.

Calibration and testing

The suspended particle concentration in coastal regions of Eastern Mediterranean ranges from $\sim 100 \text{ mg/l}$ at river mouths to 5-10 mg/l at typical coastal waters. For this reason the calibration and performance testing of the instrument was carried out with suspensions of kaolin (a pure scatterer [2]). The procedure involved the preparation of an initial kaolin suspension at a concentration of 500 mg/l which was successively diluted by adding distilled water to produce several samples. Prior to each measurement, vigorous stirring ensured that the particulate material remained in suspension.

Experimental results and a fitted calibration curve are depicted in Figure 1. The instrument's response to concentrations up to 62 mg/l is notably linear (correlation coefficient 0.997). Cross-calibration with commercially available transmissometers is under way.

Conclusions

The initial laboratory version of the instrument appears to be stable and sensitive enough for typical field measurements. The value of the materials used does not need to exceed 100 euros. Laboratory experiments are in progress for the pure scattering and fluorescence modes. Here the same electronics are used, however the geometry changes. For chlorophyll fluorescence measurements, the sample excitation is achieved by two opposite to each other ultra-bright LEDs placed at an angle of 40° to the photodiode, and emitting a 20° light cone at 470 nm.



Fig. 1. Beam attenuation coefficient as a function of suspended kaolin concentration.

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BOTTOM SHEAR STRESS IN THE GULF OF LION GENERATED BY WAVES AND CURRENTS

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Abstract

Simulations of both currents and waves for the entire year 2001 are performed in order to assess their statistical contribution to the erosive potential over the shelf of the Gulf of Lion. Bottom circulation patterns are also analysed in response to wind forcing. *Keywords : Waves, Currents, Gulf Of Lions.*

Models descriptions

The hydrodynamic processes are modelled using the MARS-3D code [1, 2], a three-dimensional model with reduced (s) vertical co-ordinates. The model is forced by atmospheric conditions (modelled wind field and solar fluxes given by Météo-France), diurnal river discharges, and lateral fluxes and elevations at the open boundaries. The applied model has a resolution of 1.2 km and 30 vertical levels. Wave fields are modelled in the Western Mediterranean Sea with the resolution of 0.1° using the third generation wind-wave model WAVEWATCH-III [3] forced by Météo-France wind fields.

Statistics on bottom shear stress

In order to determine the origin of current induced bottom shear stress (τ_c) in response to wind forcing, an analysis has been done separating continental winds (on-shore winds) and marine winds (off-shore winds) for the entire year 2001. The probability of occurrence of high bottom shear stress greater than 0.04 N/m² linked to one of these wind origins has been calculated (figure 1). The 0.04 N/m² value corresponds to the mean critical shear stress of erosion observed by Shaff et al. [4, 5] on the superficial layer of fine sediment on the Gulf of Lion shelf. The bottom shear stress in this study refers to the skin friction component of the total bottom shear stress, considering that this study is applied to sediment dynamics.



Fig. 1. Origin of bottom shear stress generated by currents. Probability (%) of having, simultaneously, bottom shear stress greater than 0.04 N/m² and off-shore winds (direction from 45° to 225°). The dotted line corresponds to the iso-probability τ_c >0.04 N/m² equal to 1%, the continuous line corresponds to 0.2%. The white area corresponds to zero probability. The 160 m isobath (slope) is plotted.

It clearly appears that on the top of the shelf break (circle c), strong currents may occur during south-eastern wind storms (bright area).

The probability for the shear stress to reach the critical value is nevertheless low (in the order of 0.1%) Near the coast, marine winds have a greater influence (further from the shore). Continental winds are also able to mobilise bottom water layers in some coastal locations. For instance, upwelling cells, described by Millot [6] in front of the Petit Rhône, are however mainly active during Mistral or Tramontane wind events (black area, circle A). For that case, the probability of occurrence of erosion is about 1%.



Fig. 2. Probability of having a wave induced bottom shear stress greater than the stress induced by current when the total friction (τ_{cw}) is greater than the critical value of 0.04 N/m² ($\tau_w > \tau_c$ and $\tau_{cw} > 0.04$ N/m²). Isobaths 30, 50, 100 and 160 m are plotted.

The analysis of wave induced bottom shear stress (τ_w) for year 2001 shows that the effect of waves dominates the effect of currents on most of the shelf when total skin friction (τ_{cw}) is high (>0.04 N/m²) (figure 2). Nevertheless, current seems to be dominant on the external shelf near the top of the slope (between 100 and 160 m). At 100 m depth, swell can exceptionally have an effect on the bottom during big storms. Waves with significant height of 5 m and mean period of 12 s may also generate a bottom shear stress of 0.04 N/m² in this relatively deep area.

Conclusion

This study has underlined the effect of winds on the bottom circulation patterns of water and sediment. Marine winds are able to induce sediment transport and erosion on most of the shelf because of simultaneous generation of strong coastal current and efficient swell. Continental winds (Mistral and Tramontane) appear to have erosive potential exclusively along the shore and essentially in the upwelling cells. These winds are however associated to wind waves of low amplitude and, in this way, they will probably not constitute the major forcing process of the sediment transport on the shelf of the Gulf of Lion.

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TRANSFORMATION OF LEVANTINE INTERMEDIATE WATER TRACKED BY MEDARGO FLOATS IN THE WESTERN MEDITERRANEAN

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Abstract

A clustering methodology is applied to investigate the thermohaline structure of Levantine Intermediate Water (LIW) in the western Mediterranean basin. Sixteen free-drifting hydrographic profilers were deployed in the framework of the MFSTEP project (EUK3-2001-00174) from September 2003. A total of 925 CTD profiles collected up to the beginning of February 2006 have been used in the analysis. The results are in good agreement with the general circulation scheme for intermediate waters in the basin and confirm the hypothesis of a "discrete-continuous" thermohaline structure of LIW.

Keywords : Intermediate Waters, Salinity, Temperature, Western Mediterranean.

In 1985 the hypothesis of a "discrete-continuous" structure of LIW was proposed [1]. According to this idea, the LIW layer can be thought of as an "emulsion" of background water with high temperature and salinity, in which lenses and sheets of even more saltier and warmer waters are dispersed. The background is initially formed by LIW, sunk down to the corresponding isopycnal level in its formation region before circulating at intermediate depths. New volumes of LIW, generated due to density increasing by cooling in winter of water salinizied in summer due to evaporation in the surface layer, continue to sink down to the depth of the isopycnal level of this background water [2]. These saltier and warmer volumes of LIW are eventually broken into smaller ones by mixing processes, mainly of double diffusion nature. The smallest lenses dissipate, maintaining the high temperature and salinity of the background layer.

CTD data from 16 profiling floats (MEDARGO component of the MF-STEP project) operating in the western Mediterranean from September 2003 until the beginning of February 2006 were analysed. Objective cluster analysis [3] was used to classify the ensemble of 925 LIW θ -S curves to unveil classes of differently transformed waters. A maximum radius r=0.05°C was applied so that, to be included in the same cluster, θ -S curves may differ at most in θ by 0.05°C or in S by 0.0125 from the central θ -S curve. As a result seven clusters were obtained. In Fig.1 one can see three main groups of clusters, represented by their centres of mass.



Fig. 1. Representative θ -S curves for 7 clusters.

Clusters 1, 2 and 3 are situated in the saltier and warmer part of the θ -S diagram and correspond to the saltiest LIW located in the Tyrrhenian subbasin. Less saline clusters 5, 6 and 7 include the θ -S curves in the interior of the Provençal and Algerian sub-basins (Fig. 2). θ -S curves included in cluster 4 lie in the channel of Sardinia area and in the central part of the Provençal and Algerian sub-basins marking the transition between less transformed LIW from the eastern part and more transformed LIW from the western part (Fig. 2).



Fig. 2. Float positions, marked according to the cluster they belong to.

The θ -S curves belonging to the largest cluster (number 6) are encountered everywhere west of Corsica and Sardinia, and they should be considered as the background LIW. Less transformed LIW from cluster 5 and more eroded one from cluster 7 are embedded into the area occupied by the background LIW from cluster 6. An interesting fact is that some floats sampled differently transformed LIW in consecutive casts. This means that the floats did not park at the same portion of LIW and that their trajectories were significantly affected by surface drift, during their periodic ascent, surfacing and descent motions to transmit data by satellite link. The clustering method used to analyze the θ -S curves in the western Mediterranean basin allowed classifying in a canonical, automatic way the spatial distribution of differently transformed LIW. We have also shown that differently transformed intermediate waters were embedded into this background but at specific, different geographical areas of the basin. These results confirm the LIW "discrete-continuous" hypothesis.

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OPERATIONAL OCEANOGRAPHY OF THE BLACK SEA BASIN: MAJOR STEPS

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Abstract

Methods and principles of operational oceanography developed for the Black Sea basin investigations are described. The concept of a modern Black Sea observing system is presented. *Keywords : Black Sea, Models, Remote Sensing.*

Implementation of methods and principles of operational oceanography could be considered as the dominant concept of the Black Sea basin investigations during the last 15 years. It was started by the formation of the Black Sea international oceanographic community during the realization of the HydroBlack and ComsBlack projects. Both projects were oriented to the fulfillment of the basin scale multidisciplinary surveys, which were carried out by the Black Sea riparian countries [1]. The concept of international cooperation and necessity of regular observations was recognized as the real need to meet the challenges posed by the basin degradation. The next important common efforts were done in the framework of the NATO SfS project TU Black Sea. An efficient multidisciplinary data base, which was built by the project team, was used then as the base of the multidisciplinary modeling of the Black Sea dynamics and ecosystem. The experience obtained during the HydroBlack, ComsBlack and NATO SfS projects has shown that new observational technologies should be adopted by the Black Sea oceanographic community to achieve success in the development of an efficient regional observing system. The concept of a modern Black Sea observing system was proposed as the outcome of the NATO CCMS project in the mid of 90-ies [2]. The Black Sea GOOS project was arranged then for the implementation of the elaborated strategy [3].

An initial cost-efficient operational observing system was built in the basin at the beginning of the second millennium based on space remote sensing data, measurements from surface drifting buoys and profiling floats, and a network of coastal observations [4]. The implementation of the initial observing system stimulated the development of a nowcasting and forecasting system of the Black Sea dynamics and ecosystem. A successful realization of the system and its pilot operation was carried out by the consortium of scientists of the Black Sea riparian countries in 2005 in the framework of the EC FP5 ARENA project [5]. Prof. Umit Ünlüata leaded the implementation of the oceanography principles for the Black Sea basin during many years. Now we are ready to make the next step and build an efficient tool, not only for investigation of the Black Sea basin but also for management of its resources and achieve those dreams and hopes discussed with Umit 15 years ago.

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INVESTIGATION OF EASTERN MEDITERRANEAN TRANSIENT INFLUENCE IN THE IZMIR BAY

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Abstract

Recent changes in water mass characteristics of the Aegean Sea have considerably influenced the Eastern Mediterranean thermohaline circulation since 1990 and vice versa. A combination of salinity increase and temperature drop in the Aegean Sea has caused massive dense water formation, and a strong outflow towards the deep and bottom parts of the Eastern Mediterranean. In order to balance the dense water outflow, LSW (Levantine Surface Water) and LIW (Levantine Intermediate Water) enter into the Aegean Sea. The eastern coast of the Aegean Sea was mostly influenced by these newly entering warm water masses. The purpose of this study is to examine the warm and highly saline Levantine waters LWs (LSW and LIW) in the vicinity of the Izmir Bay, where LWs were observed especially in winter and spring.

Keywords : Circulation, Hydrology, Aegean Sea.

İzmir Bay is conventionally divided into three areas according to their physical characteristics: Outer, Middle and Inner Bays. The depth in the Outer Bay is about 70 m. It decreases significantly towards the Inner Bay to about 10 m depth. The northerly wind that blows for most of the year is a constant feature of the Izmir Bay area.

The Mediterranean circulation has shown changes due to climate changes in recent years. Therefore, it is studied in two periods, as before and after 1990. During the latter phase, Aegean Sea has become the source of a new type of Eastern Mediterranean Deep Water (EMDW) [1, 2, 3 and others]. Levantine Surface Water (LSW) occasionally entering into the Aegean Sea before 90's could be a main triggering mechanism for Eastern Mediterranean Transient (EMT). Increasing salt content results in rising density levels and therefore outflow of Aegean Sea Water through the straits at both sides of Crete over the sills. The resulting outflow from the deep layers is fed back again, and causes an intensification of the inflowing waters of Levantine origin (LSW and LIW). These water masses influence the Outer Bay water in the vicinity of Izmir Bay. Therefore the purpose of this study is to examine how the LWs change the water properties of the İzmir Bay. For this purpose, data sets from 16 cruises and hourly wind data between 1994 and 2005 are examined. A numerical model (Killworth's Ocean Model) is used to calculate the general circulation patterns.

In the bay, three distinct water masses exist: ASW (Aegean Sea Water), IBW (Izmir Bay Water) and IBIW (Izmir Bay Inner Water). They affect the thermohaline structure of the bay [4]. ASW is influenced especially in winter and spring by LWs. After EMT LWs enter into the Aegean through the Rhodes and Karpathos straits towards the north. Northwardflowing Levantine surface current, carrying warm, highly saline LWs, influences the coastal area along the western Turkish coast. LW masses can be observed mainly in winter and spring in the vicinity of Izmir Bay with a temperature of 16.3-16.5°C and salinity 38.8-38.95 (Figure 1). In summer, the water mass that influences the Izmir Bay environment is the dense and cold upwelling water formed along the eastern coastal area of the Aegean Sea. This water mass is about 2°C colder (about 19°C) than the water mass observed near the western Aegean Sea coastal area [5]. The origin of the upwelling water is the area near Cape Baba and Edremit Bay. The northerly Etesians influence the waters off-shore of Cape Baba, causing upwelling. Southeasterly winds, which are prevalent through the year in the vicinity of Edremit Bay, force water masses to flow outwards through Müsellim strait, and these two effects cause a surface current to flow from Cape Baba towards the central Aegean Sea. This saline and cold water, especially formed in summer, has a salinity of 39.0 and temperature less than 19°C. The upwelled water flows southwards influencing a big area from the west side of the Lesvos Island up to the Chios Basin, forming two cyclonic eddies. One eddy is formed in the western coastal area of Lesvos Island and the second one evolves in the Chios Basin off the western off-shore side of Chios Island.



Fig. 1. Surface temperature contours in Spring 1992

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COHERENT VORTICES IN THE MEDITERRANEAN SEA

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Abstract

Some of the ideas and methods commonly used to study coherent structures in turbulent flows have been applied to analyse the role of coherent vortices in the Mediterranean Sea. Results have provided for the first time a general picture of the evolution of mesoscale eddies in the Mediterranean basins, and allowed analyzing in detail the relationship between their spatial structure and the transport and mixing of tracers, as well as the impact of ocean structures in the statistical properties of the Mediterranean circulation. A remarkable novel aspect is that the Mediterranean circulation is approached by extracting and isolating the dynamical role of the coherent structures. *Keywords : Mesoscale Phenomena, Remote Sensing, Turbulence, Circulation.*

Coherent structures are recognized to be a key component to understand the dynamics of turbulent flows, and to have a great impact on the mixing properties of tracers. The quasi-bidimensional nature of the ocean flows together with the view, as seen in satellite images, of an ocean surface populated by mesoscale structures, lead to consider the two-dimensional and geostrophic turbulence theories as a paradigm for understanding the ocean dynamics.

Following these theories, the identification of vortices in two-dimensional geophysical flows has been proposed in terms of the Okubo - Weiss parameter W [1], defined as the square of the normal component of flow strain, plus the square of its shear component, minus the square of relative vorticity. We use W to identify a vortex (in fact the vortex core) as the simply connected region with W <- 0.2 σ (the spatial standard deviation of W), a useful threshold to establish the dominance of vorticity over strain.

Application of the method to altimeter sea surface anomaly maps [2] allows computing a census of vortex in the Mediterranean Sea. We have defined a coherent vortex as a vortex with amplitude (maximum of W inside the vortex) higher than 2σ . Figure 1 shows the centers of coherent vortices identified in altimetric maps for a period of seven years. The different Mediterranean sub-basins do not have the same characteristics, and the detected structures concentrate mainly in areas where mesoscale eddies have been commonly observed by other means. The spatial distribution of most intense coherent vortices is correlated with the areas of high levels of eddy kinetic energy [3].



Fig. 1. Spatial distribution of the centers of observed intense vortices (a $>2\sigma_W$) for the period October 1992 - October 1999

An important outcome from 2D turbulence simulations is that coherent structures are responsible for the non-Gaussian character of the statistics on velocity fields [4]. Evidences on the non-Gaussianity of ocean velocity fields have been signaled from altimeter data, currentmeters and Lagrangian floats [5]. In the Mediterranean Sea probability density function (PDF) of velocity fields derived from Lagrangian buoys and from altimetric maps exhibit similar characteristics: a Gaussian core with tails separating from the Gaussian behaviour (Fig. 2). Using a field separation based on W we can determine the field associated to intense vortices and the contribution from the resulting background field. Fig. 2 shows that the non-Gaussian part of the velocity PDF is due to intense vortices that represent only 20 % of the total detected structures [6].



Fig. 2. Probability Density Functions of the Mediterranean surface velocity field obtained from Lagrangian drifters (left), from coherent vortices in altimetric maps (centre), and from the background altimetric velocity field (right)

These results suggest that intense vortices play a major role in the Mediterranean dynamics. To go deeper we have also performed an analysis of the vorticity field for the same dataset, but following a completely different technique for flow separation [7]. The flow is supposed to be separated in a non-coherent and a coherent part extracted by wavelet projection of the vorticity field. The velocity field associated with the coherent part, which is built from a relatively small number of wavelet coefficients, accounts for most of the enstrophy and energy of the original field.

This reinforces the idea that the small percentage of intense vortices dominates the dynamics in the Mediterranean Sea. Indeed, these structures are the main responsibles for the non-Gaussian velocity PDFs, which induce anomalous dispersion, and then classical constant eddy diffusivity approaches should be discarded in favor of more complex formulations. To account for the particle dispersion due to vortices, Lagrangian models may be formulated through a two-component stochastic process separating the dynamical contribution associated with the background non coherent induced field and the vortex-coherent induced dynamics.

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CONTRIBUTION OF INTENSE CASCADING TO MODIFICATIONS OF WESTERN MEDITERRANEAN DEEP WATER AS SHOWN BY HYDROCHANGES MOORING

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Abstract

The effects of the cold, anomalously dry, and very windy winter 2005 in the deep water thermohaline properties are evidenced by a time series of hydrographic data recorded by the ICM HydroChanges mooring in the deep slope of the NW Mediterranean. In late January 2005 intense dense shelf water cascading was observed in the Gulf of Lions' submarine canyons, and almost simultaneously a dense deep water mass, warmer and saltier than usual, reached the deep mooring site. After 30 days, the colder, fresher and even denser waters originated on the shelf arrived at the mooring, and their signature could be detected for 35 days. By late spring 2005 the mixture of both dense water masses reached new stable thermohaline properties with higher values than those that characterized the deep layer before 2005. *Keywords : Deep Waters, Continental Slope, Time Series, Hydrography, Balear Sea.*

The NW Mediterranean Sea is the formation region for the dense Western Mediterranean Deep Water (WMDW), in a typical winter convection process that involves the salty Levantine Intermediate Water (LIW). Over the wide shelf of the Gulf of Lions and adjacent areas winter heat losses and evaporation caused by cold and dry northerly winds induce cooling and mixing of the low salinity coastal waters, which eventually become denser than the surrounding waters and sink. These dense waters flow down the continental slope, in a process known as cascading, until they reach their density equilibrium at sub-surface. Sometimes these cascading waters can be denser, reach deeper layers, and interact with the saltier LIW. In exceptional occasions, as the abnormally cold 1999 winter, waters generated over the shelf have been traced down to 1000 m together with intense down slope velocities [1]. During autumn and winter 2004-05 precipitation on the NW Mediterranean was very scarce. For some time air temperatures were lower than the climatologic average, and northerlies were dry, strong and persistent (values above 100 km/h recorded during 30 days, as reported by MétéoFrance). Winter 2005 was certainly anomalous and very favourable for dense water formation in the region.

A mooring line with a SeaBird 37 CTD recorder and an Aanderaa RCM8 currentmeter near the bottom was installed by ICM-CSIC in the deepest part of the continental slope (1890 m depth) off the Catalan coast (41° 28'N, 3° 40.4'E) as contribution to the CIESM HydroChanges program.



Fig. 1. Potential temperature and salinity recorded by the ICM-CSIC HydroChanges mooring in the NW Mediterranean at 1875 m of depth during 21 months, including the exceptional 2004-2005 winter.

A first deployment period lasted from October 2003 to July 2005. Some 120 km upstream of this location, other moorings installed in submarine canyons to analyse sediment transfer processes recorded during winter 2003-2004 shelf water cascading events characterized by decreases in temperature and increases in current speed for few days. During winter 2004-05, the persistent northerly winds and the reduction of river discharges helped to dramatically enhance the intensity of the cascading mechanism. From late January a major cascading event occurred continuously until late March, as recorded in the Cap de Creus Canyon, with a temperature decrease of the order of 3°C and down-canyon steady cur-

rents between 40 and 80 cm/s at a depth of 750 m [2].

Potential temperature and salinity values recorded at the HydroChanges station at 1875 m (Figure 1) were almost unchanged from October 2003 until the end of January 2005, indicating a water mass stable situation with typical WMDW characteristics, without any seasonal signal. Then both variables suddenly increased to 12.99°C and 38.50. In early March a drop of more than 0.2°C and 0.05 occurred, both variables remained during one month in a range of low values, and afterwards gradually increased until reaching quite steady values above the initial ones. These sudden variations precede or coincide in time with changes in the structure of deep CTD profiles in the NW Mediterranean observed by other authors after the 2004-05 winter [3, 4, 5]. These authors explain the θ and S increase as corresponding to an anomalous WMDW formed during this exceptional winter, either by involving a larger amount of LIW than usual, or this LIW having higher temperature and salinity values.

The important drop in both temperature and salinity in early March, together with an extraordinary increase in speed recorded by the moored current meter (up to 60 cm/s), seems to be a clear indication of a very intense shelf water cascading. The extremely low precipitation occurred in the region during winter 2004-05 resulted in a strong reduction of river discharges and then a remarkable increase of salinity in shelf waters [4]. As a consequence, this year the cascading waters became extremely dense and crossed our moored instruments at 1875 m with a σ_{θ} peak of more than 29.15 kg/m³, while spreading to the deepest part of the basin. Once this cascading event finished, the densest cold and fresh water was replaced and mixed with the new 2005 WMDW, until stabilizing around 12.88°C, 38.48, and 29.12 kg/m³. The resulting water was slightly warmer (+ 0.03°C) and saltier (+ 0.03), and markedly denser than the previously present WMDW, in agreement with the positive θ /S anomaly found in deep CTD casts conducted in several areas of the western Mediterranean during the first half of 2005 [3, 4, 5].

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THE TEMPERATURE AND SALINITY VARIABILITY OF THE MEDITERRANEAN OUTFLOW DURING THE TWENTIETH CENTURY

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Abstract

In order to investigate the contribution of Mediterranean Water (MW) in the warming of the Atlantic intermediate layer, we focused our analysis on the ocean area closer to the Strait of Gibraltar, where the MW source water is well observed. Temperature and salinity data from Medar/Medatlas II and MODB were used in order to correlate possible changes in the thermohaline characteristics of the Mediterranean Sea with influences on the spreading of the Mediterranean Water outflow in the eastern North Atlantic, and to identify possible variations and trend if any.

Keywords : Temperature, Salinity, Strait Of Gibraltar.

One of the key processes of the thermohaline circulation is the water mass transformation due to external forces and the continued renewal and stratification of the entire water column. In this context, the marginal seas like the Mediterranean Sea, Arctic Sea and Greenland, Iceland, and Norwegian Seas play a fundamental role by contributing on feeding the global ocean with dense dense water.

In particular the Mediterranean water (MW) is one of the intermediatetype water masses observed in the North Atlantic. It is composed by a mixture of Levantine Intermediate Water (LIW) and deep waters produced within the Mediterranean basin, and enters the Atlantic Ocean through the narrow strait of Gibraltar with a mean volume exchange of about 1 Sv.

The MW lies between 800 and 1300 meter depth characterized, albeit density compensated, by significant salt and temperature anomalies, with $\Delta S \approx 1$ psu and $\Delta T \approx 2^{\circ} C$ with respect to the overlying North Atlantic Central water. In most of the North Atlantic the core of MW is clearly recognizable along the average isopycnal $\sigma_{\theta} \approx 27.60$ surface and at ≈ 1000 meter.

The Gulf of Cadiz, including also the Strait of Gibraltar, is the transition sub-basin where the pure Mediterranean water undergoes for the first time a strong mixing and entrainment with the Atlantic water. It can be considered as the sub-basin where the source water of the MW observed in the Nord Atlantic is originated. In particular, for our study, we selected the northern region of the Gulf of Cadiz, between 35.5° N and 37.0° N and west of 5.9° W, where most of the water of Mediterranean origin flows and is clearly observed.

Data were gathered from different data banks. Unfortunately, the collected data are not uniformly distributed in time, making the analysis more suitable for the last fifty years, and moreover the data set can give a good behaviour of MW properties within the last century.

Temperature and salinity observations in the Gulf of Cadiz area show seasonal, interannual and decadal variations. Figure 1 shows salinity and temperature records at a depth of 1200 m including the standard deviation of the data. The standard deviation around the mean value can be quite variable. It has been calculated by assembling the data from the same month over the entire period; moreover it is obtained combining data from different cruises and often from different parts of the basin. Looking at the entire time series, the temperature shows a warming trend of 0.11°C/decade, and salinity an increase of 0.035 psu/decade. These results compared with those, for example, computed by Potter and Lozier [1] (temperature 0.101 \pm 0.024 °C/decade and salinity 0.0283 \pm 0.0067 psu/decade), based on hydrographic data collected since 1955, confirm that the Mediterranean outflow waters in the eastern North Atlantic show a density compensated increase in both temperature and salinity.

Any possible mechanisms to explain the observed variability of MW, certainly involve the variability of the Mediterranean water mass in connection with the physics of the Strait of Gibraltar.

In particular, our analysis has taken into consideration those processes occurring during the first stages of the spreading of MW in the North Atlantic that are most likely to be affected by changes occurring inside the Mediterranean Sea, like hydraulic control and warming of the Mediterranean source water.



Fig. 1. Salinity and temperature records at a depth of 1200 m with linear trends.

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TIDE AMPLITUDE AND WATER FLUXES RELATIONSHIP IN THE HYDRAULICALLY CONTROLLED SOUTH LAKE OF TUNIS

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Abstract

We study the hydrodynamic process that controls the water renewal of the Tunis South Lake at semi-diurnal time scales. In order to shed light on the relation between tide amplitude and renewal time, we combine current and surface level observations at the lake locks with a 2-D analytical model that takes inTO account both the M_2 tide forcing and the locks hydraulic effect. Then a numerical model, forced by the surface level observations and based on the analytical model, allows us to simulate the filling, the slack and the emptying phases. *Keywords : Lagoons, Tides, Coastal Models, Analytical Methods.*

Introduction

The South Lake (Fig. 1) is located southeast the city of Tunis $(10^{\circ}30^{\circ}\text{E}, 36^{\circ}47^{\circ}\text{ N})$. After dredging works [1], its area was reduced to 7 km² and its depth becomes uniform (H=2.2 meters). Two groups of locks allow a water exchange between the Bay of Tunis and the lake: the "Radès locks", which allow water inflow from the Bay of Tunis and the "Tunis locks", from which the water outflows, via the "Tunis Channel". Thanks to this hydraulic design, the lake water volume increases, when the sea surface level is higher than the lake surface level, and decreases in the opposite situation. In the Bay of Tunis, the surface level variations are mainly forced by the semi-diurnal tide wave M₂ [2]. Our goal is to verify and establish analytically the relation between surface level variations and currents observed at the locks, and then to numerically simulate the filling, the slack and the emptying phases, by taking advantage from the observed parameters.



Fig. 1. Location of the Tunis South Lake (top) and sketch of the water exchange between the lake and the Bay of Tunis (bottom).

Data and methods

First, a simultaneous monitoring of the incoming (Radès) and outgoing (Tunis) currents across the 2 groups of locks and the surface level variation was carried out during several semi-diurnal tidal cycles. Fig. 2 shows the typical shapes of the surface level and currents time series. Then, we developed a simplified analytical model to understand the relation between surface level variations and currents observed at the lock gates. The model takes into account the alternate opening and closing of the locks that permits only inflow at Radès and outflow at Tunis.



Fig. 2. Water level variation (left) and velocity (right) recorded at the locks during one tide cycle.

We assume that the time interval $[0,TM_2/2]$ corresponds to the tide flood, so the Radès gates are opened, while the Tunis gates are closed. At re-

verse, during the time interval $[TM_2/2,TM_2]$ corresponding to the ebb, the Tunis gates are opened, while the Radès gates are closed. On the basis of mass and momentum conservation and vertically integrated Saint-Venant equations, one can show, after some calculus, that:

$$u_{in} = \frac{S}{H_a I_a I_a} \frac{\partial}{\partial t} \int_0^{Lg} h(x,t) dx$$
 and $u_{out} = 0$ during the tide flood (E.1)

 $u_{in} = 0$ and $u_{out} = -\frac{S}{He.Le.Lg} \frac{\partial}{\partial t} \int_0^{Lg} h(x,t) dx$ during the tide ebb (E.2) u_{in} and u_{out} are the inflow and outflow currents respectively at the filling (Radès) and the emptying (Tunis) locks,

S: Lake's area, He: Water depth at the locks, Le: Locks width, Lg: Lake length, h(x,t): surface level elevation along the longitudinal axis of the lake, TM₂: Period of the semi-diurnal M₂ tide wave (12h24min). Furthermore, it is possible to show that the residence time is:

TR=TM2.H.Lg/
$$\int_{0}^{Lg} h(x,t)dx l_{0}^{TM2}$$
 (E.3)

The numerical model is forced by equation (E.1) and (E.2), where h(0,t) and h(Lg,t) are respectively the surface level at the Radès and Tunis locks. For this purpose, we satisfy a Dirichlet type condition at the two groups of locks and a Neumann type along the banks of the lake.

Main results

- The monitoring of the surface level and velocities (inflow at Radès and outflow at Tunis locks) allows us to verify experimentally the relation: $u_{in} - u_{out} = f(\delta h/\delta t)$ (E.4), as it clearly appears from the two curves of Fig. 2. The relation E.4 is in fact a combination of relation E.1 and E.2. The correlation between $(u_{in}-u_{out})$ and $\delta h/\delta t$ is about 0.75. This results means that the magnitude of the emptying or flushing fluxes, i.e. the renewal time, is a function of the speed by which the surface level varies with time.

- The renewal times deduced from current observations ranges from 6.9 to 9.3 days. Thanks to the mathematical model, that allows us to understand the overall mechanisms that is governing the lake hydrodynamic, by taking in account both the M2 tide forcing and the hydraulic control processes due to the locks (E.3), we estimate that the water time renewal varies between 6.7 and 8.2 days, depending on tide forcing condition. These values are in a good agreement with the values calculated with current observations.

- Thanks to the modelling of the hydraulic design that controls the incoming and outgoing fluxes, the model has the ability to reproduce the transient state corresponding to the slack phase. During this phase, the model shows a quick reversion of the 2D currents, which occurs during 20 minutes (not shown). It is the time needed, by the gravity wave, to cross the lake along its longitudinal axis, from the Tunis lock gates to the Radès lock gates. We have verified this phenomenon in site.

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RECENT OBSERVATIONS OF SEASONAL VARIABILITY OF THE MEDITERRANEAN OUTFLOW IN THE STRAIT OF GIBRALTAR

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Abstract

Recent observations of the outflow collected near the bottom in key points of the Strait of Gibraltar within the Spanish funded project INGRES (REN03-01608/MAR), suggest the existence of a seasonal cycle of temperature and density with warmer and lighter waters leaving the Mediterranean Sea in winter and cooler and denser waters in spring early summer. The amplitude of the signal is around 5 10^{-2} °C for potential temperature and 1.5 10^{-2} for potential density, salinity hardly showing any seasonal fluctuation. The outflow also shows a seasonal cycle with maximum volume transport in April, in coincidence with the signal of potential temperature. *Keywords : Strait Of Gibraltar, Western Mediterranean, Monitoring, Deep Waters, Water Transport.*

The experimental data of this study were collected in Espartel (ES, 35° 1.7'N, 5° 58.6'W) and Camarinal (CS, 35° 54.8'N, 5° 44.70'W) sills in the Strait of Gibraltar (Figure). The bulk of data come from ES station, which started working in September 2004 and continues collecting data. The station has an uplooking ADCP at 20 m above sea floor, a RCM9 and a MicroCat CT at around 15 and 10 m above sea floor, respectively, all instruments recording every 30 min. From February to May 2006 a second mooring line with the same configuration as ES line was deployed in CS with the aim of comparing simultaneous observations at both sills. ES station is linked to Hydro-Changes initiative and is aimed to monitor the properties of the Mediterranean outflow on the long term. Presently the station has collected data over two years and has provided useful information to investigate annual variability, which is analysed in this contribution.



Fig. 1. Map of the Strait of Gibraltar showing the main topographic features. CS and ES indicates Camarinal and Espartel sills, MB is the submarine ridge of Majuan Bank, TB is the Tangier Basin and TN is Tarifa Narrows. The plotted isobaths are 100 m, 290 m (the light-shaded contour chosen to highlight CS, -297 m), 400 m (the medium-dashed contour), and 500 m, 700 m and 900 m.

Hydrological observations are largely modified by semidiurnal tidal flow. To remove tides, the original series were divided into pieces one semidiurnal tidal cycle long and the absolute minimum of potential temperature (T-pot), and maxima of salinity and sigma-theta within each piece were identified. The resulting series of extremes represent the properties of the less-mixed Mediterranean water that is able to overflow the sills during a given tidal cycle, and they are suitable for seasonal variability studies. Extreme values in CS are mainly observed between 2 and 3 hours after the maximum tidal outflow. This is an encouraging finding because the flow over CS is able to suction water residing at the eastern side of the Strait from depths of 700 m or more [1], where Mediterranean water is less mixed and maintains purer T/S characteristics. Maximum suction will coincide with maximum outflow and, from this time onwards, the water crossing the sill will exhibit purer and purer Mediterranean characteristics until the internal bore formed downstream of CS during the flood tide [2] occurs. It happens around one hour before high tide, that is, nearly

three hours after the maximum outflow, which should be the time when the less mixed Mediterranean water is expected to be overflowing CS. It is also important to say that while the original series of T-pot and S behave differently in both sills, the time series of extremes do not, thus ensuring that low frequency signals can be analysed using data either from CS or from ES.

The series of extremes and computed outflow from ADCP observations in ES have been fitted to a harmonic function of annual and semiannual frequencies in order to investigate seasonal variability. The clearest seasonality is found in T-pot with warmer water flowing by the end of the year. A non-negligible semiannual signal, arising from the fact that T-pot drops rapidly after reaching the seasonal maximum and increases slowly towards the next maximum, combines with the annual one to produce the coldest flow around March. Salinity hardly has seasonal signal while sigma-theta shows a signal induced by T-pot. The computed outflow exhibits enhanced winter variability due to the stronger meteorological forcing in this season but also a seasonal signal whose phase agrees with previously reported values [3, 4] and coincides with the time of the year when T-pot is at its lowest value.

The behaviour depicted above suggests that the seasonal variability is closely related to the process of formation of WMDW in the manner put forward by Bormans et al. [5]. Winter deep convection would replenish the reservoir of WMDW (or WMDW plus other intermediate waters overlying this water mass, such as the Tyrrhenian Dense Water) in the western Mediterranean basin, rising the hypothetical interface some tens of meters and making colder water available for suction over CS. Coincidentally with this fact, the outflow would increase, in agreement with the observations. Should this be the explanation, the seasonal cycle would be strongly dependent on the winter conditions in the WMDW formation areas. Mild winters would lead to a reduced seasonal signal (the case of the winters in early 2000's) while hard winters, like those of 2005 and 2006, would produce noticeable signals.

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NEW HYDROGRAPHIC SCENARIOS IN THE WESTERN MEDITERRANEAN AS A CONSEQUENCE OF THE EMT PROPAGATION

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Abstract

Recent studies have definitively shown the high sensitivity of the Mediterranean Sea to the effects produced by the large-scale atmospheric systems. The rapid response of this basin, when compared with the ocean time scales, makes the interannual variability of the circulation an important signal that, in some regions, may prevail on the annual cycle. A long-term monitoring of the hydrographic properties of water masses across the Sicily Strait, initiated in the second half of the 80's, permitted the identification of the important interannual variations in the water exchange between the eastern and the western basin and to follow the evolution of the water mass characteristics under the influence of the so-called Eastern Mediterranean Transient (EMT). The well known changes in the deep thermohaline circulation of the Eastern Mediterranean led to significant changes in the western basin, modifying the outflow characteristics through the Sicily Strait and consequently those of other western water masses starting since early 90's.

Keywords : Hydrography, Western Mediterranean.

The deep water of the Western Mediterranean Sea is known to have become warmer and saltier since about the 1950s. Many authors have attempted to explain these deep trends, attributing them to an increase in surface salinity in both the Eastern and the Western Mediterranean and speculating on connections to the changing environmental conditions, e.g. the greenhouse effect, local atmospheric conditions, and river damming. An acceleration of this trend was observed during the late 90's and was attributed [1, 2] to a first sign of the influence of the Eastern Mediterranean Transient (EMT) in the Western Mediterranean.

The well known changes in the deep thermohaline circulation of the Eastern Mediterranean Sea, the EMT, which modified the outflow characteristics through the Sicily Strait, led to significant changes in the Western Mediterranean Sea since the early 90's [2].

It was possible to follow the evolution of the water mass characteristics under the influence of the climatic transient. It is only after 1988 that a clear change is observed in the central region of the Strait: the salinity of the intermediate layer increases progressively until 1992, followed by a sudden drop which lasts until 1997. During that period the EMT has the maximum influence in the Strait. Subsequently, the new phase begins and continues over the years to follow. The available observations also allowed us to establish that the EMT reached the Tyrrhenian entrance between April and May 1992 due to a huge, impulsive amount of salt and cold water mass [2]. After a first modification in the deep layer, significant changes have been observed in the intermediate layer.



Fig. 1. θ -S diagram in the deep layer in 2005 and 2006

An important factor controlling the deep water formation process in the

Gulf of Lions is the salt distribution in the water column and more specifically the LIW salt content. The further enhancement of the salt increase, present in the LIW layer for a long time, makes the western basin more prone to produce warmer and saltier deep waters.

In the deep water formation area and in the "spreading region" of the Western Mediterranean Deep Water (WMDW), in particular in the Gulf of Lions, the Ligurian Sea, the Balearic Sea, the Algero-Provencal Basin and the Algerian Basin, peculiar θ -S shapes were found in spring 2005, showing the presence of a recently formed layer of WMDW, spreading at the bottom of the whole Algero-Provençal Basin (Figure 1). It was characterized by unusual θ -S shapes, as its temperature, salinity and density were higher with respect both to the resident deep waters and to the climatological values. The influence of the EMT on the western deep water formation processes appears the most suitable candidate to explain these observations [3]. If exceptionally severe weather conditions during winter 2004-2005 were responsible for an extensive deep water production [4], the highly saline and warm characteristics can be attributed to the progressive salt and heat accumulation in the north-western Mediterranean during the previous years. The persistency of that structure has been confirmed during 2006, when similar deep water was detected in the western basin. The deep water production during winter 2004-2005 and 2005-2006 confirms an enhancement of the interannual variability in the WMED hydrographic conditions and suggests that the EMT influence on the WMED is far to be concluded, especially if high levels of salt and heat are maintained in the Eastern Mediterranean outflow. Investigation of spreading of those new waters evidences how the EMT, beside modifying the WMED hydrographic characteristics, was able to deeply influence key processes characteristic for this basin, with significant consequence on the exchanges through the Gibraltar Strait [5].

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SURFACE CIRCULATION IN THE EASTERN MEDITERRANEAN USING LAGRANGIAN DRIFTERS

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Abstract

In the period spanning from September 2005 to October 2006, 81 Lagrangian drifters were deployed in the Eastern Mediterranean using ships of opportunity or during oceanographic cruises. Surface circulation statistics, both Eulerian and Lagrangian, were performed using data recorded until 18 August 2006. The main circulation features of the area, together with their variability, are well delineated. The energy of the mean flow and of the fluctuating currents were also computed.

Keywords : Circulation Experiments, Eastern Mediterranean, Surface Waters.

As part of the EGITTO and EGYPT programs started in September 2005, the Eastern Mediterranean surface circulation was studied using Lagrangian drifters. A statistical description of the circulation based on the drifter data between September 2005 and August 2006 is presented.

Data and methods

A total of 81 SVP drifters were deployed from September 2005 to October 2006. In particular, 31 drifters were released in the Sicily Channel on a seasonal basis and 50 drifters were deployed in the southeastern Ionian, the Cretan Passage and the Levantine sub-basin during four oceanographic cruises/transits. All the drifters were equipped with a holey sock drogue centered at a nominal depth of 15 m to minimize the influence of the local winds and with a radio transmitter emitting every 90 seconds to send data (e.g., sea surface temperature) and be tracked by the Argos system aboard the NOAA near-polar orbiting satellites. The raw Argos positions provided until 18 August 2006 were edited for outliers and spikes using statistical and manual techniques [1] and interpolated at regular 2-hours intervals [2], filtered with a low pass Hamming filter of 36 hours to eliminate tidal and inertial currents and finally sub-sampled every 6 hours. Surface velocity was calculated by central finite differencing the interpolated positions.

Results

The drifters sampled adequately the Eastern Mediterranean with a maximum drifter density in the Cretan Passage and in the Sicily Channel, due to the high residence time (also because of the drifters released and trapped in the eddies) and to the large number of deployments in these areas (Fig.1). The drifter operational life is about 3-6 months because of the high probability of being picked-up by seafarer or stranding. As computed until 18 August 2006, the maximum drifter lifetime is 278 days and the mean half-life (the time after deployment for which 50% of the instruments still provide useful data) is about 110 days. The processed data include a total of 19.6 drifter-years and the maximum number of drifters operating simultaneously (34 units) occurred on the 24 April 2006. The mean flow and the variance were calculated for the whole period from the filtered data using a spatial averaging scale of 1° x 1° overlapping bins. The obtained surface currents show a strong flow of about 20 cm/s entering in the Sicily Channel and bifurcating southeast of Sicily, one branch going to the north and the other to the east. In the Ionian, the currents move southward and then veer to the west off the Libyan coast. In the Cretan Passage and Levantine Sub-basin the currents are strong (about 20-25 cm/s) and flow eastward along the continental slope off Egypt, Israel and Lebanon. Anticvclonic circulation features off the Libvan coast and in Ierapetra and Mersa Matruh areas are striking. The mean kinetic energy of the mean flow (MKE) (Fig.2a) and the mean kinetic energy of the fluctuations, also called eddy kinetic energy (EKE) (Fig.2b), were computed rejecting bins with less than 50 observation. The MKE is maximum southeast of Sicily, east of Crete, and in the eastern part of the Levantine sub-basin, with values that reach 500 cm^2/s^2 , while the EKE, as expected, is maximum (with values higher than the MKE) in correspondence to the major anticyclonic eddies and in areas with well-known strong seasonal variability. Calculating the ratio EKE/MKE, the higher values (velocity fluctuations more energetic than the mean flow) are found in the Cretan Passage and in the Ionian, while strong currents with low variance are evident in the northern part of the Sicily Channel and along the slope, especially in the eastern Levantine Sub-basin. Lagrangian statistics were computed after the Eulerian mean flow had been subtracted from the drifter velocities.

Energy levels, diffusivity and integral time scales are larger in the zonal direction. The covariance at zero time-lag is about 220 (200) cm^2/s^2 in the zonal and meridional directions respectively; diffusivity reaches an asymptote after about 4 days with values about 3 x 10⁷ (2 x 10⁷) cm²/s. Additional drifters will be deployed in the Eastern Mediterranean until March 2007. The above-described statistics will be then re-computed using the upgraded dataset.



Fig. 1. Drifter trajectories between 1 September 2005 to 18 August 2006.



Fig. 2. MKE (a) and EKE (b) for the period 1 September 2005 - 18 August 2006. Only bins with more than 50 observations were taken into account.

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DETERMINATION OF THE LOCATIONS OF SOUTHEASTERN LEVANTINE ANTICYCLONIC EDDIES FROM CTD DATA

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Abstract

The degree of depression in the profile of potential density is proposed as a criterion of the anicyclonality at the cast location. This criterion was calculated for profiles in the historical CTD data set from the Southeastern Mediterranean in order to map the region of transient anticyclonic eddies. Most of the casts with a higher degree of anticyclonic activity are clustered in the region between Cyprus and Haifa. The absence of anticyclonic depression in the potential density profiles outside of an intensive eddy suggest that the so called "Shikmona Gyre area" is not an area of weak anticyclonic circulation, but rather is an area of general cyclonic circulation with the periodic generation of energetic anticyclonic eddies.

Keywords : Levantine Basin, Circulation.

The climatological pattern of the Southeastern Levantine circulation has been the subject of extensive investigation since the first evidence of energetic anticyclonic eddies in this region were discovered in CTD data collected by the Israeli R/V Shikmona in the "Mediterranean Climate" (MC) cruises during 1979-1984 [1, 2]. Prior to this, the commonly accepted picture of a general cyclonic circulation was based on sparse casts (about 50 eastward of 30°E for the classical Ovchinnikov scheme [3]). In an analysis of the CTD data collected by R/V Shikmona during the first two POEM cruises (Oct 1985 and Mar 1986), Brenner [4] determined that among several warm core eddies in the region of study, the most intense eddy was located near 34.2°N, 34.2°E. He referred to this as the Cyprus eddy. Using the same CTD data Oszoy et al, [5] defined a broad area with a relatively high geopotential anomaly and referred to it as Shikmona Gyre. This area appeared to contain three small scale anticyclonic eddies. In summarizing the POEM cruise data and supporting evidence from numerical model simulation, Robinson and Golnaraghi [6] defined the southeastern Levantine as a region with a "system of anticyclonic eddies, among which is the recurrent Shikmona eddy south of Cyprus". Pinardi et al, [7] described the southeastern Levantine circulation as being dominated by an along shore cyclonic circulation with the presence of the Mid-Mediterranean Jet (MMJ) south of Cyprus and the Shikmona gyre area. This description (excluding the MMJ) was corroborated by Hamad et al, [8] based on analysis of remotely sensed sea surface temperature data. Using a unique set of CTD data (1995-2005), Zodiatis at al, [9] demonstrated the persistence of the MMJ south of Cyprus accompanied by a complex structure of anticyclonic eddies south of the jet. To distinguish between anticyclonic eddies located west of and east of 33.5°E, they used the names Cyprus eddy and Shikmona eddy, respectively.

One of the intriguing questions is how to interpret the Shikmona Gyre area: as a region where anticyclonic eddies are generated and migrate or as a relative large area with a slow anticyclonic circulation and periodically generated energetic anticyclonic eddies? Unfortunately the historical CTD data collected in the Southeastern Levantine is too sparse to resolve this question. In order to estimate the presence of anticyclonic circulation at a point where we have only CTD data, we calculate the degree of depression of the vertical profile of potential density in the layer deeper than 250m. We assume that the degree of the depression is proportional inversely to the second derivative from the vertical distribution of the potential density. Depression of the density profile is caused by downwelling resulting from near surface horizontal convergence in an anticvclonic circulation. Fig. 1 shows the locations of casts where depression of the density profile is significant. Most of the anticyclonic eddies are found in the region between Cyprus and Haifa. However stations with depressed profiles are also found southwestward and northwestward of this region. This picture supports the suggestion of Brenner [5] that antyclonic eddies are trapped by topographic effects. Density profiles with a high degree of depression are often adjacent with profiles typical of cyclonic activities (absence or low degree of depression). This suggests that the area between Cyprus and Haifa is not an area of weak anticyclonic circulation, but rather an area of general cyclonic circulation with the periodic generation of energetic anticyclonic eddies. Therefore the "Shikmona eddy generation area" would be a more appropriate name for this area instead of the commonly used "anticyclonic Shikmona Gyre".



Fig. 1. Locations of casts with significant anticyclonic activity (shadowed) in the South Eastern Mediterranean.

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ABRUPT CHANGE IN THE DEEP BALEARIC SEA IN 2005; A YEAR LATER

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Abstract

The properties of the Western Mediterranean Deep Water in a wide area located at the western boundary of the Mediterranean Sea revealed intense changes when sampled in summer 2005 after the extremely severe winter 2004-05. The progressive warming trend observed since 1996 in deep waters north of the Balearic Channels reverted dramatically, and in the deepest levels nearby the Balearic Islands a complex and unprecedented thermohaline structure appeared. In the following year, the temperature of deep water north of the Balearic Channels experienced the highest annual cycle observed, ending by June 2006 with a weak interannual recovery. The new structure in deeper waters persisted with some evolution, indicating that the change was not a short-term transient anomaly. *Keywords : Western Mediterranean, Deep Waters, Balear Sea.*

Western Mediterranean Deep Water (WMDW) has been immersed in a process of warming and salt-increase since, at least, the beginning of the 20th century. The net heat and salt gain values presented by different authors are similar:

Béthoux et al. [1]; 1959-1997; 0.13 °C and 0.04 (PSS scale)

Rixen et al., [2]; 1950-2000; 600 dbar-bottom; 0.09°C and 0.035

A similar tendency was observed in the 10-year time-series of θ S properties at hydrographic stations in the Balearic Sea performed by the Spanish Institute of Oceanography (IEO). Until 2005, the waters deeper than 600 dbar in station 33 (Figure 1c, 1360 m depth) suffered a progressive warming and salt-increase trend of 0.011±0.004 °C yr⁻¹ and 0.003 ± 0.001 yr⁻¹ (salinity).

However, measurements in June 2005 revealed dramatic changes in the deep waters at the area, as described in [3]. The warming trend observed north of the Balearic Channels was disrupted with a drop in potential temperature of 0.14 $^{\circ}$ C, higher than the accumulated increase observed since 1996, and higher than the reported net accumulated warming of the whole WMDW during the last half century. At the same time, the deepest waters that bound the Balearic Islands showed intense transformations presenting a striking structure below 1400 dbar (see Figure 1abd). The changes were related to the most intense heat loss in the area of formation of WMDW (MEDOC area) since at least the last 50 years [3]. The formation of the new structure was explained in terms of intense deep convection of salty surface waters combined with strong cascading at the shelf-slope [4]. The extension of the changes affected the whole Western Mediterranean basin [5] and may be influenced by the Eastern Mediterranean Transient [3, 5].

The sampling of the Balearic Channels during the following year revealed a variability not observed before at these levels in the area during the previous 10 years. There was an annual cycle of nearly 0.10° C for water temperature below 600 dbar, reaching a maximum in spring but ending in June 2006 with a value hardly 0.02° C higher than that found in June 2005 (not shown). This finding indicates firstly that the change was not a short-term transient anomaly, and secondly the existence of heterogeneity in the spatial structure at these depths, causing the local alternation of waters with different properties as a response of the local advective regime.

After summer 2005, the deep structure with a clear fingerprint in the θ S diagram (Figure 1d) remained year round, but experienced some evolution. The node of maximum salt and temperature increased slightly its values, whereas the signature at the interface with newly formed waters and also the bottom water seem to be less conspicuous (partially eroded) when observed in summer 2006. The combination between diffusive mixing and advection causing the observed evolution of the θ S diagram supposes a future challenge for the models when trying to interpret this exceptional event.



Fig. 1. Western Mediterranean at the Balearic Islands area and stations referred in the text (c). Potential temperature (a) and salinity profiles (b) at a station C for summers 2004-2006 and θ S diagram from the same profiles (d).

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CLIMATE REGIME SHIFTS OF THE ADRIATIC SEA ECOSYSTEM

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Abstract

While increased atmospheric CO_2 flux is assumed as a general warming factor, essential climatic influence in the Adriatic Sea comes through the water exchange with the Mediterranean, that reflects an air pressure variability over the wider area. Based on the pressure index and CO_2 time series we have examined the effects of climate shifts/changes to the Adriatic Sea ecosystem. *Keywords : Adriatic Sea, Primary Production, Atmospheric Input.*

Introduction

Continuous increase of atmospheric greenhouse gases is the main factor of the global temperature increase. We wanted to discover the changes in the marine ecosystem triggered by climatic changes, and eventually quantify the causes and the effects in the complexity of the feed back processes of the atmosphere-sea system. Trends and fluctuations were already observed in various biotic systems in the world seas, including the Mediterranean and the Adriatic Sea [1]. Long term oceanographic records from the Middle Adriatic enable better understanding of the ecosystem response to changes of atmospheric and sea conditions through physical, chemical and biological processes. In order to analyse ecosystem response to climatic forcing, the changes and shifts of primary productivity and climatic indicators were compared and analysed.

Datasets and methods

A sea level pressure index, taken as a climatic indicator, was defined via Principal Component Analysis of the mean annual sea level pressure data over the Northern Hemisphere from the area $30^0 \text{ W- } 40^0 \text{ E}$ and $30^0 - 65^0 \text{ N}$, for the period 1948-2003, from the NCEP/NCAR reanalysis (http://www.cdc.noaa.gov). The obtained index describes the mean annual pressure variability over the central northern Atlantic [2]. A warming index is defined through a detrended series of relevant CO₂ fluxes in the atmosphere. For the ecosystem index, the primary productivity data since 1962, collected monthly at the open sea station Stončica (STS) and the coastal station Kaštela Bay (KBS) were analysed (unchanged method over the analysed period). Regime shifts were detected via the SARS method proposed by Rodionov [3]. The locally-weighted scatter plot smoothing (LOWESS) method was used for displaying nonlinear trends.



Fig. 1. Primary productivity regime shift and sea level pressure indexes.

Results and discussion

At a multi-decadal scale changes of productivity in the coast and the open sea show a high degree of correspondence (r=0.70; n=41; p<0.001); al-though coastal waters have few times higher productivity rate. Coherent fluctuations point to the influence of a common external forcing. The application of the LOWESS method on productivity reveals non-linear relationships, and distinguishes the three different periods (1962-1979), (1980-1997) and (1998-2005) in which the mean value and dispersion is different in amount and sign from a normal period (Figure 1).

Till 1979, at open sea, there was no significant trend of primary productivity. In the same period an increase of primary productivity was observed at KBS, but primarily due to an increase in the first ten years, which had huge anthropogenic load. An abrupt primary productivity regime shift was observed in 1979 in the coastal waters and a year later at open sea. While trends could be partly influenced by eutrophication, the abrupt change in the atmosphere over the Northern Hemisphere probably caused productivity multi-decadal changes in the Adriatic Sea. The changes of climate and the abrupt climatic shifts in the atmosphere could be the forcing factors that controlled the Adriatic ecosystem dynamic. By the end of the first normal period, the abrupt jump in primary productivity occurred at STS, followed by a regime shift of the pressure index, connected to CO_2 fluxes (Fig.2).



Fig. 2. Mean annual primary productivity at the Middle Adriatic open sea station (STS), RSI weighted values, and arrows indicating shifts in the atmosphere.

The warming begun around 1978, accompanied by a decrease of precipitation and an increase of the E-P value. The increase of the winter NAO index in the period 1978-1992 was recorded. This period was characterized by the shift of primary productivity. The question is, what has caused such an abrupt increase of productivity? We believe that the increase of primary productivity in the Middle Adriatic can be associated to the climatic shift. The atmospheric response to CO_2 flux jump resulted in a temperature increase. The changed pressure distribution over the northern Atlantic and wider, extending to the SE Mediterranean, has influenced the exchange between the Adriatic and the Mediterranean. This has regulated the corresponding salinity fluctuation, nutrient enrichment and consequently the primary productivity changes/shifts in the Adriatic.

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MIXING FROM THE BLACK SEA TO THE AEGEAN VIA THE BOSPHORUS

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Abstract

The waters surrounding western Turkey contain a rich variety of mixing regimes owing to differing combinations of currents, stratification and bathymetry. Examples from disparate situations observed between 1994 and 2004 will be compared while identifying and quantifying the major mixing processes encountered.

Keywords : Bosphorus, Black Sea, Aegean Sea, Water Transport.

Meeting Umit Unluata at the 1991 IUGG nutured an interest aroused by a recent paper [1] about the exchange through the Bosphorus into a broader curiosity about the fascinating oceanographic environments feeding into the strait. Working from R/V Bilim in 1994 with Emin, Latif and Sukru, we examined hydraulics and turbulence of the Bosphorus in detail, discovering that the exchange flow is far from the idealized case described by analytical models [2]. In particular, the complex bathymetry and shape result in the narrowest part of the channel, known as the Contraction, not having the smallest cross-section and upper and lower parts of the exchange flow crossing the southern sill on opposite sides of the channel [3]. Owing to the intense turbulence, the regime appears to be at least partly controlled by friction rather than being the simple exchange of ideal fluids assumed in many hydraulic models.

During late summer we found very weak background mixing on the shelf north of the strait [4,5], very different than on shelves adjacent to the open ocean where tidal currents produce turbulence levels decades larger than the nearly molecular diffusivities we observed. No so, however, during late winter of 2003, when, working from R/V Knorr we found a strong rim current flowing over sharp cliffs apparently produced by massive slumps that removed portions of the continental slope. Where the slope is smooth, e.g., just west of the Bosphorus, mixing was much weaker, but above the levels found in late summer.

In the middle of the Black Sea's western gyre turbulent dissipation rates in the oxycline were moderately strong during a cold air outbreak that cooled the overlying surface water to 6.1° C [6]. Owing to the very strong stratification produced by the halocline, these dissipation rates correspond to diapycnal diffusivities of only $(1-4) \times 10^{-6} \text{ m}^2/\text{s}$, too low to resupply the suboxic layer by vertical mixing. In spite of the winds accompanying the cold air outbreak, turbulence in the weakly stratified water below the halocline was so weak that we are reformulating the way we compute dissipation rates to distinguish very weak turbulence from noise.

As we found while working on R/V Oceanus during late autumn of 2004, the Aegean has a two-layer density structure similar to the Black Sea, with equally weak mixing away from land. To our great surprise, internal tides, though weak, are significant and produce mixing signatures near some bathymetry. Low-frequency flows along the continental slopes seem to be the other process generating strong mixing close to the bottom.

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APPLICATION OF CREEPING SEA-FILL METHODOLOGY TO THE WIND SPEED OVER THE CASPIAN

SEA

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Abstract

Numerical weather prediction (NWP) products include possible errors near the coastal regions. Effects of such errors on near surface wind speed, which is one of the critical variables for coastal applications are investigated over the Caspian Sea. For this purpose, a creeping seafill methodology developed by [1] was applied to the coarse resolution $(1.125^{\circ} \times 1.125^{\circ})$ wind speed data obtained from European Centre for Medium-Range Weather Forecasts (ECMWF), and the results compared with the relatively fine resolution (0.25° x 0.25°) satellite based wind speed data. It is shown that the applied methodology improved the accuracy of the wind speed near the coastal regions. Keywords : Coastal Processes, Air-sea Interactions, Brackish Water.

Coastal applications (e.g regional ocean models, wave models etc.) need accurate wind speed over the sea surface and proper representation of this variable is important. However, atmospheric models do not have enough resolution for inland waters like the Caspian Sea. Since many NWP models are generally designed for global or regional applications, small water bodies are not considered in great detail. Also, because of the irregularities in coastline the few grid points over inland waters can be contaminated by land. For this reason, the wind speed field requires special treatment before using it in coastal applications.

The Caspian Sea is an enclosed water body and very sensitive to the atmospheric forcing, thus improper representations of air-sea fluxes in a regional ocean model could lead to unrealistic trends of total heat, mass, and momentum. For this reason, special attention should be taken to properly represent the atmospheric forcing in this sea. The main goals of this study are (1) to show the effects of land on the surface wind speed near the coastal regions, and (2) to evaluate the success of the applied methodology for reducing the effects of land contamination.



Fig. 1. The land sea mask from a satellite-based product (QSCAT, right), and ECMWF interpolated to the 1/25° grid (left)

Land-sea mask values from ECMWF [2] (European Centre for Medium-Range Weather Forecasts) (Fig. 1a) and SeaWinds scatterometer on the QuikSCAT satellite (Fig. 1b) are shown. It is clearly seen that the relatively coarse resolution ECMWF land-sea mask is more contaminated by land values effecting the interior of the sea compared to QSCAT land-sea mask, which has relatively fine resolution. In this figure, a contour value of 0.8 in the land-sea masks implies that the interpolated wind speed values are approx 80% contaminated by land values on the OGCM grid.

In this study, a creeping sea-fill methodology was applied to the wind speed at 10 m obtained from ECMWF 40-year Re-Analysis (ERA40) data for June 2000. The creeping sea-fill simply means that winds are postprocessed, so that only values over the ocean (or sea) are used. It replaces the value associated with each land-masked point by using only nearby sea values. For demonstration purposes, the original values were interpolated

to a 1/25° x 1/25°, cos (lat) resolution Caspian Sea HYbrid Coordinate Ocean Model (HYCOM) domain. HYCOM, described in [2], is a community ocean model (http://oceanmodeling.rsmas.miami.edu/hycom/). It behaves like a conventional σ (terrain-following) model in very shallow oceanic regions, like a z-level coordinate model in the mixed layer or other unstratified regions, and like an isopycnic-coordinate model in stratified regions.



Fig. 2. Spatial variations of wind speed from ECMWF, QSCAT and seafill field.

Performance of the creeping sea-fill methodology is evaluated using measurements of wind speed magnitudes at 10 m above the surface from QuikSCAT satellite. ERA40 (Figure 2a), QSCAT (Figure 2b) wind speed data and the sea-filled field (Figure 2c) are plotted to examine wind speed during June 2000. While ERA40 wind spped data shows abrupt features along the southern and western coast of the Caspian Sea, QuikSCAT data is more smooth over these regions. An improvement in the accuracy in ERA40 wind speed data is seen after applying creeping sea - ïňAll methodology, as these fields display more or less smiliar features compared to QuikSCAT data.

This study shows that applying a creeping sea-fill methodology successfully reduces the error due to the land contamination associated with the coarse NWP grid, and improves the accuracy of wind speed near the coastal regions. To investigate possible effects of improved atmospheric forcing on the dynamical features of the sea, a regional ocean model should be used as a tool for a further study.

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IMPACT OF NUMERICAL MODEL RESOLUTION ON OPEN-OCEAN CONVECTION REPRESENTATION: CASE STUDY OF WINTER 1986-87

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Abstract

A strong open-ocean convection episode occured during winter 1986-87 in the NWMS (Northwestern Mediterranean Sea). Two numerical 3D simulations of 1968-87 have been performed using an eddy-permitting and an eddy-resolving model. The convection is reproduced similarly in both simulations on a global scale. However, mesoscale structures are better reproduced by the eddy-resolving model, explaining most of the differences between both simulations

Keywords : Western Mediterranean, Circulation Models, Mesoscale Phenomena.

Open-ocean convection is one of the major dynamic processes in the NWMS (Fig. 1a), where it plays an important role in the functioning of pelagic planktonic ecosystems. It is therefore important to reproduce correctly this process with 3D circulation models. Somot [2] performed a realistic numerical study of winter 1986-87 using an eddy-permitting model (EPOM). Given the importance of mesoscale structures during convection episodes, it would be interesting to perform a realistic study of this winter with an eddy-resolving model (EROM). In the present study, we investigate the impact of model resolution on the representation of the 1986-87 convection episode by comparing results of two realistic 3D simulations performed with respectively an EROM and an EPOM.

A Mediterranean limited area version of the $1/8^{\circ}$ resolution (~10 km) circulation model OPA [2], and a 3 km-resolution model, SYMPHONIE [3], are used. Since the Rossby radius in the NWMS is about 10 km, the present version of OPA, resp. SYMPHONIE, is an EPOM, resp. an EROM. The atmospheric forcing is provided by the air-sea fluxes coming from the ERA40 reanalysis [4]. A correction of -130 W/m² is added to correct the difference between the ERA40 heat flux and the observations [5]. During winter 1986-87 five meteorological events (highlighted in grey on Fig. 1) were observed.

Both models reproduce similarly the convection episode on a global scale: position of the convection area (4°30' E - 41°30'N), timing consistent with the atmospheric forcing (see the mean mixed layer depth (MLD) evolution on Fig. 1a), total volume of newly formed deep water (DW, ρ >29.10 kg/m³) exported from the NWMS (Fig. 1d).



Fig. 1. Water column characteristics from 12/01/1986 to 05/30/87. MLD (a), columnar buoyancy and integrated buoyancy flux (b) and KE (c) averaged over the LION area. DW surface formation, storage, net transport and mixing in the NWMS (d).

The main difference between both models is the mesoscale structures representation. We observe on sea surface density that mesoscale structures of scale smaller than 60 km are much more important, and in better agreement with previous studies [1,6] in EROM than in EPOM. This is confirmed by the kinetic energy (KE) analysis, where we observe the evolution of KE associated to processes of scale larger (LSKE) and smaller

(SSKE) than 60 km (Fig. 1c). These mesoscale processes are known to be responsible for the lateral advection of positive buoyancy into the convection area [1], as confirmed by a buoyancy analysis (Fig. 1b): the difference between the columnar buoyancy and the integrated surface buoyancy flux means that lateral advection of positive buoyancy, more important in EROM than in EPOM, occurs. Consequently, the mesoscale structures slow down the MLD deepening, help to the restratification and limit the lateral extension of the convection area. This corresponds to the difference both models. Indeed, in EROM, the MLD deepening is slower, the restratification is faster and the convection volume, proportional to the mean MLD, is smaller (Fig. 1a). The maximum MLD being similar in both models, this volume difference is mainly due to a smaller convection surface in EROM. Moreover these structures play an important role in the mixing of DW formed at the surface with lighter surrounding water (Fig. 1d). This mixing is much more important in EROM (57%) than in EPOM (8%), consequently less DW is stored in the NWMS in EROM. The DW formation rate is 1.7 Sv for EROM vs. 2 Sv for EPOM. For more details about these analysis, see [7].

In conclusion, EROM and EPOM reproduce convection similarly on a global scale. However, EROM finer spatial resolution enables to reproduce mesoscale structures better.

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CIRCULATION TRIDIMENSIONNELLE DE LA BAIE DE M'DIQ (MAROC) DURANT L'AUTOMNE

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Résumé

La circulation tridimensionnelle de la baie de M'Diq, située en Mer Méditerranée marocaine, a été appréhendée à l'aide du modèle hydrodynamique MIKE3-HD durant le mois de septembre 2001. La marée observée est de type semi-dirune et la circulation de surface de la baie est, en outre, régie par les vents qui sont sur cette période d'observation de directions dominantes Nord-Ouest à Sud-Est. *Mots clès : Alboran Sea, Circulation, Coastal Models, Coastal Processes, Tides.*

Introduction

De par son importance socio-économique pour la région et présentant de fortes potentialités en aquaculture, la baie de M'Diq ($35^{\circ}40'N$, $-6^{\circ}21'O$) a fait l'objet de diverses études visant la compréhension de son écosystème [1, 2, 3, 4, 5, etc]. Cependant, les études portant sur son hydrodynamique sont quasi-inexistantes et l'objectif de cette étude est d'étudier par modèle numérique la circulation marine régissant cette baie.

Matériel et méthodes

La circulation tridimensionnelle des eaux de la baie de M'Diq a été étudiée à l'aide du modèle hydrodynamique MIKE3-HD. La période de simulation a concerné le mois de septembre 2001 et le modèle a été forcé localement par la marée et les vents observés au voisinage du site. Des mesures de courant, enregistrées sur une courte période d'observation dans la baie, ont été utilisées pour calibrer et valider les résultats du modèle numérique de circulation.



Fig. 1. La baie de M'Diq (Maroc) et sa bathymétrie.

Résultats

La marée observée durant l'année 2001, au voisinage de la baie de M'diq, est semi-diurne (de type M2), dont l'amplitude et la phase sont respectivement de 0.30 m et de 50° (GMT). Les vents dominants durant l'année 2001 sont de secteurs Est à Sud-Est et Ouest à Nord-Ouest [6]. Durant l'automne 2001, ils sont généralement de secteurs Nord-Ouest et Sud-Est, d'intensités moyennes de 6 m.s⁻¹ environ. Etablis sur le mois de septembre 2001 couvrant ainsi un cycle de marées de vive-eau et de morte-eau, les résultats du modèle montrent que la circulation de surface de la baie est fonction de la direction des vents et permettent ainsi de mieux comprendre l'hydrodynamique qui régit cette baie.

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TOWARDS CLIMATIC MODELLING OF THE CASPIAN SEA THERMO-HYDRODYNAMICS

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Abstract

Three-dimensional primitive equation models including sea ice thermodynamics and air-sea interaction are used to study seasonal circulation and water mass variability in the Caspian Sea under the influence of realistic mass, momentum and heat fluxes. The models successfully simulate sea-level changes and baroclinic circulation and mixing features, partially verified with observed data. *Keywords : Sea Level, Currents, Circulation Models.*

The isolated Caspian Sea, under the influence of large rivers and atmosphere-ocean-land interactions, is extremely sensitive to regional climatic variability. With a large catchment area extending towards the Urals and Caucasia, river runoff dominates the water budget. Annual precipitation is about one third of the runoff or evaporation, which are roughly comparable in magnitude and would individually account for about 1 m/yr of sea level change. The water budget drives inter-annual, inter-decadal and longer term variations in sea level [1,2].

The water budget variability, which depends on external factors as well as on the atmosphere - sea interaction, most probably is the key phenomenon influencing the physical state of the sea. Changes in water balance lead to significant changes in stratification of the upper waters, which can result in overturning or eutrophicated conditions in the deep basin, phenomena known to have occured in the past [1,3]. Seasonal variation in sea level is about 30 cm, while interannual variation in the twentieth century alone has been in the range of 300 cm. The water input is either compensated by surface evaporation (increased when flat areas are flooded) or balanced by sea level changes.

The strategy for studying the Caspian sea thermo-hydrodynamics is based on successive development of models capable to represent the physical state of the sea from intra- to interannual timescales, to answer the following yet unresolved questions: What is the three-dimensional general circulation of the sea? What thermodynamical processes are specific for the Caspian Sea in controlling the seasonal sea level changes and how sensitive is the energy transformation cycle to variations of atmospheric forcing?

3D primitive equation models including sea ice thermodynamics and airsea interaction have been developed and applied to study the seasonal circulation and water mass variability in the Caspian Sea under the influence of realistic mass, momentum and heat fluxes. River discharges, precipitation, radiation and wind stress are specified in the model. The evaporation rate, sensible and latent heat fluxes at the sea surface are computed interactively by an atmospheric boundary layer sub-model, using the ERA40 atmospheric data and model generated SST. The model simulated sea surface topography is verified with observed sea level data. Model heat and water budgets confirm climatological estimates. Experiments performed with variations in external forcing suggest a sensitive response of the circulation and the water budget to atmospheric and river forcing. The most important issue from the model is connected with transformation of water and energy in sea - atmosphere system. In the warm period solar energy is accumulated in the sea and transmitted to the atmosphere through thermal radiation, sensible and latent heat fluxes. Latent heat flux by evaporation is a stabilizing mechanism acting against sea level rise.

The seasonal cycle of wind stress is crucial in producing the basin circulation, resulting in cyclonic gyres in December-January; west to southwestward Ekman drift accompamied by an upwelling front in the east, coastal jets along the western and eastern shelf regions in February-July, and transitional types in August-November. Upwelling along the eastern shelf is a persistent feature in summer, also confirmed by satellite data [4], subject to active exchange and mixing across the front.

Considering the general lack of observational data of the Caspian Sea currents the first drifter experiment hasstarted in October 2006, in the

framework of the NATO SfP / MACE project. The three surface buoys deployed in the cooling period indicate mainly cyclonic circulation in the mid and south Caspian sub-basins, with smaller embedded cyclonic / anticyclonic eddies, as predicted by models and also confirmed by satellite data.

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IMPACT OF AN ATYPICAL WINTER OVER THE CATALAN CONTINENTAL SHELF

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Abstract

During the 1998-99 winter, the hydrodynamics of the Catalan continental shelf and slope was significatively altered. Pascual et al. (2002) have reported the presence of a very energetic eddy (diameter >100 km) located in the northern part of the Balearic sea from september 1998 to March 1999. This structure altered the normal dynamics in the downstream region (the Catalan shelf-slope). In this paper, we show the consequences of this atypical behaviour, in particular the effects of the eddy dissipation when a great amount of Winter Intermediate Water accumulated over the northern shelf was released.

Keywords : Circulation, Coastal Waters, Time Series, Western Mediterranean.

The dynamics of the Catalan shelf-slope region (NW-Mediterranean) is very influenced by the upstream processes [1]. The slope current, which is part of the so-called Northern Current [2], advects dynamical structures (i.e. eddies, filaments) and water masses downstream. This mechanism allows the presence in the southern Catalan shelf-slope of eddies and water masses generated in the Gulf of Lions.

In September 1998 a very intense and large (100 km) anticyclonic eddy was generated in the northern part of the Balearic basin [3] (figure 1). This structure remained almost in the same place until March 1999, when it dissapeared. The authors proposed a combination of effects such as the Mistral wind induced curl and the weakening of the Northern current to be at the origin of the eddy formation. Such a strong and large structure had, probably, an important impact over the circulation in the Balearic basin. Nevertheless, until now, no evidence of that impact has been reported.

On the other hand, in the frame of the YOYO project (1998-1999), several moorings were placed in the shelf-slope region near the Ebre delta, downstream the large eddy position (figure 1). Those moorings were instrumented with current meters and thermometers at different depths as well as with a thermistors chain between 100-200 depth.

When looking at the current and temperature data the main conclusion is that the slope current was not altered by the presence of the eddy. The differences found during the 1998-99 winter were similar to those found in other years., showing the typical seasonal variability.



Fig. 1. Study region. The large eddy reported in [3] is represented as well as the typical path of the Northern current (grey arrow). The stars show the location of the mesurement points.

However, the temperature presented a striking feature. Between the 26 March and 6 April (days 1180-1190 in figure 2), the temperatures suddenly decreased by 0.6° C simultaneously between 100 and 500 m. This is a variation much more important than all other variations observed during the YOYO period and corresponds to the arrival of WIW (Western Intermediate Water) advected from the North. What is very unusual is the amount of such WIW filling the whole water column. In fact, this extraordinary release of rich waters probably favoured the increase of seabirds observed in 1999 (Daniel Oro, pers.comm.).

Our explanation to that phenomena is the following. The Catalan continental shelf in the north of Barcelona is a favourable place to generate WIW due to the cooling and convection of dense waters. Usually, the waters generated by that process over the shelf are advected downstream by the slope current, as it is done with the waters generated in the Gulf of Lions. However the eddy blocking prevented them to leave the generation place. The winter 1999 was especially strong and an important quantity of intermediate waters was generated in the Gulf of Lions [4], so it is expected that the same thing happened in the Catalan shelf. On the other hand, due to the eddy blocking, this water mass didn't displace and was accumulated during the winter months over the shelf. When the eddy dissipated in March, the current circuit was restablished and the cold and rich waters accumulated began to be advected southwards filling the whole water column and reaching the southern part of the Catalan shelf-slope in several days.



Fig. 2. Comparison of 100 m velocities (top) and temperature distribution between 100 and 500 m (bottom) measured over the slope.

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WIND SPEED ACCURACY NEAR THE COASTAL BOUNDARIES OF THE MEDITERRANEAN SEA

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Abstract

The atmospheric model grid from NWP (Numerical Weather Prediction) products tend to include land values over the ocean in near coastal regions. This is due to improper land-masks of the NWP products, causing serious errors in wind speed for coastal applications. Possible corrections are introduced to overcome such problems.

Keywords : Air-sea Interactions, Coastal Waters, Eastern Mediterranean.

Introduction

Wind speed differs greatly between ocean and land surfaces due mainly to land-sea heterogeneity. For example, the land roughness can be significantly larger than ocean roughness. NWP centers are commonly used as sources for obtaining global coverage of winds. These NWP products include (1) $1.0^{\circ} \times 1.0^{\circ}$ Navy Operational Global Atmospheric Prediction System (NOGAPS), (2) $1.125^{\circ} \times 1.125^{\circ}$ European Centre for Medium-Range Weather Forecasts (ECMWF), and (3) $1.875^{\circ} \times 1.875^{\circ}$ National Centers for Environmental Prediction (NCEP). A serious problem arises when using these products, for example, for determining coastal upwelling and in forcing fine-resolution ocean models. This is because winds over water during interpolation to the finer ocean grid are contaminated by values over land near coastal regions, mainly because of the much coarser atmospheric computational grid [1].



Fig. 1. The land-sea masks interpolated to the 1/12°HYCOM grid.

Land-Sea Mask

The model near-surface grid in NWP products is divided into sea and land points using a land-sea mask. The original land-sea masks can be represented as values 0 (for sea) and 1 (for land). Land-sea mask values from the 40-year ECMWF Re-Analyses (ERA-40) and Quick Scatterometer (QSCAT) products are formed to illustrate possible land contamination issues in the Mediterranean Sea (Fig. 1). For demonstration purposes, the original ERA-40 winds were interpolated to a $1/12^{\circ} \times 1/12^{\circ} \cos(\text{lat})$ resolution global HYbrid Coordinate Ocean Model (HYCOM) domain (http://oceanmodeling.rsmas.miami.edu/hycom/) zoomed for the eastern Mediterranean region. Unlike ERA-40, the daily mask is 1.0 for 100% data void and 0.0 for valid QSCAT data.

The interpolated representation of the original land-sea mask on the HY-COM grid clearly reveals that some of the ocean points are contaminated by land values, as typically seen from ERA-40 (Fig. 1). For example, a contour value of 0.4 in the land-sea masks implies that the interpolated wind speed values are $\approx 40\%$ contaminated by land values. ERA-40 winds are therefore consistently weaker (e.g., 2 m s⁻¹) than QSCAT near the land-sea boundaries (Fig. 2).

Special action must be taken to ensure that wind speed over land value is not contaminated by that over the sea surface. One possibility is to correct winds from NWP products using satellite-based QSCAT winds. The left panel in Fig. 2b shows the accuracy of such a correction, based on a linear regression analysis. That means, assuming QSCAT winds are perfect, monthly ERA-40 wind speeds were regressed against those from QSCAT as there was high correlation (mostly > 0.8) between the two over the seasonal cycle. Slope and constant values were calculated at each grid point. The resulting corrected wind speeds (cERA-40) are almost identical to those from QSCAT. Another possibility for correcting NWP winds is to apply a creeping sea-fill [1]. The creeping sea-fill simply means that nearby sea values for winds are used at the coastal boundaries.

(a) Wind speed at 10 m above the sea surface during Aug 2001 OSCAT ERA-40



(b) Difference from QSCAT winds during Aug 2001 cERA-40 ERA-40



Fig. 2. Spatial variation of QSCAT and ERA winds, and differences for the corrected (cERA-40) and original (ERA-40) with respect to QSCAT.

Conclusions

A near optimal solution to obtain reliable winds near the land-sea boundaries would be to launch new satellites. That will provide a higher time and space resolution than existing ones now.

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MECHANISMS MODULATING TELECONNECTION PATTERNS IN THE EASTERN MEDITERRANEAN

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Abstract

Major atmospheric modes of variability can have a significant effect on oceanic variability. Environmental data that characterize the climatic and oceanic conditions that dominate the Eastern Mediterranean were analysed using the Barnett-Preisendorfer Canonical Correlation Analysis, to describe the mechanisms linking large-scale atmospheric phenomena to regional climatic and oceanic variation. *Keywords : Eastern Mediterranean, Air-sea Interactions.*

Atmospheric, meteorological and oceanic data analyses suggest a strong correlation between climatic and/or oceanic variability and the oscillations of the prevailing global atmospheric patterns. Connections at a distance, or teleconnections, can occur by the direct transfer of mass through changes in regular circulations or by propagating waves initiated by a variety of mechanisms.

Recent research efforts are oriented towards the identification of physical mechanisms that characterize observed teleconnection phenomena and could provide the basis for explaining them. The proposed mechanisms either describe teleconnections as an internal oscillation of the coupled ocean-atmosphere system [1] or suggest that they are modulated as propagating Rossby-waves [2] and/or by solar activity [3]. The aim of the present study is the description of teleconnection phenomena observed in the Eastern Mediterranean and of their underlying mechanisms.

Data sets of environmental variables available for the Eastern Mediterranean (atmospheric pressure, precipitation, wind speed and direction, sea surface temperature, salinity, sea level height, chlorophyll concentration and parity) were organized in a GIS database. Indices of atmospheric oscillatory patterns were either generated from atmospheric data or derived from the literature. Barnett-Preisendorfer Canonical Correlation Analysis (CCA) was used: CCA was applied on a number of Principal Components (PC), derived from Empirical Orthogonal Function (EOF) analysis. The EOF method decomposes spatiotemporal data into modes ranked by their temporal variance and was therefore applied on each variable in order to reduce the dimensions of the data, and identify physically interpretable dominant spatial and temporal variability patterns. The EOF analysis is in essence a type of filter that throws away much of the small-scale noise. CCA is a statistical method for finding spatially coherent patterns in different data fields that have the largest possible temporal correlation. CCA yields two sets of weights that give the combinations of the corresponding sets of patterns with the maximum temporal correlation. In order to determine possible relationships between the atmospheric indices and the observed oceanic variability, the amplitude functions corresponding to the most relevant PCs were selected and cross-correlation analysis was applied. Pre-processing includes decomposition of the time series in order to remove seasonality and thus avoid artificial cross correlations.

The surface pressure field in the Eastern Mediterranean is influenced by the oceanic Azores High, the Siberian winter anticyclone, and the northwestern extension of the South Asian summer thermal low. The main atmospheric pattern identified in the Mediterranean is the Mediterranean Oscillation. The Mediterranean Oscillation has been suggested to be related to recent variability and trends of the Mediterranean precipitation [4], to air temperature [5], cyclogenesis [6], sea surface temperature [7], sea level height, salinity [8] and surface wind [9]. Altimetry and sea surface temperature have been linked to the Southern Oscillation and the North Atlantic Oscillation indices, while atmospheric regimes related to the North Atlantic Oscillation seem to play a regulatory role in the oceanic circulation regime, influencing eddy and deep water formation. We present results on the spatiotemporal links between the various environmental variables and on the proposed teleconnection mechanisms in a region that is influenced by a large number of modes of atmospheric variability.

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VARIATIONAL DATA ASSIMILATION IN A TRANSPORT MODEL

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Abstract

A variational algorithm for data assimilation is considered. It is based on the minimization of a certain quadratic functional of the prediction quality and the solution of the adjoint problem. Numerical model experiments demonstrating the potentialities of this approach, and prospects of its application for solving practical problems, have been carried out.

Keywords : Models, Black Sea, Pollution, Radionuclides, Surface Waters.

The need to conduct monitoring and prediction of the Black Sea ecological state requires the elaboration of methods for identifying the sources of pollution. A methodology to solve such problem may be based on minimization of a quadratic functional of prediction quality, characterizing the deviation of the model estimates from the observed data. The functional minimum is found under the proviso that the model estimates are defined as a solution of an equation of passive impurity transport. This approach is based on the realization of direct and adjoint models of the process being investigated. In this method, the solution of the adjoint problem is the influence function. Information agreement between the model and the measurements is attained by variation of the input parameters provided by the extremum of the prediction quality functional. The form of the latter depends on the modeling objectives. Computations of the required function through the solution of the adjoint problem, yields a possibility to solve numerous practical problems, including an estimation of the influence of the different initial field areas and of the model coefficient, on the model prediction.

Computations aiming at the reconstruction of the initial field have been performed using the variational algorithms. Data on ¹³⁷Cs for the Black Sea area for May - June 1986 were used as measurements of passive impurity. Figures 1,2 shows the model field of concentration (Fig. 1) compared with initial one (Fig. 2) with its maximum at the Caucasian coast, where just after the Chernobyl accident intensive rains have fallen. The model was integrated for 40 days.

Different aspects of the application of variational methods for data assimilation in modeling the passive impurity propagation are considered.



Fig. 1. Modelled field of ¹³⁷Cs concentration (Bk/m³).



Fig. 2. Reconstructed initial field of ¹³⁷Cs concentration (Bk/m³).

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ANALYSIS OF THE BLACK SEA SURFACE CURRENTS RETRIEVED FROM SPACE IMAGERY

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Abstract

Variational assimilation of space imagery observations into a transport-diffusion model is applied to the study of surface currents in the Black Sea basin. The processing of NOAA-AVHRR observations allows retrieving surface currents with a spatial scale of one kilometer in areas of few hundred kilometers. The examples presented here show that surface currents induced by mesoscale features with typical spatial scale up to few kilometers are very intense. The current speed obtained by processing satellite imagery sometimes exceeds twice that retrieved from altimetry measurements, which assumes at least ten km spatial averaging. *Keywords : Black Sea, Mesoscale Phenomena, Remote Sensing, Inverse Methods, Currents.*

In the last couple of decades many space missions launched a set of visible and infrared (IR) sensors. They have spatial resolutions of few hundred meters to one km and are able to resolve the manifestation of the mesoscale ocean dynamics in the sea surface. The analysis of space imagery shows that a significant part of these phenomena have typical spatial scales about one-two kilometers and are not resolved by a global marine observing system based on the altimetry data, profiling floats, or ships of opportunity. The quantitative formalisation of space imagery analysis is capable of improving ten times the resolution of the marine observing system, and make possible much more accurate mesoscale nowcasts and forecasts by models of marine dynamics.

Contrasts on the IR or visible band space images due to mesoscale eddies, jets, filaments or mushroom-like structures are transported by currents. Therefore surface velocity is an important state variable of the marine system that could be retrieved from the set of space images. There have been many attempts to retrieve velocity information from satellite images [see, for example 1, 2, 3, 4, 5]. However, they are based on the application of different kinds of formal regularisations that introduce uncontrolled uncertainties in the final product.

We are using here a variational assimilation method [6] that allows retrieving the sea surface velocity from a set of NOAA-AVHRR images with 1 km spatial resolution. Our method is also based on the assumption that the evolution of image contrasts is described by a transport - diffusion model [7]. We are assuming also that the surface velocity field varies much slower than the temperature field observed by space imagery. This is the real case for marine processes, as mesoscale eddies, that have typical temporal variability scale of about 10 days, whereas space images obtained even within one day interval show transport of contrasts.

A set of images of the Black Sea surface is processed to analyse surface current scales and intensity. Geographic and radiation correction of images were carried out by the Remote Sensing Department of the Ukranian Marine Hydrophysical Institute (NASU). The final files contain 11 μ m radiation temperature in 1.1 x1.1 km pixels.

The analysis is based on space observations of fine scale meandering of the Rim Current Jet, fine structure of mesoscale eddy currents, and detachment of wind-induced coastal upwelling.

The first set of images used to retrieve surface velocity shows a patch of cold water detached from the coast and transported by currents to open sea. The current field obtained from image processing is compared with the velocity distribution obtained by assimilation of space altimetry in a circulation model with 5 km grid mesh. The velocity field structure from image processing corresponds in general to that retrieved from altimetry. However, surface currents are much stronger. The maximal velocity reaches 0.52 m/s, whereas altimetry assimilation shows a broad jet with current speed about 0.1-0.15 m/s.

The next example concerns a mesoscale eddy situated South from the Crimea peninsula. The eddy is about 120 km along the meridian and 100 km in zonal direction. The general anticyclonic circulation is contaminated by smaller scale features situated along the periphery of the main eddy. It is possible to identify an anticyclonic eddy on the western side of

the plot with diameter about 20 km, and a set of meanders of the anticyclonic jet that belts the main eddy. This anticyclonic jet is rather intense; its average speed is about 0.35 m/s, while its maximum value reaches 0.44 m/s. The intensity of currents induced by the eddy well corresponds to the general concept of oceanic mesoscale variability.

The next area of interest is the Rim Current structure above the convexity of the Anatolian coast. The Black Sea Rim Current jet is rather narrow and subject to strong meandering. The most intense meanders induce the formation of cyclonic and anticyclonic eddies to the left and to the right of the jet. The current speed of the jet is up to 0.45 m/s that fits with the few direct measurements available in the Black Sea. Comparison with independent measurements of surface currents by drifters indicates good quality of the estimated velocity field.

The presented examples show that surface currents induced by mesoscale features, with typical spatial scale up to few kilometers, are very intense. The current speed obtained by image processing sometimes exceeds twice that retrieved from altimetry measurements, which assumes at least ten km spatial averaging.

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A MONITORING AND FORECASTING SYSTEM FOR THE BLACK SEA

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Abstract

A near-operational system has been developed in the framework of the EU FP5 ARENA project to continuously monitor and forecast the state of the Black Sea. The results of an experiment on the operational functioning of the Nowcasting/Forecasting System, carried out for the first time in the Black Sea region, are described.

Keywords : Black Sea, Remote Sensing, Circulation Models, Sea Level, Coastal Models.

A monitoring and forecasting system for the Black Sea was developed as part of the European FP5 project ARENA (A REgional capacity building and Networking programme to upgrade monitoring and forecasting Activity in the Black Sea basin), which was aimed at designing a pilot nowcasting/forecasting system [1] in collaboration with the Black Sea GOOS, as well as with other ongoing international projects interested in the development of operational oceanographic services in the basin [2].

The elaborated strategy for the Black Sea nowcasting/forecasting system is based on the evaluation of the available resources in the region. An extended initial near-real time observing system exists in the basin. It comprises remote sensing data of AVISO altimetry, IR AVHRR data, JPL/QUIKSCAT scatterometry, and NASA SeaWiFS/MODIS sea color data together with international surface drifting buoys and NICOP/ONR profiling floats programs and NCEP atmospheric model data. The Black Sea basin-scale circulation model of the Marine Hydrophysical Institute (Ukraine) assimilates remote sensing data for the near-real time nowcasting of three-dimensional temperature, salinity and current fields [3]. The development of a nowcasting/forecasting system assumes the extension of the regional atmospheric models supported by the Hydro-Meteorological Institutes of Bulgaria and Romania in the framework of a Météo-France ALADIN project for the entire Black Sea area, plus an improvement of the ecosystem model of the Institute of Marine Sciences (Turkey) to a threedimensional, near-real time operating one. The use of high-resolution regional atmospheric model makes possible a medium-range forecasting of the Black Sea circulation.

Special attention is paid to the accurate prediction of circulation in the coastal zone. As part of the Black Sea nowcasting/forecasting system a set of high-resolution models is implemented for the six nearshore regions of the Black Sea [4]. The models are nested in a basin-scale model. Two regional models - for the Burgas Bay and for the Georgian nearshore zone - are domestic models (Bulgarian and Georgian respectively) in z-coordinates. The other regional models represent the version of the Princeton Ocean Model for the Kalamita Bay near the western Crimea, for the Romanian nearshore zone, for the North-Western Shelf zone and for the Russian nearshore zone of the Black Sea. With the nesting technique, velocity, temperature, and salinity along the boundaries are interpolated from the relevant basin scale model variables. An integral constraint is applied so that the net mass flux across the open boundaries is identical to the net flux in the basin scale model. The main improvement is in the simulation over the narrow shelf region, which is not adequately resolved by the basin-scale model.

An experiment on operational functioning of the Black Sea Nowcasting/Forecasting System has been carried out for the first time in the Black Sea region and showed that the developed system can operate in near-real time regime.

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THE IMPACT OF THE EASTERN MEDITERRANEAN TRANSIENT ON THE VERTICAL DISTRIBUTION OF DISSOLVED OXYGEN AND NUTRIENTS OFF THE ISRAELI MEDITERRANEAN COAST

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Abstract

Changes in vertical distribution of dissolved oxygen and nutrients due to the Eastern Mediterranean Transient (EMT) evolution were detected close to the Israeli coast since 2002 during ongoing seasonal cruises. Although the EMT has now relaxed, this is not yet reflected in the vertical distribution of the chemical parameters in the area, and it remains in 2006 as in 2002, much different than prior to the EMT. *Keywords : Circulation, Oxygen.*

Changes in the vertical distribution of the physical and chemical parameters in the Eastern Mediterranean basin following the EMT evolution [1] were documented in the eastern Levantine Basin only since 1999 [2] while the easternmost part of the basin close to the Israeli coast was not surveyed. From 2002, seasonal oceanographic surveys are performed along a 50 mile transect from Haifa, Israel, westwards (up to 1700 m water depth), representing the easternmost part of the basin. While in 1991 there was no evidence of the EMT in the area, from 2002 there is an extreme manifestation that is reflected in the physical parameters (Fig. 1) and on the vertical distribution of dissolved oxygen and nutrients (Fig. 2).



Fig. 1. Long term changes in temperature and salinity properties of the deep water mass near the Israeli coast, Levantine Basin.

If before the EMT there was no minimum-oxygen/maximum-nutrient layer at mid depths, since 2002 it exists even at the station located only 16 miles from shore. Dissolved oxygen increased by ca. 5μ mol/ kg at the deep layers μ mol/ kg (Fig. 2). while silicic acid decreased by ca. 2.

The concentrations of nitrate and phosphate decreased as well (not shown) creating a maximum layer at ca. 500 m depth. The changes influenced primarily, but not only, the deep layers. While in the central Levantine the influence of the EMT seems to be veering off, there are essentially no changes in the vertical distribution at the stations occupied during this study between 2002 and 2006. Continuing survey of the area will make it possible to follow the influence of the relaxation on the chemical properties of the water masses as well as possible influence on the upper layers.



Fig. 2. Vertical profiles of dissolved oxygen and silicic acid concentrations before and after the EMT at stations close to the Israeli coast, Levantine basin.

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EXTREME OCEANIC EVENTS IN THE LAGOON OF VENICE SIMULATED BY AN ATMOSPHERIC/OCEANIC MODEL

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Abstract

A very high resolution oceanic model forced by a regional atmospheric model is used to investigate, under realistic conditions, storm surges observed in the Lagoon of Venice and scenarios of sea level variations related to local manifestations of larger scale climatic changes. Keywords : Adriatic Sea, Lagoons, Tides, Circulation Models, Atmospheric Input.

The hydrodynamics induced by tidal, wind and atmospheric pressure forcing, in an oceanic region including the Adriatic sea as well as the lagoon of Venice, was investigated using an oceanic and an atmospheric numerical model (Figure 1). The adopted approach is required in order to realistically model those storm surge events in the Adriatic sea that, leading to high water levels in the lagoon of Venice, pose a threat to the city of Venice ("acqua alta"). In fact, these events are due to the simultaneous occurrence of large astronomical tides, seiches, and strong atmospheric pressure gradient in the region [1].

The atmospheric model (BOLAM) is a hydrostatic regional model based on the primitive equations, which are solved on a regular horizontal grid on 42 vertical sigma levels. The main forcing is provided by the ECMWF TL511 model and the simulations are performed with two different discretizations, namely 20 km and 5 km grid step. In particular, the simulations performed with the higher resolution permit an accurate description of topographically generated wind intensifications, including Bora wind events, which are known to exert a noticeable influence on the dynamics of the northern Adriatic basin [2].

The oceanic model is based on curvilinear, boundary fitted coordinates and, due to a technique for the treatment of numerical movable boundaries, allows one to simulate the coastal flooding and dry up with great accuracy [3], as it provides a complete solution of the elliptic equations for elevation in a morphologically complex domain. Since the curvilinear discretization permits to vary the mesh size to focus on specific hydrodynamic features, the grid resolution was increased in the northern area and in the lagoon of Venice (maximum grid resolution O(50m)), in order to achieve a satisfactory description of small scale circulation features. The hydrodynamical model was first optimized for the prediction of the astronomical tides in a homogeneously spaced set of gauges.

The model results were compared with a dataset made by measurement of the Italian APAT network and with literature data [4, 5]. The results are in excellent agreement with the data, the error in prediction being of the same order of state of the art models for the area [4, 6]. Different numerical experiments were carried out in order to test the sensitivity of the hydrodynamic model to the input provided by the atmospheric one. In particular, the effect of different horizontal resolution of the meteorological model and the frequency at which the meteorological forcing is updated in the oceanic model was investigated. The oceanic-atmospheric model was then applied to the simulation of a series of exceptionally high tides observed between November 25, 2005, and December 10, 2005 in the lagoon of Venice. This period was characterized by the, almost daily, occurrence of surges with maximum elevations higher than 80 cm, which is considered the alert threshold for "acqua alta". Observed phenomena induced by Bora winds inside the lagoon and in the outer coastal area were captured. In particular, the strong horizontal gradient of the water level inside the lagoon caused by the Bora wind was correctly reproduced as well as the maximum difference in the sea surface elevation between two locations on the main axis. Moreover, the model correctly reproduced the current intensification and the evolution of the sea surface level along the coast of the north Adriatic sea induced by the Bora.

Based on the above findings, the modeling approach was used for investigating the consequences of larger scale climatic changes on sea level variation. This analysis was carried out by forcing the model with atmospheric forcing intensification according to scenarios proposed by the IPCC.



Fig. 1. Hydrodynamic (gridded plot) and atmospheric (circle plot) model domains.

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VARIATIONS OF THE SEASONAL SEA LEVEL CYCLE IN SOUTHERN EUROPE

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Abstract

The present study attempts to quantify the temporal and spatial variability of the seasonal sea level cycle in the Mediterranean and the Iberian coasts on the basis of tide gauge data and to identify the changes in the forcing responsible for this variability. *Keywords : Sea Level, Air-sea Interactions.*

The seasonal cycle, a prominent feature in all climatic parameters, has widely been considered to be fairly constant in time. However, interdecadal and climatic changes are likely to affect the seasonal cycles as well as the mean values of sea level.

In the Mediterranean Sea, the inter-decadal variability of the seasonal cycle displays spatial coherence [1, 2]. Most part seems to be related with atmospheric forcing, with the main factor being the wind rather than the atmospheric pressure.

The data set consists on tide gauge monthly data from the Mediterranean Sea and the Atlantic Iberian coast. The meteorological contribution to sea level has been quantified using the output of a barotropic oceanographic model forced by wind and atmospheric pressure [3]. Finally air surface temperature, mean sea level atmospheric pressure, geostrophic wind and air-sea heat fluxes available from ECMWF (European Centre for Medium range Weather Forecasts) ERA-40 Reanalysis are used for comparison with the sea level data.

The mean seasonal sea level cycle has amplitudes of 3-7 cm and 1-3 cm for the annual and semi-annual signals respectively, with standard errors of 0.5 cm. Annual cycle reaches its maximum values between October and November, while the semi-annual cycle peaks in February. In average, the mean seasonal cycle accounts for the 20% of the total variance of monthly sea level records.



Fig. 1. Mean seasonal cycles of the observations (solid lines), modelled data (dashed lines) and residuals (dashed-dotted lines) for the tide gauges in Marseille (upper plot) in the western Mediterranean and Antalya (lower plot) in the eastern Mediterranean.

Atmospherically-induced seasonal sea level reaches up to 4 cm and 2 cm for the annual and semi-annual signals respectively. Maximum amplitudes take place in both cases in the eastern basin. Phases for the two harmonics vary spatially more than three months over the domain.

The consequences of the direct atmospheric forcing on the mean seasonal cycle are an increase and a sooner annual cycle and a decrease in the amplitude of the semi-annual cycle. The semi-annual cycle in the atmosphere has roughly the same phase as the semi-annual cycle in the ocean in this region, so the residuals (observations minus atmospherically-induced sea level) have reduced semi-annual cycle in around 25%.

The seasonal sea level cycle is unsteady in time with large variations in

amplitudes and phases. Decadal changes in annual and semi-annual signals are consistent among most stations, although regional differences are also noted. After removing the atmospheric pressure and wind effects the seasonal cycle of the residual records is primarily steric. Long term variations are now consistent between Adriatic and western Mediterranean but show different patterns in the Atlantic and the Strait of Gibraltar.

The temporal variability of the atmospherically-induced seasonal cycle is mainly related to changes in meridional wind, especially in the Atlantic and Adriatic. On the other hand the variations of the seasonal cycle of the residual series are related to changes in atmospheric variables.

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A MESOSCALE INDEX TO DESCRIBE THE REGIONAL OCEAN CIRCULATION AROUND THE BALEARIC ISLANDS

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Abstract

The formation of Western Mediterranean Intermediate Water (WIW) in the Gulf of Lions and its later presence in the Balearic Channels play a significant role in the regional circulation. The presence of WIW, given by the intermediate water temperatures in the Ibiza Channel, has been related to air temperature in the Gulf of Lions, providing a continuous and long index of regional circulation. *Keywords : Balear Sea, Circulation, Hydrography, Atmospheric Input.*

The multidisciplinary IDEA project (www.ba.ieo.es/idea) has analyzed the population dynamics of demersal fishery resources in the Balearic Islands from an ecosystemic perspective (i.e. taking into consideration their natural fluctuations and the forcing factors). One of its objectives has focused on the study of how the inter-annual variability of abiotic factors (oceanographic structure and dynamics) could impact on the demersal ecosystems, and to be more concrete, on the population dynamics of two species exploited by bottom trawlers on deep shelf and slope bottoms: hake (*Merluccius merluccius*) and red shrimp (*Aristeus antennatus*).

Historical oceanographic surveys carried out around the Balearic Islands (western Mediterranean) suggest two different scenarios for the regional ocean circulation during late spring-summer. In one scenario, occurring after cold winters, cool water is formed at intermediate layers (100-300 m) in the Gulf of Lions. This Western Mediterranean Intermediate Water (WIW) usually moves southward reaching the Balearic channels at spring, deflecting the warmer Levantine Intermediate Water (LIW) coming from the eastern Mediterranean, and even stalling the Ibiza channel. On the other hand, during mild winters, less WIW is formed and then LIW flows through the channels, appearing at their characteristic depths. The oceanographic surveys around the Balearic Islands (1985-2004) have provided a qualitative index, indicating the presence or not of WIW in the Ibiza channel, based on the analyses of θ -S diagrams. A quantitative index based on mean water temperature between 100 and 300 meters depth in the channels may also be defined. Both indexes, the qualitative and the quantitative, are well correlated for the period 1985-2004, however, both are short in time and gapped.

In order to obtain a longer and continuous index of presence of WIW and then of regional ocean circulation, sea-air heat fluxes at the Gulf of Lions during winter months are obtained from the meteorological NCEP/NCAR reanalysis dataset and compared with other meteorological data as surface air temperature. The standardized air temperature anomaly at 1000 hPa in the Gulf of Lions during winter (December-March) has been shown to be the simplest and best indicator of absence/presence of WIW in the Balearic Islands channels in late spring.

In general, correspondence between heat fluxes and air temperatures is very high for the whole available period suggesting that surface air temperature is a strong contribution to heat fluxes variability in this region during winter (Fig. 1). Furthermore, it is particularly remarkable that significant discrepancies observed between heat fluxes and air temperature for the period when oceanographic data are available (1985-2004), are restricted to those years when heat fluxes seem not to reproduce later WIW presence in the Balearic Channels (1991 and 1993). Also the fact that no WIW was detected in 2001 seems to be better reflected in the air temperature anomaly than in the heat fluxes. This suggests that air sea temperature anomalies seem to be a better indicator for WIW generation than heat fluxes themselves. The reason is not clear but it could be related to the fact that heat fluxes involve many parameterizations and indirect measurements which could cause some bias in its determination. Air temperature is a variable much easier to compute in the reanalysis models and is less subjected to any source of error than an indirect data as heat fluxes. Results shown here seem then to suggest that WIW formation in the Gulf of Lions is basically controlled by the air surface temperature anomaly, at least for the interannual time scale. Other factors, obviously involved in the deep convection process, as surface water temperature and salinity, cloud covering or winds, among others, seem to play, at least, a secondary role in this formation.

Assuming that air temperature is the key factor for WIW formation in the Gulf of Lions, the comparison with WIW presence/absence in the Balearic Channels would suggest that an air surface temperature anomaly larger than its standard deviation would imply non presence of WIW in the channels the following spring. Standardized anomalies between 1.0 and 0.5 would suggest some uncertainty and values below 0.5 would indicate clear presence of WIW [1].

The estimation of this index has allowed the analysis of the influence of oceanographic scenarios on the population dynamics of hake and red shrimp, two of the most important demersal resources in the western Mediterranean. Recruitment of both species seems to be enhanced during low IDEA index periods, when colder-than-normal winters, producing high generation of WIW in the Gulf of Lions, which flow southwards, reach the Balearic Islands channels in spring and reinforce the Northern and Balearic slope currents, increasing the productivity in the area [2].

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Fig. 1. Time series of air-sea heat flux losses from the NCEP/NCAR reanalysis data set averaged for the period December-March at the grid point closest to the Gulf of Lions (dashed dark line) and standardized winter (December-March) air surface temperature anomalies from the same data base and at the same grid point (solid dark line). Data of in-situ mean water temperatures at Ibiza channel region (grey line with small circles), computed for the period

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SEA SURFACE TEMPERATURE TREND OF THE LAST 125 YEARS IN THE MEDITERRANEAN SEA: FROM DAILY TO DECADAL VARIATIONS

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Abstract

AVHRR data have been used to investigate the recent SST variability at basin and sub-basin scale in the Mediterranean Sea starting from 1985. The low frequency analysis has be carried out using historical in situ data available, at lower spatial and temporal resolution, from the ICOADS database. Focusing on the two more recent decades both datasets show an increasing of the mean SST from the 19.4 °C of the second half of 80' (to the 19.8-20.0 °C of the beginning of the new century. The analysis of the longer time series indicates that before 1940 the SST was between 0.5 °C and 1.0 °C lower than the 1961-1990 reference mean, from 1945 to 1990 the SST oscillates between +0.3 °C and -0.1 °C respect to the 1961-1990 reference mean while after 1990 a continuous increase is observed. *Keywords : Remote Sensing, Air-sea Interactions, Global Change, Temperature, Time Series.*

AVHRR SST data estimates permit to analyse SST trends from the beginning of the 80's to today. Within this time window it is possible to investigate either the high frequency variability or the interannual variability but the analysis of lower frequency variations is not feasible due to the relatively short time period. The study of decadal or longer periods variability requires a longer time series not yet available from satellite data only. This low frequency analysis can be carried out using historical in situ data available, at lower spatial and temporal resolution, from the ICOADS database. 1 degree resolution monthly time series are available starting from 1960 while using 2 degree spatial resolution ICOADS it is possible to extend the time series up to 1880.

Our strategy was to use the higher quality and space-time resolution satellite POISST (Pathfinder Optimally Interpolated Sea Surface Temperature) to investigate recent high frequency variability at basin and sub-basin scale and to use 2 degree resolution monthly ICOADS to study the lower frequency variability and to contextualize in a larger time window the more recent satellite estimate.

The Pathfinder Mediterranean Forecasting System Toward Environmental Prediction (MFSTEP) OISST are currently produced in on a daily basis in the framework of the MFSTEP project . This time series consists of a daily series of optimally interpolated SST maps over the regular grid of the operational MFSTEP OGCM model of the Mediterranean basin from 1985 to today. A complete validation of this POISST product with in situ measurements has been performed in order to exclude any possibility of spurious trends due to instrumental calibration errors/shifts or algorithms malfunctioning related to local geophysical factors. The validation showed that satellite POISST is able to reproduce in situ measurements with a mean bias of less than 0.1 $^\circ$ C and RMSE of about 0.5 $^\circ$ C and that errors do not drift with time or with the percent interpolation error (Marullo et al. 2006)

Focusing on the more recent decades (from 1982 to 2005) it results that all the two datasets (Satellite and ICOADS) show an increasing of the mean SST from the 19.4 $^\circ$ C of the second half of 80' (the mean Mediterranean SST in the period 1961-1990) to the 19.8-20.0 °C of the beginning of the new century. The analysis of the full ICOADS time series permits to divide the analysed period in three distinct intervals: before 1940 when the filtered SST was between 0.5 °C and 1.0°C lower than the 1961-1990 reference mean SST, from 1945 to 1990 when the filtered SST oscillates between +0.3 °C and -0.1 °C respect to the 1961-1990 reference mean SST and after 1990 when a continuous increase of the SST is observed. The zonally averaged SST shows a tendency of isotherms to move northward. This northward shift of isotherms was particularly evident from about 1910 to 1950. During this time period the 19 $^\circ \dot{C}$ isotherm (for example) moved from 35 N to 39 N. After 1950 this isotherm continued to oscillate around 35 N. Zonally averaged temperatures below 17 °C are observed only before 1935. A second period of northward shift of the isotherms is observed after 1995.

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INCOMING SOLAR RADIATION OVER EASTERN ADRIATIC SEA: A COMPARISON OF DIFFERENT PARAMETERIZATIONS

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Abstract

Two commonly used formulas that estimate solar radiation were analyzed with data collected in the period 2000 - 2003. It was found that Reed's formula gives a correct mean value but significant seasonal error connected with different air masses that occur over the Adriatic Sea during the year. Octa model was calibrated for the study area and was found that it shows significantly less seasonal error and is appropriate for investigation of smaller scale processes.

Keywords : Air-sea Interactions, Adriatic Sea.

Heat fluxes for the Adriatic Sea are basically controlled by solar radiation flux, cloudiness, and different atmospheric and marine properties at the air-sea boundary. Regional heat flux estimation is available from several authors with significant differences between them. Dispersion of the results is mostly caused by different selection of atmospheric and marine data sets and parameterizations used in the bulk formulas. Solar radiation is calculated using the formula proposed by Reed [1], and cloudiness obtained from reanalysis of different meteorological models and using stations monthly means [2, 3]. In order to minimize the error of one component of the total heat flux, the incoming solar radiation will be analyzed in detail in this paper. We will examine two formulas: the one proposed by Reed [1] and a second one called "octa" model proposed by Dobson and Smith [4].

The incoming solar radiation (SR) was measured in the period 2000 to 2003 with 10 minutes sampling using an Aanderaa sensor mounted on a meteo-ocean station located in front of the Institute of Oceanography and Fisheries (IZOR), Split, Croatia. The sensor was calibrated by the manufacturer. Quality control was regularly performed. Cloudiness was observed hourly by the Meteorological and Hydrological Service on the meteorological station Split - Marjan located 2 km northeast from the meteo-ocean station.

The original octa model was calibrated for the eastern Adriatic Sea using linear regressions on the observed transmission factors grouped by cloud categories form 0 to 8 octas. New coefficients and associated errors are listed in table 1. The error is rising form lower to higher cloud amount.

Tab. 1. New coefficients A_i and B_i of the octa model [4]: $Q_s^{Okta} = I_0$ ($A_i + B_i \cos z$) calibrated for eastern Adriatic Sea.

N	A_i	B_i	RMSE
0	0.4456	0.3939	0.0604
1	0.4365	0.4026	0.0634
2	0.4149	0.4265	0.0773
3	0.3918	0.4267	0.0936
4	0.3796	0.4055	0.1110
5	0.3527	0.4033	0.1349
6	0.3224	0.3217	0.1556
7	0.2126	0.2668	0.1510
8	0.1198	0.1047	0.1069

Table 2 shows monthly means of measured and calculated SR using calibrated and original octa model and Reed's formula. Usually Reed's formula slightly underestimates SR, opposite to the original octa model that significantly overestimates SR. As expected, the calibrated octa model does not show differences in annual mean, but all formulas show a significant seasonal error. A seasonal error also appears in estimated clear sky radiation. Following [5] we can conclude that seasonal error is caused by different air masses present over the Adriatic Sea. Also, overestimation of SR for higher cloudiness (C>4/8) in July and August can be connected to daily coastal circulation and cumulus cloud formation.

Tab. 2. Monthly and annua	al means of incoming solar	radiation measured
(first column) and calculate	ed: using octa model with ne	ew and Dobson and
Smith [4] coefficients, and	Reed's formula.	

Month	Mearsur.	Okta cal.	Okta	Reed
1	62.56	62.83	67.76	60.30
2	98.99	100.53	107.06	103.31
3	163.67	156.18	167.78	148.81
4	198.68	198.59	219.20	192.00
5	274.01	271.56	290.90	255.55
6	318.91	317.06	328.31	313.88
7	296.20	312.10	321.71	311.98
8	245.72	272.85	278.51	278.97
9	191.18	190.83	202.21	181.26
10	119.24	118.57	127.79	111.72
11	71.35	68.64	75.13	63.50
12	53.25	51.22	55.55	49.17
Year	176.31	176.75	186.83	172.54

Using Reed's formula with [5] correction is acceptable for annual means of SR. However, SR has a seasonal error as a consequence of the constant transmission factor used in the clear sky formula. Because the octa model is calibrated for the Adriatic Sea, it has significantly smaller seasonal error and is therefore suitable for smaller scale analysis.

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VARIABILITY OF THE ITALIAN COASTAL CURRENT IN THE CENTRAL ADRIATIC SEA

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Abstract

The Italian coastal current is studied form July 2002 to January 2005 using MODIS surface chlorophyll concentration images. The current, marked by the sediment-rich water of Po River origin, has a strong signal in the visible wavelengths. Baroclinic instabilities protruding out of the coastal current are present all year round along the Italian central coast, and have a temporal scale of 1-2 days. Some of the instabilities expand offshore and evolve into filaments extending to the Croatian coast. Their temporal scale is longer (about 4 days). The location of the expanded instabilities is controlled by the local bathymetry.

Keywords : Adriatic Sea, Circulation, Mesoscale Phenomena.

Introduction

Coastal waters under Po River influence, rich in nutrients, dissolved organic matter and chlorophyll, flow to the southeast along the Italian Peninsula contributing to the Western Adriatic Current (WAC). This water mass is easily traced in the visible during the entire year. The development and evolution of particular baroclinic instabilities of the WAC are studied during the period from July 2002 to January 2005 using satellite chlorophyll and surface drifter data as part of the DOLCEVITA project [1].

Materials and Methods

MODIS satellite data were downloaded from the NASA web site, processed and extracted with the WIM software to provide maps of surface chlorophyll concentration. Low-pass filtered (to exclude tidal and inertial currents) trajectories of the DOLCEVITA satellite-tracked drifters were obtained and superimposed on selected MODIS images. The typical temporal scale of the instabilities was estimated using the autocorrelation statistical method applied to all the images.

Results

Daily images were analyzed to study the formation and the development of the baroclinic instabilities along the WAC. Particular focus was put on specific locations where the instabilities evolve either into elongated filaments extending offshore in the central part of the basin and eventually reaching the Croatian coast (Fig. 1) or as a wide bulge (Fig. 2).



Fig. 1. MODIS chlorophyll concentration in the Central Adriatic Sea on 30 August 2003. The 100 and 200 m bathymetric contours are shown. Drifter tracks over 27-30 August 2003 are superimposed (with a white circle showing the last day).

The region south of Ancona shows the maximum extension of the instability structures and the development of long filaments localised on the northwestern flank of a bathymetric depression (the Middle Adriatic Pit -MAP). Farther to the southeast, the MAP, and the typical cyclonic circulation around it [2], hamper the offshore extension of the WAC instabilities. The region southeast of Ancona and offshore of the WAC shows high chlorophyll mean content and variance. The drifters reveal local cyclonic circulation and enhanced variability of the surface currents.



Fig. 2. Same as Fig. 1 but for 4 July 2004.

The autocorrelation method was applied to all the chlorophyll images to compute the typical time scale of the chlorophyll variability. All along the central coast the scale is around 1-2 days, with the exception of the area southeast of Ancona, were the scale is longer (around 4 days) corresponding to the persistence of the instabilities in this area. In general, our results do not show any significant seasonal variations in the occurrence and characteristics of the instabilities.

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HYDROCHANGES AT GIBRALTAR

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Abstract

3-year T+S time series are now available at the sill (270 m) and on the Moroccan shelf (80 m). The outflow, observed at both places, displays a several-month non-seasonal variability; its denser part can clearly originate mainly from either the western or the eastern basin. The inflow encounters a huge salinification that could explain all changes observed within the sea. Results are detailed in papers published [1], submitted [2] and on hand [3].

Keywords : Strait Of Gibraltar, Hydrology, Monitoring.

Introduction

We first specify our basic understanding of the processes and our major feelings. For the outflow, we focused during the CIESM 2004 Barcelona HydroChanges Round Table on the fact that it originated, in 2003-2004 at least, mainly from the eastern basin with no recognisable western water, as was the case in the early 1980s and before. Because the early 1980s were intensively covered and the few data collected thereafter not analysed yet, it was generally assumed that the outflow's denser part was always composed of Western Mediterranean Deep Water (WMDW) from the western basin. Our feeling was that not enough attention was generally paid to the densest waters from the Aegean and Adriatic subbasins that form the Eastern Overflow Water (EOW) in the channel of Sicily. Indeed, EOW cascading down to 2000 m in the Tyrrhenian mixes with the resident waters (including WMDW) and forms the Tyrrhenian Dense Water (TDW). Depending on the amounts and characteristics of EOW vs. those of WMDW, TDW can be more or less different from WMDW, hence have an origin more eastern or western. And WMDW can be identifiable at Gibraltar only if produced in relatively large amounts; otherwise, it can outflow just as part of TDW! In any case, the outflow must be considered as composed of 3 different Mediterranean Waters (MWs): Levantine Intermediate Water (LIW) always outflowing on the strait's northern side, TDW always present with changing characteristics and WMDW that can be entirely included into TDW. For the inflow, the hypotheses published about the sea warming and salinification assume that the water of Atlantic origin (AW) has constant characteristics. Our feeling was that this should be checked at first, furthermore worldwide long-term changes are now specified.

Two moorings have been set on a small plateau at ~ 270 m and on the outer continental shelf at ~ 80 m near Tangiers to monitor the MWs and AW. They were initially deployed in mid-Jan. 2003 and serviced in early Apr. 2004 and in mid-Oct. 2005 (actually providing 30-month time series).

The results

About the outflow, we have first compared the 270-m time series in 2003-2004 with other time series in the mid-1990s and with all available CTD casts [1]. It is clear that the densest outflowing MWs have been continuously changing from the mid-1990s at least; T and S have been increasing, being in the early 2000s much warmer ($\sim 0.3^{\circ}$ C) and saltier (~ 0.06) than ~ 20 years ago, a feature possibly related to the Eastern Mediterranean Transient. This period is roughly period #1 in fig. 1 [2]. Points are very different from those representative of WMDW and very few characterise the MWs at 80 m. During period #2 (fig.1b), WMDW is still absent but more numerous values are retained at 80 m, and they are denser than at 270 m, an easily explainable feature [3]. In fig.1c, the outflow there is clearly of western origin, in particular at 80 m, while it comes to be composed mainly of TDW in fig.1d. There is clearly no seasonal variability in the composition of the outflow [3]. Various quantifications of the salinification at 80 m lead to \sim 0.05/year during these 30 months (fig. 2) [2] which could explain alone both the salinification and the warming in the whole sea. In addition to homogenisation of the AW layer [2], such changes reduce the mixing with the MWs, hence leading to an outflow less and less mixed with the inflow [3].



Fig. 1. θ -S diagrams from a selection of data aimed to represent relatively unmixed MWs at 270 m (.) and 80 m (+), separated in 4 periods (d#1 is Jan. 1, 2003), with 29.08 and 29.09 isolines.



Fig. 2. Variation with time at 80 m of S values aimed to represent relatively unmixed AW.

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IMPACT OF OPTICAL WATER TYPES ON THERMOHALINE PROPERTIES AND DYNAMICS OF THE ADRIATIC SEA

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Abstract

Optical properties in the Adriatic show large variation in space and time. The effect of changed optical types was tested, with the simplified assumption for the two optical types, via the Z-coordinate nonlinear levels model during the four cold months in 2005-2006, with the available atmospheric forcing. Significant vertical and regional differences were observed in warming between the utilized optical types. This indicate differences in stability of the water column between the two cases. The currents were also changed. *Keywords : Adriatic Sea, Temperature, Currents, Models.*

Introduction

Solar energy propagation in the water depends on water transparency. Seasonal differences of optical properties, and transparency decreasing trends in some Adriatic regions cover a full scale of optical types, and hydrodynamical modeling should take this into account. Recent PAR attenuation measurements enabled the determination of present optical types in the Adriatic, while historical measurements [1] allowed an assumption about earlier types. Although a variety of types were found for different sites of the Adriatic, especially in the coastal region, the simplified experiment that utilized two optical types has already demonstrated significant differences in results. Changes of optical water properties lead to different warming of the water column and a different stability, causing changes of other properties too.

Methods and data

A numerical experiment was performed with the Z-coordinate nonlinear levels model developed by Bone [2, 3], exploring the effects of the different optical water types. A description of the model and the source code can be found at www.math.izor.hr. The integration area was the Adriatic Sea from Otranto northward, and the integration time was four months, in the cold period from December 1st 2005 to March 31th 2006. The wind, cloudiness and other meteorological data were the Aladin model reanalysis for 10 m height above the sea surface, at the spatial scale of 8 km every 3 hours, obtained from the Meteorological and Hydrological Service of Croatia. In the numerical experiments a complex forcing included surface fluxes (momentum, heat and evaporation), river runoffs (heat and salinity), solar and backward radiation, and tides. Ane horizontally equally spaced Arakawa E grid, with the vertical z-coordinate divided in layers of equal thickness, was used in the model, split into external and internal mode with some common variables insuring feedback binding. The horizontal grid step was 10 km with 5 m level thickness. The heat fluxes in the water from infrared and visible spectrum are introduced in the model via the respective attenuation coefficients. The experiment was performed using the coefficients for visible spectrum for optical water types I and II [4], which enabled different heat transfer conditions.

Results and discussion

Consequences of introducing higher attenuation coefficients were observed in all the layers. Changing the optical type, notable differences of temperature through the integration time were obtained. Consequently, the density field also changed. The corresponding currents also changed considerably, and differences were observed down to the deepest layers of the south Adriatic Pit. Different conditions of heat transfer changed the Richardson number i.e. vertical turbulent exchange of momentum. After the integration period, in the surface layer, the largest temperature differences have been found in the Northern Adriatic and in the shallow areas close to the Italian coast (Fig.1, left). The temperature differences slightly warmer while Jabuka Pit becomes slightly colder, after the optical type was changed.



Fig. 1. Predicted spatial distribution of temperature differences after integration period at 2.5m depth (left) and at 150m (right), for the Adriatic Sea, resulting as a change in optical water type, after four months of integration.

The results demonstrate that thermal energy was trapped in the shallower layer, producing higher vertical density gradients and increase of water stability, i.e. decrease of turbulent energy. They also demonstrate that there are considerable differences between the two optical types, pointing to the need for better definitions of the water attenuation coefficients in hydrodynamical modeling. This may be particularly important for seas with high seasonal and regional variations of optical properties.

We have demonstrated that light conditions in the water influence thermohaline and dynamical properties, but light also influences photosynthesis, metabolic processes, fluorescence, primary production rates etc. Changed light conditions therefore, create complex feedbacks between biological and physical systems, which should be further studied and taken into account in ecological modeling.

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CLIMATOLOGICAL CIRCULATION OF THE IONIAN AND LEVANTINE BASINS USING: HISTORICAL DATA AND NUMERICAL MODELLING

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Abstract

A climatological circulation analysis for the Ionian and Levantine Basins has been defined using the MEDATLAS grided data set for temperature and salinity fields. This has been carried out by computation of the geostrophic current using the dynamic height method with a 400 m as reference level. The Princeton Ocean Model has been implemented inorder to simulate at the climatological scale, the mesoscale features of the area. Several simulations have been done with different model configurations and different atmospheric forcing. Results obtained from the model are compared with the observed climatological circulation characteristics. *Keywords : Circulation, Ionian Sea, Levantine Basin, Models.*

The work aims at analysing the climatological general circulation of the Ionian and Levantine basins by means of historical data (MEDATLAS temperature and salinity monthly gridded data set)[1]. The MEDATLAS data reveals the main water masses of the area and their seasonal variability, in particular the Atlantic Water (AW) and the Levantine Intermediate Water (LIW). From the MEDATLAS gridded data dynamic height has been computed with the geostrophic method using 400 m as reference level. The resulting geostrophic current gives a realistic picture of the main circulation patterns in the area in agreement with previous analyses [2, 3], as shown in Figure 1.



Fig. 1. Monthly average surface current in October: (A) Geostrophic current according to the dynamic height method using 400 m as reference level in $m.sec^{-1}$; (B) OGCM perpetual year surface current in $m.sec^{-1}$.

In order to get insight on the mesoscale characteristics of the Ionian and Levantine basins, the Princeton Ocean model has been implemented with a horizontal resolution of $1/12^{\circ}$ and $1/24^{\circ}$ with a vertical resolution of 25 sigma layers. Simulations of the general circulation have been carried out under perpetual year monthly variables. The model is one way nested with the Global Mediterranean General Circulation Model [4]. Several simulations have been carried out using different model configurations and different atmospheric forcing. The performed climatological runs of the nested model have presented the complex dynamics of the interested

area. Comparing the model monthly average net volume transport across the open boundaries with the model monthly average water flux showed a consistency to demonstrate the skill and robustness of the simulation.

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STATISTICAL ANALYSIS OF THE SEA SURFACE TEMPERATURE IN THE GULF OF TRIESTE (NORTHERN ADRIATIC) USING SATELLITE DATA (2000-2005)

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Abstract

Six years of Advanced Very High Resolution Radiometer (AVHRR) satellite data were acquired to study the spatial and temporal variability of the sea surface temperature (SST) in the Gulf of Trieste between January 2000 and December 2005. Monthly, yearly and 6-yearly SST statistics (mean, median and standard deviation) were produced. The Empirical Orthogonal Function (EOF) analysis was also applied to the entire dataset. The results show that the seasonal cycle of the SST generally exhibits values ranging between 8 and 25 $^{\circ}$ C with a typical standard deviation of 1.5 $^{\circ}$ C. The first EOF mode describes more than 80% of the total signal variance and its temporal amplitude provides the seasonal SST cycle.

Keywords : Adriatic Sea, Temperature.

Introduction

The Gulf of Trieste [1] is located in the northeastern part of the Adriatic Sea approximately between $13-13.8^{\circ}$ longitude East and $45.4-45.8^{\circ}$ latitude North. The main riverine freshwater discharge is due to the Isonzo River in the northern part of the Gulf. The maximal depth of the study area is less than 25 meters. The main wind forcing in the Gulf of Trieste is through intermittent events of northeasterly cold, strong and dry wind, called Bora, that blows more frequently in winter. The spatio-temporal SST variability is studied using AVHRR satellite data between 2000 and 2005.

Data and methods

AVHRR data of the NOAA satellite constellation were acquired by the OGS receiving station and used to compute the SST. In order to exclude the diurnal warming effect in our analysis we chose one NOAA-12 night-time pass per day. Moreover, we only considered images with cloud coverage less than 90% before performing the statistic analysis. Two steps were conducted to minimize the effect of the non-uniform temporal distribution of the data (there are less cloudy and more images in summer): (1) the images were subsampled on a monthly basis, selecting a maximum of ten images per month; (2) coastal areas with less than 45% of good data (with respect to the maximum of 914 in the open sea) were discarded. We produced monthly, yearly and 6-yearly composites of the mean, median, standard deviation of the SST and the corresponding images with the data density. The EOF analysis was then applied to the entire dataset.

Results

The seasonal cycle of the SST in the Gulf of Trieste over 6 years is well described using the monthly spatio-temporal means [Fig. 1].



Fig. 1. Monthly mean of SST (\pm standard deviation) in the Gulf of Trieste versus time between January 2000 and December 2005.

The minimal (in winter) and maximal (in summer) temperature values are respectively about 8 and 25 $^{\circ}$ C, with a standard deviation of 1.5 $^{\circ}$ C.

Winter 2001 and summer 2003 are warmer with respect to the other years by approximately 1.5 °C. The 6-years mean of the SST [Fig. 2] reveals a general meridional gradient of the temperature field with values ranging between about 16 and 18 °C (the standard deviation is between 5.5 and 6.5 °C). The northern portion of the area is, on average, colder than the southern part by about 1 °C. The near-coastal areas, and particularly the Grado lagoon to the north, are warmer than offshore by 1-1.5 °C. The first EOF mode describes more than 80% of the total signal variance and its temporal amplitude provides the seasonal cycle of the SST.



Fig. 2. SST composite (mean of the monthly means during 2000-2005) in the Gulf of Trieste.

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OPERATIONAL OCEAN FORECASTING IN THE ADRIATIC SEA: RECENT IMPROVEMENTS

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Abstract

The Ocean Forecasting System for the Adriatic Sea implemented within the framework of the ADRICOSM Project has recently been upgraded in terms of resolution (both vertical and horizontal), parameterizations, and numerical schemes. The results of these improvements are shown.

Keywords : Adriatic Sea, Circulation Models, Water Transport.

Within the ADRICOSM (ADRIatic sea integrated COastal areaS and river basin Management system) partnership (http://www.bo.ingv.it/adricosmpartnership/), near real time monitoring and basin-shelf marine forecasting systems have been implemented, and are now being used in operational mode for the Adriatic Sea. The numerical forecasting model used (AREG, Adriatic REGional model) is based on the Princeton Ocean Model [1]. Its implementation covers the entire Adriatic Sea and extends into the Ionian Sea.

Every week the operational system produces 7 days of hindcast (from noon of the previous Tuesday up to noon of the current week Tuesday) and 9 days of forecast. The hindcast is forced at the surface by the European Centre for Medium Range Weather Forecast (ECMWF) atmospheric analyses; it uses the Mediterranean Forecasting System (MFS) [2] analyses as lateral open boundary conditions, and the observed daily Po run-off. For the forecast the model is forced using ECMWF and MFS operational forecast, while the last available Po values are persisted.

The operational runs take place every Wednesday morning and the results of the forecast and hindcast are available on a dedicated ftp server, both for research and commercial users. Furthermore, many images of all the calculated fields are visible on the web (http://www.bo.ingv.it/adricosm).



Fig. 1. Predicted Sea Surface Elevation anomalies (m) for 10 October 2006 by the previous operational system.

The AREG model has recently been improved in terms of resolution, parameterizations, and numerical schemes. A detailed description of the model implementation can be found in Oddo et al., 2005 [3]. The resolution has been upgraded both horizontally and vertically. Horizontally it changed from approximately 5 km to 2.2 km (the grid is regular in both cases), while vertically it changed from 21 to 31-sigma levels.

The surface boundary condition for the vertical velocity has been changed from the old standard POM kinematic condition [3] to the new dynamic condition taking into account the water balance as follows:

$$w|_{z=\eta} = \left(\frac{\partial\eta}{\partial t} + \bar{v}\cdot\nabla\eta\right)\Big|_{z=\eta} = (E - P - R)$$
 (1)

where η is the surface elevation; E, P, and R are evaporation, precipitation and river runoff; w is the vertical velocity; and v is the horizontal velocity field. In the new implementation a flux limiting advection scheme [4] has been implemented allowing a better reproduction of the horizontal and vertical gradients. This change has the effect to mitigate some previous model deficiencies related to the overestimation of numerical diffusion [3]. After these major changes most of the model deficiencies [3] seem to be fixed. In figs.1 and 2 the sea surface elevation anomalies for 10th October 2006 predicted by the model are shown The new solution (fig.2) indicates the model capability to reproduce smaller scales features and to better represent the dynamics in the Southern part of the basin.



Fig. 2. Predicted Sea Surface Elevation anomalies (m) for 10 October 2006 by the improved operational system.

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RECENT PROGRESS ON THE BLACK SEA CIRCULATION AND ECOSYSTEM DYNAMICS

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Abstract

Its highly energetic mesoscale-dominated circulation and complex shelf-deep basin interactions, together with an array of natural and human impacts on a continuously changing perturbed ecosystem and biogeochemical structures, make the Black Sea a unique example. Some observational and modeling efforts that have been performed within the framework of several international programs explored, quantified, and predicted circulation, ecosystem and biogeochemical variability from the overall basin scale to coastal/shelf domains, and over time scales extending from weeks to decades.

Keywords : Black Sea, Circulation, Paleoceanography.

The Black Sea, once relatively an unexplored and isolated site of global oceans, has been a major focus of international and regional efforts since the early 1990s. Following the collapse of the former Soviet Union, Prof. Ünlüata was the leading person who initiated and promoted these collaborative efforts by bringing key scientists from the region as well as the international oceanographic community. Prof. Unluata's scientific vision and personality have been a key factor for successful implementation of the HydroBlack, ComsBlack and NATO-SfS and NATO-SfP programs during the 1990s. Even though he moved to IOC during the late 1990s, his interest on the promotion of Black Sea oceanography continued till the last moment. The EU-funded projects, which are emerging during the present decade, are surely based on the earlier achievements made on his leadership.

Here, an overview of the progress achieved so far and the current stateof-the-art on the Black Sea oceanography is presented in terms of its circulation and ecosystem dynamics using a set of observational findings and modeling products.

The hydrographic, and remotely-sensed altimeter and ocean color observations as well as the modeling studies, reveal a complex, eddy-dominated circulation system with different types of structural organizations within the interior cyclonic cell, the Rim Current flowing along the abruptly varying continental slope and margin topography around the basin, and a series of anticyclonic eddies in the onshore side of the Rim Current [1, 2]. The interior circulation comprises several sub-basin scale gyres, each of them involving a series of cyclonic eddies. They evolve continuously by interactions among each other, as well as with meanders, and filaments of the Rim Current. The Rim Current structure is accompanied by coastal trapped waves with an embedded train of eddies and meanders propogating cyclonically around the basin. Over the annual time scale, westward propogating Rossby waves further contribute complexity to the basinwide circulation system. The Rim Current jet has a speed of 50-100 cm/s within the upper layer, and about 10-20 cm/s within the 150-300 m depth range. The mesoscale features evolving along the periphery of the basin as part of the Rim Current dynamic structure apparently link coastal biogeochemical processes to those beyond the continental margin, and thus provide a mechanism for two-way transports between nearshore and offshore regions.

Among marginal sea ecosystems, the Black Sea is of special interest because of dramatic changes that took place in its ecological properties from the early 1970s to the 1990s under cumulative effects of excessive nutrient enrichment, strong cooling/warming, over-exploitation of pelagic fish stocks, and population outbreak of gelatinous carnivores [3]. The Black Sea ecosystem was reorganized during this transition phase in different forms of top-down controlled food web structure through successive regime-shifts of distinct ecological properties. The Secchi disk depth, oxic-anoxic interface zone, dissolved oxygen and hydrogen sulphide concentrations also exhibit abrupt transition between their alternate regimes, and indicate tight coupling between the lower trophic food web structure and the biogeochemical pump in terms of regime-shift events.

The first shift, in 1973-1974, marks a switch from large predatory fish to small planktivore fish-controlled system, which persisted until 1989 in the form of increasing small pelagic and phytoplankton biomass and decreasing zooplankton biomass. The increase in phytoplankton biomass is further supported by a bottom-up contribution due to the cumulative response to high anthropogenic nutrient load and the concurrent shift of

the physical system to the "cold climate regime" following its ~20-year persistence in the "warm climate regime". The end of the 1980s signifies the depletion of small planktivores and the transition to a gelatinous carnivore-controlled system. By the end of the 1990s, small planktivore populations take over control of the system again. Concomitantly, their top-down pressure when combined with diminishing anthropogenic nutrient load and more limited nutrient supply into the surface waters due to stabilizing effects of relatively warm winter conditions switched the "high production" regime.

The Black Sea regime-shifts appear to be sporadic events forced by strong transient decadal perturbations, and therefore differ from the multi-decadal scale cyclical events observed in pelagic ocean ecosystems under low-frequency climatic forcing. The Black Sea observations illustrate that eutrophication and extreme fishery exploitation can indeed induce hysteresis in large marine ecosystems, if they can exert sufficiently strong forcing onto the system. They further illustrate the link between the disruption of the top predators, proliferation of new predator stocks, and regime-shift events. Examples of these features have been reported for some aquatic ecosystems, but are extremely limited for large marine ecosystems.

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A FRESH LOOK AT DYNAMICS OF THE ADRIATIC SHELF-BREAK AREA

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Abstract

First results of extensive ADCP and CTD measurements, performed in the Adriatic shelf-break area between February and September 2006, are presented. Pronounced diurnal oscillations were observed, apparently related to internal tides and periodic upwelling and downwelling events. Moreover, inertial oscillations were documented. Finally, summertime change of the east-coast inflow to the Adriatic was recorded, lasting only one month at two ADCP stations, three months at one station.

Keywords : Adriatic Sea, Circulation, Upwelling, Tides.

The presentation focuses on the Adriatic shelf-break area. Previously, it has been found that the along-basin flow there is oppositely directed in the winter and summer seasons, that seasonally dependent circulation contributes to a strong temporal variability of thermohaline properties, and that barotropic-like currents reverse on a few-day scale [1]. More recently, it has been shown that during the stratified season diurnal internal tides are generated in the area by the interaction of diurnal barotropic tides with topography [2]. As the previous detection of internal tides was based on a limited data set, the project entitled "Internal Tidal Hydrodynamics and Ambient Characteristics of the Adriatic (ITHACA)" was initiated in order to provide a more complete information. The aim of the project was also to consider the way changes of background stratification and currents modify internal waves, and vice versa - to address a possible influence of internal waves on deductions based on measurements that are scattered in space and time.



Fig. 1. Depth-frequency plots obtained from (a) temperature time series collected at Lastovo and (b) cross-basin currents recorded at a nearby station and detided by allowing for seven barotropic tidal constituents. Darker shadow implies higher spectral density. Also indicated are the 24-h, 12-h and 8-h periods as well as the local inertial period.

The field phase of the project lasted from February to September 2006. During the experiment (1) ADCP measurements were performed at three stations using trawl-resistant bottom mounts (called barnys), (2) thermistor data were collected on the islands of Lastovo, Sušac and Biševo utilizing 3 x 10 sensors deployed on steep cliffs opened to the southeast, (3) shipboard CTD surveys were carried out on four occasions at an along-basin transect comprising 13 closely spaced stations, (4) optical surveys were performed at thermistor stations while deploying and recovering them, (5) surface tides were monitored at the permanent Split and Dubrovnik stations and at one of the ADCP stations, and (6) meteorological conditions were documented by permanent stations in the area (Split, Dubrovnik, Hvar, Komiža and Palagruža). The project was successful, as all the instruments were recovered except one of the thermistors. Preliminary analysis of the data collected has shown that diurnal temperature oscillations were particularly strong at one of the islands (Lastovo) and that corresponding baroclinic current variability was largest at a nearby ADCP station (Figure 1). Apparently, the diurnal signal was related not only to internal tides but also to periodic upwelling and downwelling events that were especially pronounced in July 2006. Inertial oscillations were also well visible in both the temperature and ADCP time series. Lower frequencies were dominated by the eastcoast inflow to the Adriatic, which, however, underwent a summertime change - recorded in July 2006 at two of the ADCP stations, between May and July 2006 at one station.

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A BOOTSTRAPPING METHOD FOR PARAMETERIZATION DEVELOPMENT OF OVERFLOW MIXING FOR CLIMATE MODELS

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Abstract

Mixing in overflows may have a significant effect on the oceanic thermohaline circulation. The drastic separation between the scale of mixing and horizontal grid size in climate models is spanned by dividing the problem into several sub-problems: direct numerical simulation (DNS) is used to develop a subgrid-scale model of stratified mixing for large eddy simulation (LES); LES is used to develop mixing parameterization for an ocean model (HYCOM); in-situ observations are used to validate regional overflow simulations with HYCOM; and finally, the so-called marginal sea overflow boundary condition (MSBC) is used as a parameterization of an entire overflow for climate studies, on the basis of an ensemble of experiments using high-resolution HYCOM. *Keywords : Stratification, Circulation Models.*

The main objective of this effort is to develop parameterizations of overflow mixing for ocean general circulation models used in climate studies. Given the challenging multi-scale problem of representing the net effect of mixing taking place on the order of the overturning (Ozmidov) scale of O(10 m) in climate models, with typically 100 km horizontal grid resolution, the so-called bootstrapping technique has been pursued. By noting that most of mixing taking place near the density interface between the gravity currents and the ambient fluid is carried out by overturning eddies, and the smaller scale structures arising from the break-down of these eddies into turbulence mainly play a role in energy dissipation, subgrid-scale models have been developed for large eddy simulation (LES) using direct numerical simulation (DNS) results as ground truth [1]. Then, LES of gravity current simulations are used to provide testbeds and benchmarks for ocean general circulation models [2]. HYCOM is a suitable OGCM for this problem because it is designed to prohibit entirely all diapycnal mixing, except for that prescribed by parameterizations. Benchmark LES of bottom gravity currents are then used to develop parameterizations of entrainment as a simple algebraic function of the layer shear Richardson number [3, 4]. This parameterization is then tested extensively for regional simulations of overflows, namely for the Mediterranean Sea overflow using the in-situ observational data from the Gulf of Cadiz Experiment, and the Red Sea overflow [5] using the Red Sea Outflow Experiment. Both of these studies indicated that these overflows were satisfactorily reproduced, and no further fine-tuning of the parameterization was needed. It was noted that the Red Sea overflow appears to be more challenging than the Mediterranean Sea overflow, because the former bifurcates into narrow channels and accurate representation of domain geometry becomes as important as the representation of mixing. In order to make the final step from regional overflows to climate model scale, the results from the so-called marginal sea boundary condition (MSBC, [6]) and regional Mediterranean Sea overflow simulations are compared under a variety of climate conditions, represented by different combinations of changes in the properties of the Mediterranean Sea overflow and the ambient North Atlantic water. Consistent results are obtained from HYCOM and MSBC, indicating that MSBC can be used as a well-founded parameterization of the Mediterranean Sea overflow in climate models [7].

In summary, bootstrapping technique consists of using DNS as ground truth for LES, LES as benchmark for idealized HYCOM, observational data sets to validate regional simulations of overflows, and regional simulations to fine-tune and validate MSBC, such that the needed range of scales from small overturns to climate model grid size could be spanned for this particular problem.

In addition, LES of gravity currents have been used to conduct studies of more delicate processes. In particular, the behavior of turbulent gravity currents in the presence of ambient stratification is studied for cases in which equilibrated product water masses are formed [8]. The main objective was to explore how the ambient stratification impacts entrainment and the properties of product water masses, which are of ultimate interest to climate modelers. Results also show that, for the case of constant slope angle and linear ambient stratification, the gravity current separates from the bottom such that the entrained mass flux is independent of the slope angle. The product mass transport and product salinity then depend only on the ambient stratification, and these quantities are approximated as simple algebraic functions of the ambient stratification parameter that modify

the source properties. Also, by recognizing that oceanic overflows follow the sea floor morphology, which shows a self-similar structure at spatial scales ranging from 100 km to 1 m, the impact of topographic bumps on entrainment in gravity currents is investigated [9]. It is found that in the case of smooth bottom, the overturns can only dilute the upper part of the overflow, and the densest water masses near the bottom escape dilution and set equilibrium level of the product water mass. Bottom roughness and in particular form drag exerted on the overflows are then recognized as an important mechanism that needs to be considered.

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EIGENFREQUENCIES OF VELA LUKA AND STARI GRAD BAYS (EAST ADRIATIC)

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Abstract

Fine-resolution measurements of water pressure were performed along two elongated bays, where on several occasions extremely large, high frequency sea level oscillations have occurred. The time series reveal spatial variability of the natural modes. At the eigenmode frequencies, energy is strongly enhanced from the open towards the closed end. In the inner part of the basins, natural modes are being excited, giving rise to high-frequency oscillations of large amplitude.

Keywords : Adriatic Sea, Sea Level, Coastal Processes.

Occasionally, some bays along the east Adriatic coast experience extremely large, high frequency sea level oscillations that may cause great damage to the coastal infrastructure. Particularly vulnerable are westwardopen funnel-shaped inlets. The phenomenon has been observed also in some other parts of the Mediterranean (e.g. Balearic Islands) and elsewhere in the world. It is induced by atmospheric gravity waves which, through the process of Proudman and successively harbor resonance, excite normal modes of propitious basins.

The most intense episodes at the Croatian coast have been documented (Orlic, 1980) and closely studied using available sparse data and mathematical modeling (Vilibic et al., 2004). However, until now, no specific sea-level measurements at the exposed sites have been made to empirically back up the findings. An experiment was therefore designed to investigate spatial variability of normal modes of two harbors where the phenomenon occurs most often, namely Vela Luka and Stari Grad bays. Hence at each site several small pressure sensors with integrated data loggers were placed on the sea bottom along the bay and one was used to measure the air pressure. The pressure was recorded at 3 min sampling interval, during three summer months of 2006.



Fig. 1. Power density spectra of the water pressure adjusted for the air pressure, recorded from 18 to 21 June 2006, at three sites along Stari Grad (left) and Vela Luka bays (right), from the open (SG1/VL1) to the closed end (SG3/VL3) of the basins.

During the experiment several intervals of intense seiche activity, particularly in the inner part of the basins, have been recorded. Power density spectra for one episode that occurred simultaneously at the two locations are shown in Figure 1. At both locations there is a general growth of energy as we move from the open end towards the head of the basin. In Stari Grad Bay, three distinct energy maxima, at periods of 25.7 min, 10.2 min and 8.6 min, are resolved, the latter two being observed only at the two inner stations. In Vela Luka Bay, at the outermost station only a peak at 20.0 min period is seen. As we advance towards the closed end, the oscillations at this period become larger, but also natural modes of the inner part of the basin are being excited; oscillations of 11.8 min period are observed at both inner stations, the energy being largely enhanced at the closed end. Moreover, the innermost part of the bay oscillates with an eigenmode of 8.0 min.

Acknowledgement

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HIGH VS. LOW RESOLUTION ATMOSPHERIC FORCING OVER THE ADRIATIC

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Abstract

High resolution meteorological fields over the Adriatic derived from mesoscale ALADIN/HR model for the Nov/2002 - Sep/2003 period are compared with corresponding low resolution fields obtained from global ECMWF model. The analysis is performed on mean values calculated over strong bora and strong sirocco episodes. It is shown that not only bora but also the sirocco-type weather is largely influenced by local orography. The results suggest that use of mesoscale meteorological forcing can significantly improve oceanographic forecasting in the Adriatic.

Keywords : Adriatic Sea, Atmospheric Input, Circulation.

In recent years significant effort is undertaken in the field of operational oceanography of the Mediterranean Sea (e.g. http://www.moonoceanforecasting.eu). Among other goals, a numerical forecasting system at basin scale, but also on regional and shelf scales, is developed. The Adriatic Sea in particular is covered by a regional hydrodinamical model and several shelf models [1], where the necessary boundary conditions are prescribed by simple one-way nesting between respective models [2]. Available at the time, the atmospheric forcing was taken from global ECMWF model having 0.5 degrees longitude and latitude resolution which is far from enough to resolve fine structure of the Adriatic weather, known to be strongly influenced by local orography, e.g. [3]. To get a better insight into deficiencies thus introduced, in the present work the ECMWF fields are compared with the corresponding output of the mesoscale meteorological model ALADIN/HR.



Fig. 1. Mean differences between the ALADIN and ECMWF modelled air pressure (top) and the wind speed component along the main airflow (bottom) for sirocco (left) and bora (right) episodes during the November 2002 - September 2003 period. Full lines show positive, dotted lines negative differences.

We used ALADIN output fields every 3 hours, having spatial resolution of 8 km, spanning over the period from 1 November 2002 till 30 September 2003. Respective ECMWF fields that were available every 6 hours were trilinearly interpolated onto the ALADIN space-time grid. The analysis was conducted around two most prominent types of Adriatic weather, namely those characterized by strong bora and strong sirocco winds. To that end three characteristic grid points were chosen in the northern part, and three in the southern part of the Adriatic. Bora (sirocco) episodes were extracted as all instances (80 ones for bora, 63 for sirocco) where all six grid points have wind from the first (fourth) quadrant stronger than 8 m/s. Mean differences between ALADIN and ECMWF modelled fields were calculated over these bora and sirocco episodes, separately (Fig. 1).

Due to the finer spatial resolution and consequently more realistic landsea mask and topography, in the discussion below, ALADIN modelled fields are considered as referent. The air pressure differences between the models (Fig. 1, top) show large contiguous areas of the same sign with amplitudes up to 2 hPa. For the sirocco situations, ECMWF generally underestimates the air pressure over the northern Adriatic and along the middle and southern east Adriatic coast. On the other hand, almost all along the Italian coast south of Ancona, the ECMWF predicted pressure is higher than the ALADIN predicted one. The region where this overprediction is particularly wide as measured in the offshore direction extends from Ancona to Gargano peninsula. For bora conditions, the air pressure predicted by ECMWF is lower over the major part of northern and middle Adriatic, while south-eastward of Istria Peninsula and over the southern Adriatic it is higher.

A comparison between the ALADIN and ECMWF predicted sirocco and bora winds shows discrepancies generally oriented along the main airflow. Hence, Fig. 1 (bottom) presents mean differences of north-westward component of sirocco and south-westward component of bora winds. The ECMWF sirocco speeds are generally lower than the ALADIN ones (in some regions even more than 4 m s⁻¹). Further, an interesting pattern with alternation of jet-wake-jet structure is found north of Gargano. It seems to be a consequence of the blocking and splitting of sirocco flow upstream of Gargano, which is almost an ideal 3D obstacle. Accordingly, downstream of mountain a typical pattern of the airflow around the 3D obstacle emerges with the wake in the central part of the lee and jets emanating from the obstacle edges. Additionally, the jet emanating from the western flank of Gargano is amplified due to the channelling along the valley between the Gargano and Apennines. A third amplifying effect on the jet originates from the north-eastward downslope flow on the east side of the Apennines. The three amplifying mechanisms seem to result in airflow convergence northwest of Gargano above the Adriatic, which is associated with the low pressure discrepancy (Fig. 1 top). The jet penetrates far northward over the Adriatic. Over the eastern Adriatic, the regions with underpredicted sirocco winds are also found downstream of topographical obstacles, and they have similar values as over the greater Gargano area. The discrepancies between the ECMWF and ALADIN predicted bora winds also show the expected alternation of jet-wake patterns [3], thus confirming that ECMWF is not able to simulate the complex bora structure.

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PHYSICAL AND CHEMICAL PROPERTIES OF THE CILICIAN BASIN, NORTHEASTERN MEDITERRANEAN SEA

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Abstract

The water mass and chemical properties of the Cilician Basin, the northeastern Levantine Sea, are described on the basis of three hydrographic cruises. The hydrographic data reveal the presence of Levantine Surface Water (LSW) and Atlantic Water (AW) within the upper 90 m layers, Levantine Intermediate Water (LIW) between 90 and 250 m, and Transitional Mediterranean Water (TMW) further below. *Keywords : Eastern Mediterranean, Hydrography, Phosphorus.*

Introduction

While the general features of the hydrology of the Eastern Mediterranean are fairly well recognized [1, 2] a consistent representation of their characteristics in the Cilician Basin is still lacking. Although the nutrient regime of the eastern Mediterranean has been studied extensively in recent years [3, 4] the physical, chemical and biological data are too limited to reach reliable conclusions about the spatial and temporal variability of water masses in the Cilician Basin. We present here data from three cruises that can provide an exhaustive description of water mass properties and nutrient charecteristics in the Cilician Basin.

Materials and Methods

The investigation was restricted to an area 180 by 80 km on the northern Levantine part of the Eastern Mediterranean. The data were collected as part of three cruises of the R/V K. Piri Reis in May 1997 (spring), July 1998 (summer) and October 2003 (fall). During each cruise, standard CTD profiles were obtained at each station using a SBE-9 CTD, equipped with pressure, temperature and conductivity sensors. Water samples were collected from discrete depths using a General Oceanics Rosette sampler attached to the CTD. Nutrient analysis were carried out according to Strickland and Parsons [5].

Results and Discussion

The composite depth profiles of potential temperature, salinity and σ_{θ} in the Cilician Basin display an apparent seasonality. In spring, the surface mixed layer was separated from the deep water by a strong halocline at 25-50 m. Below the surface mixed layer, the LIW extends to 200-250 m. During spring the water of Atlantic origin (AW) is hardly discernible as a subsurface salinity minimum, probably due to mixing processes. In summer, the seasonal thermohaline, formed below the mixed surface layer, appears at a depth of 50-75 m. In fall, the thermocline moved downward to 75-100 m and the surface layer was saliter and cooler than in summer. During summer and fall the surface layer was separated from the less saline AW by a strong halocline. The AW layer was occupied by less saline and warmer waters between 30 and 80 m than LIW between 90 and 200 m. Combined data concluded that the water properties below 300 m were T=14°C, S=38.7-38.8 and $\sigma_{\theta} = 29.2 \text{ kg/m}^3$ (Table 1).

Tab. 1. Water masses characteristics in the Cilician Basin.

DATE		LSW	AW	LIW	TMW
May 1997	θ (°C)	19-22	×	16	14
50	S	39.2	×	39.2	38.8
	σ_{a} (kg/m ³)	27.6	н.	28.9	29.2
July 1998	θ (°C)	26-28	18	16	14
	S	39.2-39.4	38.9	39.15	38.8
	$\sigma_{\rm e}$ (kg/m ³)	25.5-26	28.3	28.9	29.2
October 2003	θ (°C)	24-26	18	17	14
	S	39.3-39.6	38.7	39.1	38.7
	$\sigma_{\rm P}$ (kg/m ³)	26.2-27.0	27.8	28.8	29.2

The surface waters of the Cilician Basin are poor in nutrients for most of the year compared to other areas of the Levantine Basin. The depthaveraged values for the surface layer were 0.3 μ M for nitrate+nitrite and 0.03 μ M for phosphate in May 1997 and July 1998. In October 2003, the upper layer was even poorer in nutrients (NO₃+NO₂=0.16 μ M, PO₄=0.02 μ M). The silicate values always remain near to 1 μ M in the surface layer throughout the year. Concentrations in the TMW were recorded as 3.3 μ M for nitrate, 0.14 μ M for phosphate and 6.8 μ M for reactive silicate in May 1997. During the July 1998 cruise, dissolved nutrient concentrations in the TMW (at a depth of 300 m) were 2.1, 0.10 and 5.7 μ M for nitrate, phosphate and silicate, respectively. In October 2003, the nutrient concentrations of TMW increased (NO₃+NO₂= 5.3 μ M, PO₄= 0.21 μ M, Si(OH)₄=10 μ M).

Conclusion

The synthesis of the three datasets revealed some new features. The LSW, which is indicated by a seasonal trend, has high salinity and high temperature as a result of the high rates of heating and evaporation. The AW appeared to be poorly defined during spring however it became better defined in summer and fall. There appeared to be no seasonal variations in the LIW and TMW. The nutriclines appear at specific density surfaces throughout the Cilician Basin even though their depths vary markedly in space and time. As nutrient deep concentration is greater than Levantine surface concentration, vertical movements in the Cilician Basin induce nitrogen enrichment of the deep layer.

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UPPER LAYER CURRENTS VARIABILITY IN THE CENTRAL LIGURIAN SEA

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Abstract

The effects of wind stress on the variability of the surface circulation in the Ligurian Sea are investigated by the analysis of a long time series of marine currents and meteorological observations and by numerical model simulations. Observed currents in the upper 50 m are mainly directed NW, according to the general circulation of the area and display the same pattern slightly attenuating the intensity with the depth. Most of the sub-daily variability is due to the inertial currents, which occur at all the examined depths very often. The direction and the intensity of the current in the near surface layer (0-8 m) is sometimes different from those recorded in the layers below. Observations and model results indicate that the wind is able to modify significantly the currents in the upper 14-15 m, thus explaining a huge part of the observed variability.

Keywords : Air-sea Interactions, Circulation, Ligurian Sea, Time Series.

Data and methods

In order to investigate the variability of the upper layer currents and the relationships with surface atmospheric forcing, a mooring equipped with an upward-looking ADCP (Acoustic Doppler Current Profiler) [1] RDI Sentinel 300 kHz and CTD sensors was deployed in the open Ligurian Sea $(43^{\circ} 47.77' \text{ N}; 9^{\circ}02.85' \text{ E})$ near the meteo-oceanographic buoy ODAS ITALIA1. The ADCP sampled the upper 50 m of water column with 8 m vertical resolution and 1h time interval from 13 September 2003 to 25 May 2004. Meteorological parameters, in particular wind speed and direction and atmospheric pressure, were measured each hour from the buoy ODAS at 13.5 m above the sea surface until 11 March 2004; sea temperature and conductivity at six different depths, between surface and 36 m, were also collected each hour from the buoy.

The effects of the local wind were estimated by means of a 1-D numerical model integrating the Ekman equations in the vertical plane up to a depth of 100 m, where free-slip conditions were imposed. The vertical turbulent coefficient was chosen constant (0.01), wind stress was computed from the available time series according to [2]. Constant or linearly increasing wind stress at surface was imposed considering some test-cases based on the different observed wind regimes.

Results

Wind regime during the observed period was characterized by calm and breeze for about 60% of the recorded data, strong winds, mainly blowing from SW, occurred in 7%, moderate winds are concentrated in the northern sector. Prevailing direction is SW/W while intensity -excluding the calms- is 6.2 m/s.

Although the mean currents are mainly directed NW, according to the general cyclonic circulation of the Ligurian Sea, currents alternate periods with an almost constant NW direction and periods lasting few days characterized by strong variability, particularly meandering. Only few short events with southward component currents occurred during the studied period.

Mean velocity was about 11 cm/s with hourly mean peaks up to 80 cm/s. The vertical structure was characterized by highly correlated currents having the same pattern, with intensity weakly attenuating with the depth. Currents in the first layer differ from that of the layers below, in some case being less intense and displaying more variability and meandering.

Low frequency variability was characterised by mesoscale and atmospheric components because the 28 and 6 days components were among the more energetic peaks. Rotary spectral analysis [3] evidenced the inertial motions as the prevailing feature at sub-daily scale [4], whereas tides on both diurnal and semidiurnal band were negligible. The resulting average spectrum computed on 22 samples, 256 hours long, displayed at all depths a net energy peak in the clockwise part centred around the theoretical inertial period value for this latitude (17.3 h). Well developed inertial currents, in some cases lasting for more than a week, were in fact observed at all the examined depths for about 25% of the total period of registration.

Even correlation between wind stress and kinetic energy of the surface

currents was poor, thus indicating a minor role of surface atmosphere forcing. The results from the simulated test cases gave some insight on the local wind effect, explaining a huge part of the observed variability [5]. A constant wind stress of 0.2 N/m^2 , representing the mean observed value, can drift a mean current in the upper 10 m of about 15 cm/sec; for a wind stress of 0.35 N/m^2 , corresponding to a wind speed of 14 m/s, the velocity increases up to 28 cm/s, comparable with the intensity of the geostrophic components.



Fig. 1. Stick diagram of daily mean currents at each depth.

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SEASONAL VARIABILITY AND INTERANNUAL VARIATIONS OF THE UPPER MIXED LAYER IN THE WESTERN BLACK SEA

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Abstract

Seasonal variability and interannual variations of the upper mixed layer in the western Black sea were studied from underway highresolution near-surface temperature and salinity data along 165 occupations of the Odessa-Istanbul transect in 1998-2000. Measured every 3 s at a depth of 2-3 m, these data are representative of the entire upper mixed layer. The seasonal cycle of T and S was resolved as well as spatial differences between the Northwest Shelf and deep western Black Sea basin. Substantial year-to-year variations are noted from these data and compared with long-term mean climatological data.

Keywords : Black Sea, Temperature, Salinity, Surface Waters, Fronts.

Air-sea interaction over the northwest Black Sea is vigorous and results in strong seasonal variability of the upper mixed layer (UML), whose longterm mean annual T/S ranges are, respectively, 2 to 23°C and 13 to 18. The northwest Black Sea also features strong spatial gradients between the shallow Northwest Shelf and the deep basin. To resolve large temporal and spatial gradients in the northwest Black Sea, frequent high-resolution repeat observations of the UML characteristics (T and S) were made from R/V Georgy Ushakov (UkrSCES) along a standard quasi-meridional transect between Odessa (~46.3N) and Istanbul (~41.3N). During 165 occupations of this transect in 1998-2000, T and S were continuously measured underway by a stationary shipboard throughflow thermosalinograph linked to a PC, with TS-sensors installed in the main engine's water intake system at a depth of 2-3 m. The UML's T and S at this depth are representative of the entire UML. The throughflow system has low thermal inertia/fast response time, thus allowing frequent sampling (every 3 s) of the UML characteristics. Under a typical cruising speed of 10-12 knots, the 3 s sampling rate translates into a horizontal resolution of ~ 15 m, which allows meso- and small-scale fronts and eddies to be resolved.

The Odessa-Istanbul transect extends across two different oceanographic zones - the NW Shelf (NWS) and the deep basin. The NWS is subject to strong winter cooling, when T(UML) drops to 1-2°C, whereas farther south minimum winter T(UML) is fairly constant, 6-7°C, along the Odessa-Istanbul transect. Timing of maximum winter cooling of the NWS varies interannually from mid-December to late January-early February. South of the NWS, maximum winter cooling occurs later, typically in mid-February. Spring warming begins almost simultaneously between 46N and 41N and can be quite abrupt, especially in late May-early June, when T(UML) increases from 15°C to 21°C in just two weeks, with a maximum rate exceeding 0.5°C /day. Summer warming is spatially uniform as T(UML) peaks at about the same time between 46N-41N. From long-term mean climatological data, T(UML) has a single maximum, in mid-August. The Odessa-Istanbul transect data revealed a much more complicated pattern of seasonal variability of T(UML), particularly with regard to timing and number of summer maximums. Indeed, the Odessa-Istanbul transect data show up to three or even four maximums of T(UML), with the first maximum as early as June (in 1998), and the latest maximum in August. Autumn cooling progresses from north to south, although the north-south time lag between 46N-41N is relatively small, 1-2 weeks. The Odessa-Istanbul transect data revealed a discontinuous nature of autumn cooling in 2000, when T(UML) dropped from 26°C to 15°C in three well-defined steps, particularly noticeable in the southern part of the study area. These rapid cooling events were likely related to synoptic atmospheric events such as frontal passages.

Salinity regime of the NWS largely depends on freshwater discharge of three major rivers: Danube, Dnieper, and Dniester. Timing and extent of spring freshets varies interannually. From long-term mean climatological data, S(UML) drops below 13 north of 46N in April. This freshening gradually spreads south, down to 44.5N in May-June. From the Odessa-Istanbul transect data, the 1998 spring freshet's influence was small and short-lived, whereas spring freshets in 1999 and 2000 were much more extensive in time and space. The Dnieper spring freshet waters (S<14) reach the Odessa-Istanbul transect in late March and remained there through mid-May. The Danube spring freshet waters (S<15) reach the Odessa-

Istanbul transect in mid-May, about six weeks later than the Dnieper spring freshet waters, and remained there until late June. In the southern part of the study area, over the deep sea basin, salinity is hardly affected by river runoff and therefore varies within a relatively narrow annual range, between 17-18, rarely exceeding 18.2-18.3 psu. In summer 1999 and spring 2000, local salinity maxima were observed over the southern part of the transect, with S(UML)=18.2-18.3, that slowly drifted douthward. These moving salinity maxima likely corresponded to meso-scale cyclonic eddies that were advected along the Odessa-Istanbul transect by the large-scale circulation of the Black Sea.

Underway continuous measurements of the UML characteristics allowed correlation between T and S to be studied. The sign and the nature of this correlation changes with season and location. Over the NWS in spring, TS-correlation is negative. In summer (July-August) TS-correlation is weak and variable. In autumn and spring, TS-correlation is strong and positive, up to +0.97. Spatial scales of TS-variability over the NWS (30-50 miles) are determined largely by river runoff accumulation from Danube, Dnieper and Dniester. Smaller spatial scales, down to 8-10 miles, are common over shelf areas and are probably caused by sub-mesoscale surface-intensified eddies.

The Odessa-Istanbul transect data also contain valuable information on a front over the mid-NWS, previously studied from satellite sea surface temperature (SST) data [1]. This front is strongest in winter when it has repeatedly been crossed by the Odessa-Istanbul transect near 44.5N, with cross-frontal steps of up to 3° C and 1 in salinity. We are presently investigating this front from both the Odessa-Istanbul in situ data and satellite SST frontal data archive assembled at the University of Rhode Island.

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INVESTIGATION OF THE EASTERN MEDITERRANEAN BASIN BY UKRAINIAN OCEANOGRAPHERS DURING 1986-1991

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Abstract

Ukraine oceanographers carried out large series of cruises in the Aegean Sea as well as Ionian and Levantine Basins at same time that POEM cruises were carried out. The data collected in Ukrainian cruises contain unique information about processes of deep convection in the Eastern Mediterranean during winter 1987 as well as about the structure of the most energetic anicylonic gyre, Ierapetra. Merging the Ukraine data with the POEM data collected in the Levantine Basin (summer 1990) produces a detailed pattern of the Mid Mediterranean Jet during the early stage of the Eastern Mediterranean Transient (EMT). Most of the data set is available now for the oceanographic community.

Keywords : Eastern Mediterranean, Circulation, Water Convection, Deep Sea Processes.

Experimental research of the Eastern Mediterranean by former USSR oceanographers led by Prof. I. M. Ovchinnikov (1931-1997) can be subdivided into two main stages. The first one is a series of basin wide cruises on the R/V "Vityaz" (1949-1979) that resulted in a comprehensive monograph "Hydrology of the Mediterranean Sea" [1]. The second one is a series of cruises on research vessels belonging to the Odessa Branch of the State Oceanographic Institute (1986-1991) and focused on investigation of sub basin circulation and processes. Unlike POEM results, which are published widely and are the major knowledge sources about sub basin Mediterranean circulation [3], the results of the second stage of the Mediterranean investigation by Soviet oceanographers are almost entirely unknown to the wide oceanographic community. The end of the second stage coincided with the collapse of the USSR, and results of those investigations have not been fully processed and were published very scarcely. However during the period from 1986 to 1991 Ukrainian oceanographers carried out about 3000 CTD casts, mostly in the Aegean Sea, Ionian and Levantine basins. The major contribution belongs to R/V "Jakov Gakkel" (64% from the total cast number) and R/V "Vladimir Parshin" (16%).



Fig. 1. Dynamic topography from merged data of Ukraine (Gakkel 38 and Parshin 06) and of POEM (LBDS02) cruises, summer 1990. Mid Mediterranean Jet path is following the -0.5 dyn. m. contour.

Unfortunately, the accuracy of the Soviet equipment used in these cruises (about 0.02° C for temperature channel and about 0.03 for salinity channel) was hardly sufficient to find out long-term changes of water mass parameters in deep layers which were connected then with the EMT [5]. However, for investigation of the upper 1000 m layer processes as well as of the intensive sub basin circulation (Fig. 1) one can neglect this data problem [6]. The most important scientific results of these cruises are: (i) first description of the deep sea convection event in the Rhodes Gyre region (winter 1987 - cruise Gakkel 28, [4]); (ii) detailed quantitative characteristic of the Aegean Sea water masses during the early stages of the EMT (winters 1988 and 1990 - cruises Gakkel 31 and 36, [8]); (iii) detailed description of genesis and development of the Iereapetra anticyclonic eddy (summer 1990 - cruises Gakkel 38 and Parshin 06, [7]); (iv) first detailed description of the intensive emission of the Cretan Sea water in the Eastern Mediterranean interior (summer 1990 - cruises Gakkel 38

and Parshin 06, [2]). Unfortunately, because of circumstances independent of the authors, not all the data from these cruises is finally processed and available to the oceanographic community. But now all efforts are undertaken to solve this problem.

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THERMOHALINE PROPERTIES OF THE MEDITERRANEAN SEA AS MEASURED BY PROFILING FLOATS BETWEEN 2000 AND 2006

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Abstract

The temperature and salinity data collected by profiling floats throughout the Mediterranean Sea from 2000 to 2006 are used to study the spatial distribution and temporal evolution of the Mediterranean thermohaline properties and compared them with climatological values and ancillary ship-based hydrographic measurements published in the literature. Results indicate that the Mediterranean Sea is warmer and saltier (most importantly in the western basin) with respect to climatology mainly based on observations of last century. *Keywords : Temperature, Salinity, Open Sea.*

Introduction

Since 2000, more than 70 profiling floats equipped with CTD sensors were deployed in the Mediterranean to monitor its thermohaline structure for scientific and operational purposes. In particular, starting in mid-2004, float operations were coordinated at the international level in the framework of MedArgo, which is part of the EU-sponsored MFS project [1] and is integrated into the worldwide Argo program [2]. The Mediterranean float data, with profiles extending as deep as 2000 m and spreading most areas of the Mediterranean, are analyzed to study the spatio-temporal variations of the thermohaline properties and compared with climatological values and results of hydrographic surveys.



Fig. 1. Potential temperature (θ) and salinity (S) profiles in the northern and central Tyrrhenian Sea as measured by the profiling floats in 2004-2006 (black curves, 282 profiles). MEDAR MEDATLAS II annual mean (white curve) with ±3 standard deviations (grey envelope). The locations of the CTD casts are shown in the insert.

Materials and methods

Both APEX and PROVOR battery-powered profiling floats equipped with Sea-Bird pumped CTD sensors were operated in the Mediterranean Sea. They were programmed to descent and drift at an intermediate parking depth (between 350 and 650 m), to descend further down to depths of 650 - 2000 m before ascending to the surface while measuring pressure, temperature and conductivity. Once at the surface, they transmitted the data via the Argos satellite system and repeated the above-described sampling cycle. The cycle length was 5 days for the majority of the floats and 10 days for some units. The float temperature (T) and salinity (S) profile data were processed, quality-controlled and distributed by the CORIOLIS Operational Oceanography Data Centre at IFREMER in Brest, France. The floats provided more than 5000 CTD profiles between March 2000 and mid-September 2006. The T and D data were used to compute the potential temperature (θ). Diagrams of profiles versus depth, of the data at selected depths versus time, and θ -S diagrams were created to describe the spatio-temporal variability of the data.

Results

The θ and S values measured by the floats were studied in most sub-basins of the Mediterranean Sea. The area of the Tyrrhenian Sea locked between Sardinia, Corsica and Italia is particularly interesting. Indeed, in this area, the CTD profiles (271 to 700 m and 11 to 2000 m) show clearly that the intermediate waters between 500 and 1500 m are slightly warmer and significantly saltier when compared with values of the MEDAR MEDAT-LAS II climatology [Fig. 1]. The maximal salinity is 38.77 near 500 m. Between 1000 and 1200 m, the salinity is typically 0.1 larger than climatology, whereas potential temperature can be larger by about 0.5 C. Deeper in the water column (near 2000 m), the floats measured salinities spanning in 38.51-38.53 compared with the mean climatological value of 38.47, and potential temperatures in 13.07-13.11 C compared with 12.89 C. Since the MEDAR MEDATLAS II climatology is essentially based on hydrographic observations collected in the 20th century, the abovementioned variations are thought to be related to long-term interdecadal variability of the whole Mediterranean Sea, including changes known as the Eastern Mediterranean Transient (ETM) [3] and the Mediterranean Sea Transient (MST) [4].

Acknowledgements

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LONG-TERM STERIC EFFECT ON SEA LEVEL AT TRIESTE, NORTH ADRIATIC

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Abstract

The long-term annual and seasonal steric effect on sea level is estimated for the Bay of Trieste, in the North Adriatic Sea, using temperature and salinity observations performed during several decades. Data availability allows evaluating the thermo-steric effect since the early 20^{th} century and the halo-steric effect for the second half of the century. Data gaps are partly filled by means of objective analysis. As a result, during the period 1965-2004 the steric effect on Trieste sea level amounts to 1.0 mm/100 yr, where the thermo-steric and halo-steric components are 8.3 and -5.9 mm/100 yr, respectively. The 1915-2004 correction due to the thermo-steric effect alone is about 2.3 mm/100 yr.

Keywords : Adriatic Sea, Sea Level, Time Series.

An important component of sea level variability is connected with changes in sea water density, determined by temperature and salinity variability induced by climate variability. The effects of such changes on sea level can be quantified in terms of steric anomalies. In the Mediterranean Sea the data availability is limited, particularly for salinity, and such estimates can generally be made using temperature and salinity values averaged over relatively large areas and long time periods. Moreover, the comparison of steric changes with observed sea level is difficult because the former are mostly estimated for open ocean areas and the latter is measured at coastal sites [1, 2].

In this work annual and seasonal steric anomalies are estimated for the Bay of Trieste, an area of approximately 500 km² and 20-25 m depth in front of the Trieste sea-level station (North Adriatic). For this area multi-decadal time series of marine data exist, as well as a centennial sea-level time series, and its small size makes the steric sea-level change estimates suitable to be compared with the observed sea level.

The steric effect is estimated for the second half of the 20^{th} century, when a reasonable amount of both temperature and salinity profiles is available. Such observations come from MEDATLAS 2000 (www.ifremer.fr), ADRICOSM (www.santateresa.enea.it), PRISMA and NADS (poseidon.ogs.trieste.it) data sets. Time gaps are filled by means of objective analysis of anomalies relative to climatology. The scarcity of salinity data before 1960 does not allow a reliable estimate of the full steric anomalies except for a few isolated years, and, therefore, prevents the assessment of secular trends.

Taking into account only thermo-steric anomalies, the study can be extended backward in time to the early 20^{th} century. Monthly mean sea temperatures at 2 m depth are available for Trieste harbour during the periods 1899-1920 (with major gaps) and 1934-present (with few gaps). The period 1921-1933 is reconstructed via linear regression between temperatures measured at Trieste and Rovinj (Croatia) [3]. The few remaining gaps are filled with objective analysis. As a result a 2-m temperature time series for 1915-2004 is obtained. Temperatures at 0, 5, 10, 20 m depths are estimated on a statistical basis using the climatological MEDATLAS profiles.

From the analysis of 1965-2004 data, the annual steric effect has caused an increment of sea-level with a trend of 1.0 mm/100 yr. This represents the combined effect of increased temperature, which amounts to 8.3 mm/100 yr, and that of increased salinity, namely -5.9 mm/100 yr. In other words the "true" sea-level trend (except for vertical crustal movements) is 1.0 mm/100 yr less than the observed one.

The average annual cycle of the steric effect, deduced from the period 1965-2004, exhibits a mean value of 2.0 cm, a minimum of -2.7 cm in February and a maximum of 8.0 cm in August.

The long-term thermo-steric effect alone can be estimated for the period 1915-2004, giving a sea-level trend increment of 2.3 mm/100 yr.

On a seasonal basis, it is possible to estimate thermo-steric effects only, since salinity data are insufficient, particularly in winter. Concerning long-term (1915-2004) trends, winter and autumn have become warmer, determining 3.5 and 4.8 mm/100 yr sea-level increments, respectively. By

contrast, changes in spring and summer are much smaller, namely 0.0 and 0.5 mm/100 yr, respectively. During 1965-2004 the thermo-steric effect is positive in all seasons, with minimum trend in winter, with 3.1 mm/100 yr, larger in spring and summer (5.9 and 7.0 mm/100 yr, respectively), and particularly large in summer, with 16.9 mm/100 yr.

The results outlined above concern a specific area, characterized by very shallow water and largely affected by continental air masses, and, therefore, cannot be generalized to the open sea. However, it is evident that the sole thermo-steric effect cannot be representative for the observed density-induced variability of sea level. In absolute terms, the shallowness of the Bay of Trieste makes the steric trends almost negligible compared to the observed sea-level trends, namely 1.1 mm/yr for 1915-2004 and 0.8 mm/yr for 1965-2004.

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MULTI-MODEL SUPER-ENSEMBLE OCEAN PREDICTION: AN OPERATIONAL EXAMPLE USING A KALMAN FILTER IN THE ADRIATIC SEA

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Abstract

Multi-model Super-Ensembles (SE) aim at combining optimally different models. A dynamic Kalman Filter version of this technique has been applied on a unique set of in-situ data and operational ocean models during the Dynamics of the Adriatic in Real-Time (DART) field experiment and is shown to significantly improve forecast skills.

Keywords : Adriatic Sea, Models, Monitoring, Acoustics, Mesoscale Phenomena.

An increasing number of models are routinely providing operational weather forecasts and climate predictions. The SE technique [1], which uses an optimised combination of an ensemble of models, has previously been demonstrated to improve forecast skills in atmospheric models. Applications in the ocean are promising [2, 3]. However, they suffer from the lack of *in-situ* time series available in real-time.



Fig. 1. Time series of sound velocity (m/s) profiles, from top to bottom and left to right: SEPTR data, ADRICOSM, HOPS, NCOM and ROMS models.

The trawl-safe bottom mounted SEPTR platform developed at NURC (NATO Undersea Research Center), which is equipped with an ADCP and a CTD profiling unit transmitting data in real-time through a dedicated Globalstar link, now overcomes this limitation. During the DART (Dynamics of the Adriatic in Real-Time) field experiment in March 2006, 6 SEPTR were moored in the Gulf of Manfredonia in the Adriatic. In parallel, a suite of atmospheric, wave and ocean models were run operationally for the same period. This unique combination of data and models (Fig. 1) was used to derive SE products using a Kalman Filter-like Dynamic Linear Model [4] to account for the rapid changes in individual model skills and derive associated uncertainties. Our results suggest that the combination of SEPTR and operational models may decrease the errors on sound velocity profiles from 3-5 m/s down to 1-2 m/s (Fig. 2) at a marginal cost.





Fig. 2. Error on sound velocity for a 4-day forecast: (top) Standard Superensemble (bottom) Kalman Filter Dynamic Linear Model.

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INTERDISCIPLINARY SCIENCE OF THE MEDITERRANEAN AND BLACK COASTAL SEAS IN A GLOBAL CONTEXT

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Abstract

Physical and biogeochemical processes and interactions of the Mediterranean and Black Seas are overviewed and the implications for the health of this semi-enclosed sea system discussed. The interdisciplinary processes of the Mediterranean and Black Seas are integrated into a discussion of similar semi-enclosed seas of the global coastal ocean in the context of the IOC/SCOR COASTS synthesis study. *Keywords : Coastal Systems, Infralittoral, Western Mediterranean, Eastern Mediterranean, Black Sea.*

The western Mediterranean basin exchanges waters with the North Atlantic through the narrow Strait of Gibraltar, which influences the Atlantic circulation and drives the Mediterranean circulation together with winds and buoyancy fluxes. The western and eastern basins are linked through the Strait of Sicily, and the shallow Aegean Sea of the eastern basin is linked through the Dardenelles and Bosphorus Straits to the Black Sea. The generally narrow shelves of the Mediterranean are dominated by open-ocean/shelf exchange processes and strongly influenced by riverine inputs. Although coastal downwelling is prevalent, the shelf structures and variabilities are a composite of site specific dynamic scenarios. The Mediterranean is an oligotrophic system with relatively poor biological production and average phytoplankton biomass decreasing eastwards. The most productive regions lie along the coasts of France, Algeria, Egypt, Turkey and in the northern Adriatic. The Black Sea shelves are very narrow in the south, east and northeast but there is a broad northwestern shelf sea. An eddying Rim Current circulates around the basin on the continental slope which links importantly coastal and deeper sea biogeochemical processes. River discharges particularly in the northwest have resulted in eutrophication, which together with over-fishing, a severe increase of gelatinous carnivores and decadal climate fluctuations have drastically changed the Black Sea ecosystem. Modern multi-scale interdisciplinary cooperative field research and modelling projects in both seas are contributing to progress in understanding of dynamical processes and provide the basis for advanced management methods.

The COASTS (Coastal Ocean Advanced Science and Technology Studies) of IOC-UNESCO and SCOR has recently published a comprehensive global study and synthesis of sub-regional and pan-regional interdisciplinary ocean science [1, 2], which complements a multi-scale interdisciplinary process study of the global coastal ocean [3]. Pinardi et al. [4] overview the Mediterranean coasts and Oguz et al. [5], the Black Sea. These studies are integrated into a pan-regional synthesis of semi-enclosed seas and islands by Oguz and Su [6]. The Mediterranean and Black Seas are categorized as nearly enclosed basins with limited exchanges with open oceans, and analyzed together with the Baltic Sea, Red Sea, Arabian Gulf, Bohai Sea, Sea of Okhotsk and Japan/East Sea. Together with the other European semi-enclosed seas. Baltic and North, the Mediterranean and Black Seas are considered to be generally among the most threatened marine ecosystems, with serious over-exploitation of commercial fish stocks, and endangered biotopes. Dr. Ümit Ünlüata contributed important personal scientific advances to the knowledge of the Mediterranean and Black Seas. As head of ocean science at IOC he enabled the comprehensive interdisciplinary COASTS study of the global coastal ocean.

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COULD THE EASTERN MEDITERRANEAN TRANSIENT (EMT) HAVE BEEN PREDICTED?

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Abstract

The transient that has dominated the Eastern Mediterranean intermediate and deep waters since about 1990, generated by dense-water output from the Aegean Sea, was of unprecedented magnitude and has had a rather complex cause. These features exclude an assessment based on climate statistics and a prediction of hypothetical similar events in the future.

Keywords : Eastern Mediterranean, Aegean Sea, Hydrography, Circulation, Deep Waters.

The EMT (Eastern Mediterranean Transient) was brought about by extremely high outflow of enhanced-density waters from the Aegean Sea in the 1990s, which induced a transient of unprecedented magnitude in the hydrography and circulation of the entire Eastern Mediterranean [1]. No previous such event of any similar magnitude, interrupting the prevailing predominance of the Adriatic Sea as the source of the deep waters, has ever been documented. The high densities of EMT-related Aegean outflow [2] resulted from a combination of greatly enhanced salinities in the Aegean (maximum in 1992) and of excessive winter cooling in 1991-92 and 1992-93 [3]; the high salinities presumably resulted from a blocking of upper-water exchange south of Crete, observed in 1991, that led to excessive salinity storage in the Levantine Sea [4]. Peak outflow occurred between mid-1992 and late 1994, with a maximum during 1993. The total volume of Aegean dense water output over the mid-1992 to late 1994 period corresponded to about twice the total volume of the Aegean Sea. Such fast turnover of the Aegean Sea requires that a large region beyond the Aegean Sea proper was involved in the formation of the Aegean dense waters. On the other hand, the maximum density effected by the EMT in the Eastern Mediterranean waters was not higher than that of young northern Ionian bottom waters replenished from the Adriatic previously. Aegean dense outflow continued until at least 1998, and the hydrography of the South Aegean Sea had not recovered a decade after the onset of the EMT (in about 1990). It is argued that the EMT has been a matter of coincidence of extreme events of rather unrelated cause, and that, furthermore, the magnitude of the Aegean outflow required internal, non-linear forcing within the Eastern Mediterranean system. The conclusion is that the EMT cannot be related to climate statistics, such as correlation with climatic indices, and that, particularly due to the internal non-linear feedback and in view of the decades-long predominance of the Adriatic over the Aegean previously, modelling is limited to hindcast assessments.

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ON THE CIRCULATION OVER THE ISRAELI MEDITERRANEAN CONTINENTAL SHELF AND SLOPE

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Abstract

Results are presented from a long term monitoring program of the circulation on the Israeli Mediterranean continental shelf and slope conducted using subsurface current moorings. The currents direction on the shelf and slope was found to be generally northward with maximum monthly mean velocities observed during the summer and stormy winter seasons. Winters were characterized by downwelling circulation while during summer a seaward increase in the magnitude of the along-shelf currents was observed. Both seasons also exhibited an energetic along-slope northward jet, a finding supported also by results from numerical modeling studies. *Keywords : Circulation, Levantine Basin.*

The Israeli Mediterranean continental shelf is narrow O (15 km) and has a relatively simple bathymetric relief structure with isobaths roughly parallel to the coastline. In 1987 the Israeli National Institute of Oceanography started a 10-year observational study to investigate the circulation and the thermohaline structure off the Israeli coast [1, 2, 3, 4, 5]. It was conducted with subsurface current meter moorings on the shelf and at mid-slope as well as with hydrographic across-shelf sections. Statistical and spectral analyses of the currents over the shelf show almost no evidence of currents at the semidiurnal tidal frequency; however, quite a strong signal (~0.1 cm/s) is found at a daily period during the warming season due to the sea breeze. The most important part of the current energy is present in the synoptic and seasonal time scales. The synoptic currents over the Israeli shelf are mainly northwards and follow the bathymetry. The monthly mean along-shore current over the inner or mid-shelf has a seasonal period with a maximum northward velocity magnitude during summer and winter seasons of O(0.1 m/s). During the stratified summer season, both the monthly mean currents and synoptic velocity along-shore fluctuations decrease with depth below the surface mixed layer. The decrease of the mean velocity is in agreement with the strong stratification and sloping isopycnals over the shelf, resulting in low velocities of only a few cm/s near the bottom at the outer shelf. Characteristic for this season is an offshore increase in the northward seasonal current within the upper water layer. During winter the water over much of the shelf is homogenous and the synoptic currents are highly coherent and vertically uniform. Although occasional southward currents have been observed, the winter season is characterized, mainly, by strong northward currents (O(0.6 m/s)) during the winter cyclonic storms which exhibit a strong along-shore wind stress component. These currents also imply, in addition to a large along-shore transport, strong bottom friction and vertical mixing. The magnitude of the along-shelf synoptic velocity component depends mainly upon the along-shelf wind stress and pressure gradients. The direct response to the wind is mostly confined to the inner and mid-shelf, whereas the shelf edge sites show open sea influence [4]. The cross-shelf circulation during the cooling season is characterized by onshore surface Ekman transport that is compensated for by a seaward (downwelling) flow in the bottom boundary layer. At the shelf break sites the seaward flow is also accompanied by an intensification of the northward current. Current measurements, as well as hydrographic cross sections, indicate the possibility that part of this transport is also due to gravitational advection and downslope cascading of dense shelf water, induced by winter cooling and evaporation.

Current measurements from a single mooring on the continental slope off Hadera (water depth of 500 m) reveal, occasionally, during summer and winter, the existence of a strong northward along-slope baroclinic jet confined to the upper 50-200 meters (respectively) with monthly mean velocities of 0.2-0.4 m/s. During winter storms the hourly velocities at the upper layers of the jet may reach a magnitude of 0.9 m/sec, or be as high as 0.3 m/s near the bottom, at the end of the winter mixing season. The seasonal characteristics of the along-slope jet are supported by results from numerical modeling studies [6, 1, 5]. These results suggest that the permanent northward circulation observed during the summer on the shelf, and the seaward increase in current intensity, are closely related to a strong cyclonic jet flowing along the eastern rim of the Levant Basin. In spite of the expected increase in the topographic steering effect during the winter season, the daily MFSTEP-OGCM reanalysis fields, as well as high-resolution model simulations [7], suggest that the high velocities observed on the slope are due to a local intrusion of an open sea, largescale, meander. The observations during this season show no obvious influence of the along-slope jet on the inner-shelf circulation during calm weather conditions although it does seem to affect the outer- and mid-shelf circulation.

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ADRIATIC VERSUS AEGEAN WATER IN THE ABYSSAL LAYERS OF THE IONIAN BASIN

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Abstract

In situ measurements and a numerical model for the description of bottom-arrested currents are used to elucidate aspects of the evolution of the Transient of the Eastern Mediterranean Basin.

Keywords : Adriatic Sea, Aegean Sea, Strait Of Otranto, Abyssal, Stratification.

CTD measurements carried out in the southern Adriatic sea and in the western Ionian basin (Eurafrican Mediterranean sea) during May 2003 by the German research vessel POSEIDON (POSEIDON cruise 298) and numerical simulations are used to elucidate aspects of the abyssal circulation of this oceanic region. The observations suggest that dense waters of Adriatic origin were strongly diluted along their way on the Italian continental slope, whilst their characteristics remained better preserved in a region located further east. The very steep topographic slope along the Italian shelf in the region of the Gulf of Taranto induces strong entrainment of intermediate waters in the bottom layers. Instead, the bottom waters of Adriatic origin which, along their path further east, encounter gentler topographic variations, are weakly diluted by turbulent mixing and, therefore, better preserve their original characteristics. The remarkable differences in the mixing along these two different paths are accentuated by the presence of a noticeable zonal gradient of potential density existing in the near-bottom layers of the northern Ionian basin. In order to verify our observational hypothesis suggesting that different paths for the southward spreading of ADW exist, which are characterized by different entrainment rates, we performed numerical simulations using a nonlinear, reduced-gravity plume model. In this model the only active layer is the bottom layer, which, due to a simple entrainment parameterization, can entrain prescribed ambient water over complex bathymetric features. Due to this simplified structure, a very high spatial resolution can be reached. In the simulations, a constant rate of ADW production (0.6 Sv (1Sv = $10^6 \text{m}^3 \text{s}^{-1}$)) at the constant potential density of 29.21 was prescribed in the northern part of the South Adriatic Pit. Near the bottom, the ambient density structure was determined by interpolating the near bottom density data of Levitus [1]. Moreover, from this dataset a vertical density gradient was defined, which was used to determine the density difference of the ambient water located between the top of the descending bottom-arrested current and the bottom. Fig. 1 shows the area where the simulated bottom plume is characterized by a potential density larger than 29.194 (i.e. the part of the plume having density values not smaller than those of the observed core of ADW), after 270 simulated days. The simulation evidences that the ADW bottom vein flows towards the abyssal plain of the Ionian basin following different paths. The flow along the Italian coast is characterized by very pronounced mixing, with the consequence that virtually no flow of ADW denser than 29.194 is able to escape the gulf of Taranto. The complex flow along the eastern part of the Ionian basin, instead, is affected by mixing in a less stronger extent, and, thus, it better preserves its original characteristics. Thus, in our numerical simulations, bottom water masses with characteristics closest to ADW are found in the eastern rather than in the western part of the Ionian basin. In the absence of entrainment, the situation would have been completely different. In Fig. 1 we present also the paths of different tracers, located initially within the bottom current at the strait of Otranto, after 150 simulated days of a run carried out without including entrainment. In this case, obviously, the whole bottom current preserves its original density, as no dilution processes are considered. It flows southward following exclusively the route along the Italian shelf. Such a different behavior in the two simulations can be clearly explained by the fact that entrainment acts as a further friction term and decreases the density contrast between bottom current and overlying fluid; this considerably enhances the ageostrophic flow behavior [see, e.g., 2, 3]. These differences in the simulated mixing are accentuated by the presence, in the bottom layers of the northern Ionian basin, of a zonal gradient of potential density: since the Transient, the values of near-bottom potential density increases toward east, which contributes to produce a stronger dilution of the waters of Adriatic origin in the western rather than in the eastern part of the northern Ionian basin [4].



Fig. 1. Bottom density distribution at t = 270 days simulated using the nonlinear plume model (run with entrainment) and paths of the tracers at t = 150 days simulated in the model run without entrainment.

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MESOSCALE ANTICYCLONIC EDDIES IN THE CATALAN SEA: ORIGIN AND DYNAMICS

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Abstract

The origin and dynamics of mesoscale anticyclonic eddies in the Catalan Sea is investigated using a numerical model of the NW Mediterranean circulation at 3 km resolution. Model eddies are compared with an anticyclonic eddy observed at the Catalan shelf break in September 2001. Model eddies generated at the southeast of the Roussillon coast are found to compare well with the observed eddy. The model suggests that the generation of these eddies is related to a flow separation mechanism that takes place over the shelf together with intense downwelling during NW wind events.

Keywords : Mesoscale Phenomena, Circulation Models, Continental Shelf.

As shown by previous works the presence of anticyclonic mesoscale eddies in the Catalan Sea is recurrent throughout the year and they have significant effects on the local dynamics. These eddies are responsible for local flow inversions over the shelf and are an effective mechanism for water and particulate matter shelf/slope exchanges [1].

In September 2001, a cruise in the Catalan Sea was carried out to investigate their main characteristics [2]. The joint analysis of the *in situ* hydrographic data and SST satellite imagery permitted, for the first time in this region, to make a 3D description of one of these eddies. The anticyclonic eddy was characterized by a vertical extent of 100 m, a diameter of 40-45 km, surface velocities of 30-40 cm/s and a low density (high temperature, low salinity) core. During the survey the eddy drifted south-westwards at 6-8 km/day with an associated transport across the shelf break of 0.15-0.3 Sv. Concerning the generation of this eddy, the lack of continuity in the SST images (gaps of 3-4 days between consecutive images) did not permit to investigate its origin and path.

In order to deepen into the investigation of the origin of these eddies, the SYMPHONIE [3] 3D primitive equations numerical model was used in the NW Mediterranean. Initial conditions and forcing at the open boundaries are provided by the MFS-Mediterranean model [4] and high resolution atmospheric forcing is obtained from ALADIN (Météo-France). One year of realistic simulations is performed with a horizontal resolution of 3 km and 41 vertical sigma-z levels. Simulations are validated with climatological, satellite and *in situ* data. They reproduce realistically the main characteristics of the circulation (i.e. the Northern Current path and variability, the wind induced circulation over the shelf and the generation of mesoscale eddies with similar properties to that of the observed one).

Numerical results point out two main areas of eddy generation in the NW Mediterranean: the coast in front of Marseille and the southeast coast of Roussillon. Model results for Marseille show that eddy generation in this area is linked to barotropic processes associated to perturbation of the Northern Current by the bathymetry. A major variation in the slope direction induces flow separation during the Northern Current intensifications. As a consequence of flow separation eddies generate over the slope (i.e. 600-1000 m isobaths). Due to their barotropic origin, these eddies have a deep structure (300-400 m) which does not correspond with that of the eddy surveyed in the Catalan sea. In the coast of Roussillon, a flow separation mechanism is also responsible for eddy generation. In this case flow separation occurs over the shelf and as a consequence eddies generated in this area have a limited vertical extent, around 100 m. Properties of these eddies are found to compare well with the eddy observed during the 2001 cruise. Thus, the study of the evolution of Roussillon model eddies allows us to hypothesize about the origin and path of the observed eddy.

In this area flow separation occurs downstream of Creus Cape during the coastal current intensifications (for current intensities over 30 cm/s) induced by strong NW winds in the Gulf of Lions. Moreover, as a consequence of NW winds intense downwelling processes take place over the shelf and eddies incorporate the low density downwelled waters (fig. 1).



Fig. 1. Evolution of model velocity (top) and temperature (bottom) fields at 50 m. Warmer waters are in light grey. From left to right, one sees the growth of the downwelling and its associated flow, the current separation and shedding of one anticyclonic eddy at the south-east of Roussillon. The eddy is trapping warm water in its core.

To better understand the generation mechanism of these eddies we have examined the energy (APE and EKE) transfers between mean and eddy fields during a typical eddy generation event. Energy conversions suggest that during the NW wind event the generation of these eddies is mainly barotropic (i.e. eddy shedding by a flow separation mechanism). However, baroclinic processes may also account for their growth when the wind forcing weakens. This baroclinic contribution is associated to the release of available potential energy during the relaxation of the downwelling and is significant in conditions of high stratification. After they are generated, these eddies are advected first by the coastal current towards the shelf break and then by the slope current towards the Catalan Sea.

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ENVIRONMENTAL FORCING ON ANCHOVY (*ENGRAULIS ENCRASICOLUS*) CATCHES IN THE SOUTHERN IBERIAN PENINSULA

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Abstract

Fluctuations of clupeoids catches are frequently associated to the process of survival during early stages of the life cycle. Connections between meteorological and oceanographic factors on one side and survival of anchovy early life stages on the other are explored in the southern Iberian shelf. The wind regime in the area is dominated by easterlies and westerlies, the former originates oligotrophy and advects early life stages towards open sea waters. Rain fertilizes the shelf. The combined forcing of rain and easterlies on the primary production and current system of the shelf probably originates part of the variance in the inter-annual fluctuations of anchovy landing observed in the last decades.

Keywords : Strait Of Gibraltar, Spawning, Fisheries, Ichthyoplankton, Circulation.

The Gulf of Cádiz has a wide shelf (\sim 50 Km) in a geographical context, the southern Iberian Peninsula, where this is usually narrow. Oceanographic processes at this shelf are affected by the proximity to Gibraltar and the influence this strait exerts on both the meteorology and the oceanography of the region. The strait influence on the former is neat in any analysis of the wind regime in the area. This is clearly dominated by easterlies and westerlies with strength usually increasing nearby Gibraltar. Westerlies are more frequent and, because of the coastline orientation and the Ekman pumping, they fertilize the shelf. In addition, the two major rivers of the southern Iberian Peninsula (Guadalquivir and Guadiana) discharge at the Gulf of Cádiz. Although heavily regulated with reservoirs, the fresh water of these rivers also fertilizes the inner shelf [1].

River and westerlies fertilization notably increase the primary production of the shelf, which is higher than at offshore waters of the basin. This increment is not accompanied by colder waters, as frequently occurs in tropical and subtropical latitudes, where nutrients inversely correlate to temperature [2]. The positive correlation between nutrients and temperature is associated to land-ocean interaction at saltmarshes in the region. At summer, the water inundating the marshes is heated during tidal flooding and this energy is brought back to the sea with the ebb tide [3]. This buoyancy input in the east side of the shelf (marshes at the Guadalquivir River and the Bay of Cadiz) originates the westward counter current usually present during summer in this shelf [4, 5].

The counter current and the south eastward circulation at the slope build a cyclonic cell, which is relevant for anchovy reproduction. Anchovy spawns at the slope side of the shelf, where the flow is towards the southeast. In the absence of the counter current at the inner shelf, eggs should keep flowing towards the strait of Gibraltar and from there inside the Mediterranean where oligotrophy hinders larvae survival. The counter current forces the streamlines towards the northwest and recirculates the suspended eggs towards the inner shelf, where high larvae concentration can be found one month later. This cyclonic circulation is only present during summer in connection with shelf overheating, which starts in June. June is also the peak for anchovy spawning in the Gulf of Cádiz [6]; therefore, suggesting a reproductive strategy that spawns not only where but also when currents are suitable for the survival of early life stages.

Consequently, the Gulf of Cádiz shelf offers during summer a combination of thermal, trophic and current features suitable for the success of anchovy early life stages. Nevertheless, this combination is substantially altered under easterly winds. Ekman pumping generates downwelling and oligotrophy in the shelf during easterlies. Although less frequent than westerlies, easterlies usually blow very intense when they occur. Easterlies are warm and dry during early summer, and generate a massive transport of latent heat from the surface ocean towards the atmosphere. The cooling of water they generate is enough to stop the spawning process [6]. In addition, easterlies intensity is enough to force the counter current to flow beyond the cyclonic cell and across cape Santa María. Under persistent easterlies, the westward progression of the counter current across cape Santa Maria can continue its westward progression to go beyond cape San Vicente [5] while advecting eggs and larvae from the shelf to deep sea waters of the north Atlantic. Westward advection of eggs and larvae has been observed during two synoptic surveys performed only several days apart under westerly and easterly wind regimes, respectively [7].

Therefore, the optimal combination of thermal, trophic and current features is significantly altered during easterlies bursts. Together with interannual changes in precipitation, yearly variations in easterly intensity during anchovy spawning can be at the origin of the variance in the landing of this fishery. This is the case for the fishery crisis at mid nineties, which is associated to a period of strong easterlies and low precipitation. Although one co-occurrence of negative oceanographic conditions and low landing at mid nineties does not constitute a definitive proof for a causal connection, the fact that this connection is also supported by a mechanistic understanding of the underlying process provides further evidence in support of the significant role played by oceanography for anchovy fisheries in the southern Iberian Peninsula.

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OBSERVATION OF INTERNAL WAVES IN THE STRAIT OF GIBRALTAR

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Abstract

Data analysis of temperature and current velocities from two mooring lines installed in the Strait of Gibraltar during May 2003 has been carried out. The Empirical Modes Decomposition analysis confirms the regular existence of energetic internal waves in the Strait of Gibraltar during spring tides, which are grouped in wave trains that are observed with semidiurnal periodicity. During neap tides, this phenomenon is weaker or even inexistent. The phase velocity of oscillations is 1.6 m/s in average. Nevertheless, this value has a noticeable dependence on the diurnal inequality existing in the flow, thus demonstrating that the advection is not negligible compared to the intrinsic phase velocity.

Keywords : Strait Of Gibraltar, Waves, Bathymetry, Stratification.

One of the main oceanographic features of the Strait of Gibraltar is the regular presence of internal waves [1, 2]. These waves have their origin in the internal bore formed downstream of Camarinal Sill (the main sill of the Strait of Gibraltar, CC in figure 1) during the flood tide. When the tidal current slackens, the internal bore is released producing internal waves trains.



Fig. 1. Bathymetry of the Strait of Gibraltar with isobaths plotted each 100 m. The map shows the location of the mean sill of the Strait (CC), and the positions of the two sites where the data used in the study were collected (TN, EE).

The data of this work were collected in Tarifa Narrows, the section of minimum width in the Strait of Gibraltar (35.960° N, 5.567° W, TN in figure 1), and in the eastern part of the Strait (36.056° N, 5.168° W, EE in figure). The instruments used, a set of Recording Current Meters at different depths, recorded temperature and velocity every two minutes from 29^{th} April- 22^{nd} May, and 1^{st} May- 3^{rd} June 2003 respectively.

Empirical Modes Decomposition analysis (EMD, [3]) has been carried out. EMD analysis is a recent algorithm able to deal with non-stationary and nonlinear signals, achieving a satisfactory response in time-frequency. This technique separates the signal in intrinsic mode functions (IMF), each of this IMF contains a narrow band of frequencies of the original signal, from the higher to the lower as the mode increases. The temporal reliance of instantaneous amplitude and frequency of each IMF is evaluated by the Hilbert transform. The waves have been identified by portions of the signals with high energy at high frequencies (oscillations in the first and second IMF with periods around 25 minutes). The analysis reveals that the phenomenon is especially intense during spring tides, with amplitudes around 50 meters and internal wave trains arriving with semidiurnal periodicity. On the other hand, during neap tides oscillations are weaker or they could not be detected. During the period of observations, the mean phase velocity between CC and TN was 1.59 m/s, and between TN and EE it was 1.78 m/s. Nevertheless, these average values are not very

representative because of the variability induced by the diurnal inequality existing in the flow through the Strait of Gibraltar. Such inequality is also observed in the phase velocities, due to the different importance of the advection. For instance, between TN and EE the velocity of internal wave trains observed during the same day differs in 0.45 m/s in average.

The period and amplitude of internal waves are variable within a wave train, changing from high periods and amplitudes at the head, to low values at the rear. Characteristic values are 30-10 min for periods, and 50-10 m for amplitudes. Those properties, together with the increase of oscillations in a wave packet, its spreading, and the recovery of isopycnals at the rear of the wave trains, have been well detected in the data and compared with a model based on an analytical solution of the Korteweg de-Vries equation [4].

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CLIMATOLOGICAL TRENDS FROM 32 YEARS OF OBSERVATIONS AT L'ESTARTIT STATION, NEAR THE CATALAN COAST (NW MEDITERRANEAN)

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Abstract

The air and sea temperature trends observed along the last 32 years and the evolution of the sea level during the last 15 years at a coastal station in the Western Mediterranean are presented. The results show a general temperature increase, especially during the spring period which implies an advancement of the summer conditions at sea. The evolution in the minimum annual values of the heat content in winter is related to the reported trends in intermediate and deep waters. Finally the net increasing trend in sea level is related with the thermal expansion due to the increasing heat content of the whole Western Mediterranean.

Keywords : Air-sea Interactions, Temperature, Time Series, Sea Level, Western Mediterranean.

Introduction

L'Estartit is a small town located in the northern Catalan coast, near the Gulf of Lions. Since August 1973 up to now, a station located 2.5 nautical miles offshore ($42^{\circ}N$ 03' N, 03° 15' 15''E), over a depth of 90 m has been sampled weekly (50-60 times per year) for temperature and salinity, at seven levels: surface, 5, 20, 35, 50, 65 and 80 m. Coastal meteorological data has also been recored during the whole period, and a continuous record of the sea level has been obtained since January 1990. A location map and complete description of all the measurements obtained, as well as the typical climatological annual cycle can be found in [1]. Although salinity remains almost constant around 38, it may decrease due to heavy rain episodes and the proximity of the Ter river mouth. The influence of the Rhone can also affect the surface layer salinity down to 25 m, by the end of spring. Thus, except at surface during those episodes, density is mainly driven by the temperature.

Temperature evolution

The interannual variability of the temperature cycle has been very high with differences in extreme values (annual maxima and minima) as larger as 6° C for air temperature, and 4 and 2° C for maxima and minima of the sea temperature, either at surface or even at 80 m depth. These differences are especially significative as the mean annual temperature oscillations for air, sea surface and 80 m are 12, 10 and 3° C respectively. The interannual variability of air temperature depends mainly on the general atmospheric circulation subjected to large scale cycles such as the NAO. Harmonic analysis carried out by [2] showed that there are typical periods from 3 to 5 years. The variability of sea surface temperature can be explained in general by heat exchanges with the atmosphere. By contrast, the variability at 80 m is more depending on the surface temperature. Then, it is more influenced by the intensity of the autumn storms and how early they act.

From monthly averages and besides the interanual variability, all temperatures show increasing trends along the last 32 years. These trends can be considered quite robust given the length of the time series some times longer than the typical cycles [2]. However the trends are neither regular nor the same all along the year cycle. Dividing the annual cycle in seasons: Spring (April-June), Summer (July-September), Autumn (October-December) and Winter (January-March), we obtained the trends in Tab. 1. The table also contains the trend of the mean temperature (0-80 m), calculated from the data of all sampled levels, as a proxy for the heat conent of the water column.

One of the most interesting results is the tendency of the net heat gain represented by minimum of the sea surface temperature trend ($0.011^{\circ}C$ /year). This figure can be considered as the minimum trend of heating and corresponds to a net increase of $0.35^{\circ}C$ during the period 1974-2005. This tendency coincides exactly with that observed by [3] from 1996 to 2004 at 600 m depth near the Balearic Islands.

The next outstanding result is that the most exaggerated trends are found during the spring period. They account for a net increase of sea surface temperature of 1.38° C at the end of the season along these 32 years. This result is especially relevant in the biological context because it contributes to bring forward the cycles of several species. To evaluate the advancement of the summer conditions we used the time when sea surface temperature reached 16° C, and we obtained a rate of 0.4 days/year, which is equivalent to 13 days within the whole period. This trend is still higher (0.56 days/year) if we consider a temperature of 15.5° C at 20 m depth.

Finally, this acceleration recorded on the spring phase has a consequence on the air-sea temperature difference (Table 1). In particular it has been found that since 1990 mean air temperature exceeds systematically that of sea surface during both April and May. This has implications on evaporation rates and hence on the spring precipitations over the coastal region, that have been reduced around 20%, in average, from 1974 to 2005.

Tab. 1. Summary of the relevant tempreature trends. Max. trend of sea surface temperature, for the stratified period, and min. trend for the mixing period are included.

Trends °C/year	Annual	Winter	Spring	Summer	Autumn
T. air	0.060	0.048	0.082	0.063	0.053
T. surface	0.034	0.020 0.011 (min)	0.043 0.060 (max)	0.033 0.049 (max)	0.034 0.025 (min)
T. 80 m	0.022	0.016	0.019	0.015	0.040
T. mean (0-80 m)	0.032	0.019	0.032	0.040	0.040
T. air - T. surf.	0.031	0.024	0.053	0.024	0.021

Sea level evolution

Sea level records are not so long as temperature (16 years) so that the observed trend (an increasing rate of 0.33 cm/year) is not as significant as temperature trends. The interannual variability of the sea level compensated from the effect due to the atmospheric pressure can be estimated in such a way that the result will be only depending on water expansion. This calculations gave a value of 0.28 cm/year, wich is lower than the previous but still important as it represents 4.2 cm in 15 years. If we take into account the increase of the mean temperature of the local water column (0.50°C), in Tab. 1, we obtain that the contribution of the local water column (0-80 m) to this expansion is 0.76 cm in 15 years. The remainder, 3.44 cm has to be attributed to the net heat gain within the whole Mediterranean. Assuming a mean depth of 2000 m the trend in the expansion accounts for a mean increase of 0.1° C in 15 years, which is equivalent to a rate of 0.0067°C/year. This figure is not far from the results that can be obtained by comparing recent data on deep water from those collected 20 years ago, in mid eighties: 0.12°C in 20 years; 0.006°C/year) [3]. Moreover this trend is slightly lower than the estimated rate of 0.01°C/year found at 200 m depth in several stations in the Western Mediterranean recorded in [2]. The series of compensated sea level also show some shifts, breaking the tendency, that are not correlated to any local event but with years of abundant Deep Water formation like 2005 [3].

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ATYPICAL WESTERN MEDITERRANEAN DEEP WATER FORMATION DURING WINTER 2005

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Abstract

The meteorological conditions in winter 2005, with anomalously low precipitation and unusual persistency of northerlies over the NW Mediterranean, caused a large extension both in time and space of deep convection processes. As a consequence, where convection typically gives rise to the Western Intermediate Waters (WIW) a New Western Mediterranean Deep Water (N-WMDW) was produced, slightly denser (+0.01kg m⁻³), warmer (+0.05°C) and saltier (+0.03) than the usual WMDW. Moreover, near the continental slope, a cascading of colder and even denser water was found (-0.1°C and +0.025 kg m⁻³), formed over the shelf (C-WMDW). In both cases it appears the high surface salinity as a responsible for the excess of density. The origin of this higher surface salinity is discussed. *Keywords : Air-sea Interactions, Deep Waters, Deep Sea Processes, Western Mediterranean.*

Typical convection processes in the NW Mediterranean in winter give rise to different water masses according to their density. The most dense, WMDW, is formed in the MEDOC area (around 24°N, 5°E) based on surface preconditioned waters + some amount of LIW [1]. Other dense waters, called WIW, are formed in the coastal NW periphery of the MEDOC area [2], where surface AW is less salty than in the central part. WIW are less dense than WMDW and remain above the LIW layer. During cold, windy or dry winters mixing over the continental shelves can reach high densities enough to overflow the shelves and sink through the slope by cascading [3]. The most common fate of this cascading is also above the LIW but some times has been reported below this layer down to the bottom [4]. WMDW is very homogeneous, however, a slightly warmer and salty water has been found near the bottom on some occasions. The origin of this water is still on discussion: Called Bottom Water (BW) in one of the first articles [5], it was assumed that was formed by deep convecton at open sea but not concluded under which conditions. Other more recent papers [4] consider that they originated by cascading.

Data analysed in this paper comes from EFLUBIO cruise in March 2005, covering a part of the NW Mediterranean in open sea, including the MEDOC area. Unfortunately many of the CTD casts only sampled the upper 600 m, only some of them reached 1000 m and very few 2000 m. Sampling was completed with a continuous analysis of surface TS along the shiptrack and a transect of 4 stations across the shelf-slope in front of Barcelona.

The vertical structure found revealed clear signs of a recent deep convection in a large area, confirmed by satellite images, which covered unusual regions more than 100 miles southwards of the MEDOC area. Surface salinity in this area was very high (>38.45) and LIW was found very shallow (at less than 100 m). Curiously, in one of the stations at the E of Menorca, a very "recent" LIW, with salinity >38.6, was found at its typical layer. However, the most interesting, and surprising, finding was the presence of a very thick layer of a slightly saltier and warmer (marked as N in Fig. 1), below the typical WMDW (marked as O). This water, found as shallow as 600 m in certain stations, was almost omnipresent in all the deep stations below 1200 m. Another water mass (marked as C), denser that O, was found on the transect across the slope, as shallow as 25 m over the shelf and close to the bottom on the slope.

Winter 2005 was cold but not extraordinarily cold. However it was very windy and dry. Precipitations were on a historical minimum and northerlies were strong and persistent. These exceptional conditions would explain the extent both in time and space of the DW formation process. As sinking of new DW involves a compensatory upwards flow of LIW, in such a case the amount would be much bigger than usual. This would explain the presence of this water near the surface in a large area and the extraordinarily high salinities found at surface in the zone of the continental slope. While in typical WIW formation is assumed that surface water that sinks is free of the LIW, in the present case all the typical places for WIW formation were occupied by LIW, so that the dense water formed there by open sea convection would produce a water saltier and slightly warmer than the classical WIW, as the one marked with N in Fig. 1. This important turn over of LIW would also accelerate the circulation at this intermediate layer, explaining the presence of the "recent" LIW near Menorca. The drought conditions, reducing river discharges, would also justify high salinity in the coastal waters contributing to the formation of a coastal dense water (marked C in Fig.1) that would reach the bottom of the basin by cascading. A subsequent cruise, in June-July 2005, in the Balearic sea showed that N and C waters were linked by a mixing line in the θ Sdiagram [6] forming a new Deep Water Mass.



Fig. 1. Detailed θ S diagram of all the casts. The points marked with O, N and C are referring to: the typical (Old) deep water, the New deep water and the water formed by Cascading respectively

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OCEAN FORECASTING IN THE EASTERN MEDITERRANEAN, THE ALERMO SYSTEM

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Abstract

The ALERMO ocean forecasting system was implemented and developed in the framework of the Mediterranean Forecasting System and provides five days of ocean circulation forecasting in the Eastern Mediterranean Sea on a weekly basis. New features and innovative coupling techniques have been incorporated in the forecasting system. The system reliably simulates the evolution of the main circulation features in the domain compared with available observations. Extensive validation and sensitivity experiments are carried out to investigate the forecasting skill as well as the effects of different initialisation and coupling procedures. *Keywords : Aegean Sea, Levantine Basin, Models.*

Introduction

During the last decades progress in several scientific and technical aspects of physical oceanography enabled the evolution of ocean forecasting activities for operational needs. In the Mediterranean Sea such operational activities in different countries were integrated in the framework of research projects (e.g. Mediterranean Forecasting System - MFS) or operational networks (e.g. Mediterranean Operational Oceanography Network - MOON). In the present work the ALERMO (Aegean Levantine Eddy Resolving Model) ocean forecasting system implemented in the framework of MFS is presented. MFS demonstrated the feasibility of reliable near real time 5-days forecasts at regional/shelf scale in the Mediterranean Sea, through a network of 15 models at various scales, related to the MFS observational network through assimilation. The network performs five-day forecasts on a daily basis as well as additional experiments for optimisation of the implementation and coupling procedures.



Fig. 1. ALERMO domain and sea surface temperature forecast field

Modelling System

The ALERMO model is based on the Princeton Ocean Model [1], covering the geographical area 20°E - 36.4°E, 30.7°N - 41.2°N and has one open boundary at 20° E (Fig. 1). The computational grid has a horizontal resolution of 1/30° and 25 sigma levels in vertical with a logarithmic distribution near the sea surface. The Dardanelles exchange is treated as an open boundary and a real freshwater flux boundary condition is applied at the surface. The one-way nesting with the Mediterranean OGCM is applied along the western boundary. The coupling between the ALERMO and the SKIRON/Eta atmospheric model with 1°/10 resolution [2] is designed in such a way to allow one-way feedback ocean-atmosphere mechanisms to take place. The ALERMO model is initialized from the Mediterranean OGCM using the Variational Initialization (VI) method [3]. The initialization including the tangent linear of the POM model were successfully implemented and configured in ALERMO (Fig. 2). The 5-day forecast fields are made available to the public on the web (http://www.oc.phys.uoa.gr) and are provided to 5 shelf models, nested in the ALERMO system.



Fig. 2. The ALERMO operational system flowchart

Results

From the beginning of September 2004 onward the MFS-ALERMO system provides a 5-days forecast (on a weekly basis in the initial phase and later on a daily basis). ALERMO reliably simulates the evolution of the main circulation features in the domain such as the Mersa-Matruh anticyclone, the Asia Minor Current, the Ierapetra anticyclone and the Rhodes cyclonic circulation. Results also put in evidence a large number of fine circulation features and vortices in the Aegean and Levantine basins in agreement with satellite SST data. For the first 2-3 forecast days, results of both Mediterranean OGCM and ALERMO are almost identical in the interior of the domain, with the higher-resolution ALERMO model producing more fine-structure flows in the coastal/shelf areas and near islands. In the last 1-2 forecasting days one may observe significant changes in the coastal areas such as a flow reversal in the ALERMO model near the Levantine coasts. Additional experiments with very high-resolution forcing (5 km), different initialisation procedures, and introduction of assimilation in ALERMO reveal interesting aspects of the forecasting activities. A thorough validation of the system is carried out in order to quantify the system's reliability and define tuning adjustments.

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ASCABOS - A NEW CAPACITY BUILDING PROGRAMME SUPPORTING OCEANOGRAPHIC SERVICES IN THE BLACK SEA

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Abstract

Communications, data and information exchange are the key elements of the operational ocean monitoring and forecasting networks, defined in the Global Ocean Observing System (GOOS). ASCABOS (A supporting programme for capacity building in the Black Sea region towards operational status of oceanographic services) is designed to strengthen the communication system ensuring flexible and operative infrastructure for data and information exchange. ASCABOS aims at increasing public awareness and at stimulating and motivating the utilization of operational oceanographic information in regional management and decision-making practices. To support and to strengthen the exchange between scientists, governmental managers and other users ASCABOS is planning to organize a cost-effective VOS pilot programme, applying modern technologies for data collection, transmission, storage, use and dissemination. *Keywords : Black Sea, Instruments And Techniques.*

Understanding the Earth system is crucial to enhance the human health, safety and welfare. Global Earth Observations as a critical element are sustained by operational services. Europe (EuroGOOS, MedGOOS, BS GOOS, etc.) has world leadership in this field as it has been supporting the investment in marine research and technology through EC FP 3, 4, 5, and is continuing in FP6.

The first Black Sea GOOS project ARENA [1] fulfils its mission set out in the Black Sea GOOS Strategic Action and Implementation Plan, and has fostered development of operational oceanography in the region. ARENA already contributed to the process of a sustained pan- European operational oceanographic system establishment. The following significant results have been achieved:

1. Design the basis of the Black Sea operational oceanographic system; 2. Improve the regional capacity to serve GOOS objectives; 3. Assess the capacity of the region and end users' needs [2]; 4. Establish links between partners and communication system for exchange of data and products [3]; 5. Set up initial nowcasting/forecasting system of the Black Sea circulation and ecosystem state [4]; 6. Launch a significant amount of national and international initiatives, as the ASCABOS project.

The ASCABOS project overview and end user involvement

The ultimate goal of modern oceanography is an end user oriented product. Beneficiaries include shipping, oil and gas industries, port and harbour, commercial fisheries, tourism and recreation industries, governmental agencies, coastal zone managers, etc. ASCABOS is designed as a threeyear programme and its specific objectives are.

1. Co-ordination of a flexible and operative infrastructure for data and information exchange to support observing and forecasting systems.

2. Building the scientific capacity of human resources through especially designed educational and training programme.

3. Continuously collecting and updating of the historical data and metadata bases and extending the end-users access by development of a Black Sea information system.

4. Organization of a cost-effective VOS pilot programme.

The problem, which is particularly acute, concerns the communication capacity in the region since the development of distributed observing systems and closely related operational forecasting is dependant on the exchange of significant data and information volumes. A very serious requirement is education and training of a wide spectrum of end-users, including young scientists, in order to achieve a high level of operational services and to create proper awareness and socio-economic impact. Historical metadata related to the Black Sea have been collected within different international initiatives. Enhancing the options to access data and update the metadata base is an essential user requirement, which is being settled. ASCABOS is called to further sustain the exchange between scientists, governmental managers and other users through development of a fully operational Black Sea information portal.

Analysis of operational observing systems shows that their running components are concentrated predominantly in the coastal zone. However, collection of meteorological and hydrological data in the open sea is particularly valuable for the Black Sea as a unique European basin. Therefore, ASCABOS started organising a SOOP observational programme. Suitable conditions exist in the Black Sea as there is sufficient number of regular ferry lines (Fig. 1). The goal is to provide a strategic forward look for advancing implementation of the basin-scale multi-parametric, autonomous, cost-effective system.



Fig. 1. Tentative design of VOS lines in the Black Sea

Conclusions and recommendations

Undertaking these crucial actions will assist an optimal realization of the Black Sea GOOS objectives. ASCABOS will also respond to the GEOSS requirement to turn the observations into knowledge products. It is also in unison with the GMES and GEO approach to start enhancing the existing systems with co-ordinated calibration and data exchange. A methodology to exchange multiple sources data and an operational portal, designed in ASCABOS, will enable understanding and facilitate decision making, thus, yielding information products useful to society. Furthermore, AS-CABOS is underpinning other ongoing regional initiatives and programs seeking the interoperability and coherence of all key actions. This ensures a rational development of long-term sustained GOOS.

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CHANGES IN THE AEGEAN SEA THERMOHALINE CHARACTERISTICS IN THE POST-EASTERN MEDITERRANEAN TRANSIENT PERIOD

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Abstract

Monitoring of the thermohaline properties in the Aegean Sea, with CTD surveys and profiling floats observations, and comparison with older data in the region, reveal strong variability in space and time. The results are investigated in the context of recent climatic changes (Eastern Mediterranean Transient), focusing on the evolution of the water column structure in the various sub-basins. It was found that important changes are taking place during the time of the study, related to local processes as well as exchanges with the adjacent sub-basins. In the Cretan Sea, the Transitional Mediterranean Water intrusion is evolving in time altering the stratification of the basin. *Keywords : Aegean Sea, Eastern Mediterranean, Circulation.*

Introduction

During the late 80s the thermohaline circulation and the deep-water hydrological properties of the eastern Mediterranean Sea underwent a strong and abrupt change, known as the "Eastern Mediterranean Transient (EMT)" [1]. The Aegean Sea became the new more effective source than the Adriatic Sea, since it produced not only denser water, namely the Cretan Deep Water (CDW), but also higher volumes. From 1988 to 1995, massive outflow of CDW occurred through the Straits of the Cretan Arc towards the Ionian and Levantine basins. The CDW being of particularly high density (29.3 kg/m3) sank into the near-bottom layers, uplifting the older deep waters of Adriatic origin and affecting the exchange between the Aegean and the adjacent basins with the intrusion of Transitional Mediterranean Water (TMW). The origin of the latter is water lying between Levantine Intermediate Water and Eastern Mediterranean Deep Water, which was present in the Cretan Sea intermediate levels (200-600 m) during the first stages of EMT [2]. Since 1995 the EMT event started to decay, but the rate of the Eastern Mediterranean system relaxation as well as its final state (old or modified) remain still unclear.



Fig. 1. Evolution of depth (a) and salinity (b) of the TMW intrusion in the Cretan Sea

Observations in the Aegean Sea

Aiming at investigating the variability of the Aegean Sea water column structure and the post-EMT evolution, a series of CTD surveys and profiling float deployments was conducted in various Aegean Sea basins and the adjacent west Levantine region. The acquired CTD data and data derived from profiling floats are being compared with older observations. The changes associated with EMT started to decay dramatically confirming its transitional character but subsequent changes were slower and its signal still remains present. Although changes in the stratification are notable, the basic water masses related to the EMT event are present in the Aegean Sea water column. The Cretan Sea profiles reveal a relatively less saline intermediate layer, produced by the TMW intrusion that is continuously deepening and reached the 800 m during the late observations (Figure 1). Comparison with older observations indicates important mixing processes within and outside the Aegean and a possible evolution of the exchange between the Cretan Sea and the Levantine basin. The Aegean outflow that contributed to the Eastern Mediterranean shallower layers (1500-2500 m), during 1998-99, has been obviously minimized. This current phase is characterized by the strong inflow of the TMW, at least through the deepest strait of Kassos. Changes in the stratification in the Levantine basin outside the Cretan Arc straits and the deflation of the CDW layer in the Cretan Sea, modifies the exchange between the Aegean Sea and the adjacent basins at deep and intermediate levels. The waters just outside the Eastern Cretan Straits, below 1000 m, are a mixture of deep water of Adriatic and Aegean origin, with the former contributing to a higher percentage compared to earlier observations. In the northern Aegean basin important interannual variability is observed (Figure 2). Changes in the water column characteristics in the region are influenced by local formation processes detected during the winter period.



Fig. 2. Temperature (left) and salinity (right) profiles in the Limnos basin (N.E. Aegean) during different years.

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21ST CENTURY CLIMATE CHANGE SCENARIO OF THE MEDITERRANEAN SEA : A HIGH-RESOLUTION MODELLING APPROACH

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Abstract

This study analyses the results of an IPCC-A2 transient climate change simulation over the Mediterranean Sea. We also carried out a control simulation. For both runs, a Mediterranean Sea high-resolution model was forced by high-resolution air-sea fluxes (1960-2099). At the end of the 21^{st} century, the surface warming and the salting amount to $+3.1^{\circ}$ C and +0.48 psu respectively. The Mediterranean thermohaline circulation (MTHC) is strongly weakened because of a decrease in surface density. The ocean-only simulation is also compared with a regional atmosphere-ocean coupled scenario performed with the same models. We obtain a comparable behavior for the SST and a stronger increase in SSS changing the response of the MTHC.

Keywords : Circulation Models, Deep Waters, Global Change.

A climate change IPCC-A2 scenario run with an atmosphere regional climate model (ARPEGE-Climate, 50 km horizontal resolution, [1]) was used to force a Mediterranean Sea high resolution ocean model (OPA-MED, 10 km, [2]) over the 1960-2099 period. Thus we obtained the first high-resolution transient climate change scenario for the Mediterranean Sea over the 21^{st} century [2]. A control simulation over the same period of time was also carried out under present climate fluxes in order to evaluate the potential drift of the model. This control run shows air-sea fluxes in agreement with observations, stable temperature and salinity characteristics, and a realistic thermohaline circulation simulating the formation of the different intermediate and deep water masses as described in the literature.



Fig. 1. Yeary time series of the SST ($^{\circ}$ C, in black) and SSS (psu, in grey) anomalies for the Gulf of Lions area (0° E-9.5 $^{\circ}$ E; 40° N-44 $^{\circ}$ N) for the control simulation (CTL, thin lines) and the scenario (SCN, thick lines). Exponential fits have been added for each curve (dashed lines). The anomalies have been computed with respect to the 1961-1980 period and the SSS anomalies have been multiplied by 5 for rescaling.

In the scenario, we can notice that the simulated warming and salting are in agreement with the trends observed for the Mediterranean Sea over the last decades [3]. At the end of the 21st century, the warming and the salting amount to +3.1°C and +0.48 psu respectively, over the Mediterranean sea surface (see also figure 1 for the Gulf of Lions area) and to +1.5°C and +0.23 psu respectively, when averaged over the whole water column. In addition, the Mediterranean thermohaline circulation (MTHC) is strongly weakened at the end of the 21^{st} century (see figure 2). This simulated evolution is mainly due to a decrease in the surface water density leading to a shrinking in deep water formation in winter. Thus the warming effect is more important than the salting one as shown in figure 1. In this figure, the SSS anomalies have been rescaled in order to be compared to the SST anomalies in terms of density changes. However, locally (in the Adriatic and Aegean seas) the weakening of the deep water formation is lessened by the Po and the Black Sea changes. The characteristics of the Mediterranean Outflow Waters flowing into the Atlantic Ocean are also strongly impacted. This water mass experiences a negligible decrease of the water transport (-4%, 2070-2099 period) along with an increase in temperature (+2.5°C) and in salinity (+0.45 psu) in agreement with a low-resolution Mediterranean Sea scenario [4]. Such a phenomenon could influence the

Atlantic Ocean circulation at the century time-scale. However there are numerous uncertainties related to this scenario: at least, the choice of the IPCC scenario, the choice of the modelling strategy, the choice of the ocean model, and the climate change impact on the river runoff fluxes. Among them, a key issue in the modelling strategy is the use of an ocean model, forced by air-sea fluxes instead of coupled to the atmosphere. Indeed, the way of dealing with the SST evolution is completely different and more physical with an interactive Mediterranean Sea. A scenario with a regional air-sea coupled model (ARPEGE-Climate/OPA-MED, see [5]) has also been run. The comparison with the forced ocean model shows that the SST evolution is comparable at the basin scale with some local differences. However, concerning the salinity, the regional coupled model simulates a larger increase in SSS and consequently a smaller decrease for the MTHC. Therefore we think that ensemble simulations are required to assess in details the different sources of uncertainty and thus determine more precisely the possible evolution of the Mediterranean Sea over the 21st century.



Fig. 2. Vertical section averaged over the 2070-2099 period for global Mediterranean Zonal Overturning stream Function (ZOF) for the scenario (the control run ZOF is represented in small).

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MODELLING THE MEDITERRANEAN SEA OVER THE LAST 40 YEARS USING HIGH RESOLUTION DYNAMICAL DOWNSCALING OF THE ERA40 REANALYSIS

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Abstract

Modelling the evolution of the Mediterranean Sea over the last decades is needed to understand better its functionning and thus to foresee its possible future evolution. To achieve this goal, a 40-year high-resolution simulation of the Mediterranean Sea was carried out using high resolution air-sea fluxes coming from a dynamical downscaling of the ERA40 reanalysis. This simulation enables us to study the interannual variability and the trend of various physical processes in the Mediterranean basin. It shows a good representation of the heat content temporal evolution as well as of the Eastern Mediterranean Transient.

Keywords : Circulation Models, Deep Waters, Heat Budget, Global Change, Aegean Sea.

The Mediterranean Sea is known to show a high interannual variability in terms of deep water formation [1]. It also experiences decadal variability as proved by the Eastern Mediterranean Transient event [2] and the existence of long-term trends [3]. Moreover, the first scenarios of climate change applied to the Mediterranean Sea result in a strong impact on its hydrology and thermohaline circulation [4]. Therefore simulating and understanding the evolution of the Mediterranean Sea over the last decades can be considered as quite a challenging task for the ocean and climate modelling community.



Fig. 1. Time series (1 point per year) of (a) the Mediterranean Sea heat content (expressed as a 3D mean temperature in $^{\circ}$ C) and (b) the salt content (expressed as salinity). In dashed line the observed range (Michel Rixen, personal communication) and in black, the simulated values.

Achieving such a goal requires working with high resolution models forced by a high resolution atmospheric forcing that follows the observed chronology. In agreement with this statement, we performed a dynamical downscaling of the ERA40 reanalysis with the ARPEGE-Climate model [5] (Atmosphere General Circulation Model with a stretched grid) in order

to obtain a better horizontal resolution (50 km) over the Mediterranean area (spectral nudging method). A 40-year long simulation (1960-2000) was carried out with this method. The air-sea fluxes (radiative and turbulent) were extracted and then used to force a Mediterranean version [4] of the OPA model whose horizontal resolution reaches about 10 km. The SST relaxation was computed using the ERA40 SST dataset. Climato-logical river runoff fluxes along with an additive constant correction were applied to make the water budget realistic. However, no surface salinity relaxation was applied letting free the spatial and temporal variability of this field. This simulation can be considered as a first step towards a 40-year reanalysis of the Mediterranean Sea in which only realistic air-sea fluxes and SST would be imposed.

Firstly, the temporal evolution of the heat and salt content of the whole Mediterranean Sea is analyzed using recent observed datasets [3]. The average value, the interannual variability and the observed trend of the heat content are well simulated by the Mediterranean model apart from a weak bias of about 0.1° C at the end of the 20^{th} century (see figure 1a). The spatial pattern of the warming trend is also studied compared to observations. Concerning the salinity, only the average value is well reproduced (see figure 1b) proving a deficiency in the way the sources of the salinity interannual variability are modelled. In the Western Basin, the open-sea deep convection and the formation of the WMDW show a realistic interannual variability. However, no clear time correlation is found with the observed values [1] because the long-term temporal evolution of the vertical stratification seems to be too difficult to simulate without in-situ ocean data assimilation. Contrary to the WMDW formation, the Eastern Mediterranean Transient is mainly due to atmospheric flux anomalies and is then partly reproduced by our simulation without tuning the precipitation or the Black Sea freshwater input. Very cold winter and dense water formation are observed in 1993 filling the Aegean Sea (yearly deep water formation rate of 0.7 Sv). This newly formed water goes outside the Aegean Sea but does not sink to the bottom layer of the Levantine Basin. In the future, improvements could be achieved by introducing interannual variability for the river runoff fluxes and for the Atlantic T-S characteristics as well as by using in situ ocean data assimilation. In forthcoming studies, this simulation will also be used as a reference to study the interannual variability of Mediterranean physical processes and to perform sensitivity tests in order to understand the recent past of this sea and consequently better foresee its future.

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TRENDS IN GEOSTROPHIC CURRENTS IN THE VICINITY OF ISTRIAN COAST (NORTHERN ADRIATIC)

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Abstract

The analysis of the 1966-2005 data series shows that trends in geostrophic circulation in the coastal zone off Istria are pronounced and closely follow trends in temperature and salinity in the region.

Keywords : Adriatic Sea, Circulation, Temperature, Salinity.

Intoduction

Trends in temperature and salinity of the northern Adriatic are nowadays widely investigated. In this preliminary study we analyse geostrophic currents in the vicinity of the Istrian coast over the 1966-2005 interval, in order to find out whether they are subject to trends as well. A long term analysis [1] showed that on average there is a summertime outflow of water near the Istrian coast, named Istrian Coastal Countercurrent (ICCC). The summer mucilage and autumn anoxia events in the northern Adriatic in the 1966-2002 period were observed exclusively in the years in which the ICCC was more intense [1, 2]. It is held that the ICCC is part of an anticyclonic gyre, which encircles a pool of warm and low salinity waters of Po river origin.

Data and methods

Sea temperature and salinity data were collected in August over the 1966-2005 period at stations RV001 and SJ107 in the coastal zone off Istria (Figure 1) at 0, 5, 10 and 20 m and at 2 m above the bottom, and were used to compute surface geostrophic currents relative to 30 m between the two stations as practiced before [1]. Currents are positive when they indicate an inflow to the northern Adriatic.



Fig. 1. Map of the northern Adriatic.

Results

As shown in Figure 2, over the 1966-1992 interval summertime currents near the Istrian coast were generally negative (i. e. of south-eastern direction, ICCC). However, while year-to-year changes of the currents in the 1966-1982 interval were highly pronounced, in the 1983-1992 period the currents were relatively strong and quite persistent. After 1992 the currents showed a positive trend - they were more often positive (i. e. of north-western direction) while intensity of currents with negative sign (ICCC) decreased with respect to the previous, 1983-1992 interval. Figure 2 also shows that trends in changes of coastal currents closely followed trends in the August temperature and salinity in the region (computed as average temperature and salinity of the 0-30 m layer at RV001 and S1107). In the 1966-1982 interval both temperature and salinity were highly vari-

able, from 1983 to 1992 they were rather stable, while after 1992 the values of both parameters increased.



Fig. 2. Speed of geostrophic currents determined from data collected at stations RV001 and SJ107 in August over the 1966-2005 interval in comparison with average August values of temperature and salinity in the region. Positive speeds imply an inflow to the northern Adriatic.

Conclusion

Our analysis shows that trends in circulation in the coastal zone off Istria are pronounced and closely follow trends in temperature and salinity in the region. In addition, we show that after 1992 occurrences of the ICCC become less frequent and less intense. This change coincided with the appearance of a strong positive trend in temperature and salinity in the region. A preliminary analysis indicates that changes in temperature and salinity in summer are highly influenced by the preceding meteorological and hydrologic conditions.

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NEW ELEMENTS ON THE SURFACE CIRCULATION IN THE EASTERN BASIN OF THE MEDITERRANEAN

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Abstract

An intensive survey of the circulation in the eastern basin of the Mediterranean is currently underway. One of the goals is to settle the controversy about the surface circulation main path, depicted either as first meandering offshore across the basin ("Mid-Mediterranean Jet"), or as a counter-clockwise circuit along the slope at the basin scale. Observations (both in situ and remotely sensed) focussed mainly on the southern part of the basin, where only a few in situ observations -if any- were available, and on sampling mesoscale eddies. The first results of the programs EGYPT and EGITTO, initiated in September 2005 and expected to last till mid-2008, are presented. *Keywords : Circulation, Circulation Experiments, Eastern Mediterranean, Mesoscale Phenomena, Remote Sensing.*

Historical schema and the most recent ones [1,2] depict a circulation of the Atlantic Water (AW) as a counter-clockwise circuit at basin scale, while the schema issued from the POEM experiment (1985-1995) depict a jet first meandering offshore across the basin (the "Mid-Mediterranean Jet"), before splitting, west of Cyprus [3]. This is partly due to the fact that in situ observations are very scarce in the southern part of the basin, and that the role of the mesoscale phenomena has been misinterpreted. The programs EGYPT (Eddies and GYres Paths Tracking; http://www.ifremer.fr/lobtln/EGYPT) and EGITTO (http://doga.ogs.trieste.it/sire/drifter/egitto_main.html) have been designed to acquire observations (both in situ and remotely sensed), from late 2005 to mid-2008. To date, 3 transits (EGITTO-1, Nov. 2005, EGYPT-0, Feb. 2006, and EGITTO-2, Oct. 2006) and one campaign (EGYPT-1, Apr. 2006) have allowed deploying 7 moorings equipped with 30 currentmeters and 10 hydrological probes, 81 surface drifters and 12 Argo profilers. Over 220 XBT and 125 CTD casts have been made, with a sampling interval ranging from 10 to 20 km at most (figure 1). Surface temperature and salinity were recorded underway, as well as ADCP current. Whenever possible, routes and sections were chosen in near-real time according to the mesoscale features detected on satellite images. During the transit EGITTO-1 5 eddies were sampled in the southern part of the basin, 2 during EGYPT-0, and 1 during EGITTO-2. During the campaign EGYPT-1 2 eddies were sampled with XBTs in the southern Ionian, and a dense CTD network was designed to sample a Libyan eddy (LE) centred near 33°30'N and 23°30'E (diameter 100 km), as well as the eddy Ierapetra-2005 (I-2005), centred around 33°30'N and 26°E (diameter 150 km). A transect across the whole basin from the Libyan to the Cretan shelves across LE has also been performed. Additional observations will be acquired during a transit from the Cretan to the Libyan shelves in Mar. 2007 (at least 5 surface drifters will be launched), and during the final campaign EGYPT-3 in 2008 (recovering of the mooring network).



Fig. 1. Sampling stations during EGITTO and EGYPT cruises.

Results

It is shown that thermal infrared (colour not excluded) satellite images can be efficiently used to detect and track eddies in the eastern basin too. All eddies have vertical extents >few 100s of meter at least (>1000 m for LE and I-2005, see Beranger et al., this issue, for more details). Recent AW was entrained inside and around LE, the less saline water (<38.4) of the transect being found on its northern edge. The CTD section from the Libyan to Cretan shelves across LE showed that recent AW was found only in and around LE. Drifters trajectories can be diverted sharply offshoreward by eddies located along the southern slope. This explains the occurrence of recent AW found associated with a northward current on the western side of I-2005: although I-2005 was in the central part of the basin, a coastal eddy upstream was diverting the AW flow offshore in a paddle-wheel-like effect. Most of the eddies are very coherent, so that several of the surface drifters seeded inside eddies remained trapped for months. This happened with I-2005 and with LE, which has been tracked drifting westward from April to October 2006 at least.

Conclusion

On the whole, and as shown also by Gerin et al. (this issue), the surface current is flowing eastward along the continental slope off Egypt and northward along Israel and Lebanon. Since there is a general agreement on the circulation (alongslope too) in the northern part of the basin, these results tend to favour the hypothesis of a surface circulation alongslope at basin scale, which is also comforted by some models ([4], and Beranger et al., this issue). However, mesoscale phenomena can locally and temporarily modify it (up to reverse it), and are responsible for the dispatching of recent AW offshore.

Note: EGYPT-EGITTO contributors are C. Millot and G. Rougier (LOB, CNRS/Université de la Méditerranée, La Seyne, France.), J.-L. Fuda (COM, CNRS/Université de la Méditerranée, Marseille, France), P.-M. Poulain, R. Gerin, E. Mauri and G. Notarstefano (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Trieste, Italy), M. Emelianov, A. Julià and J. Font (Institut de Ciències del Mar, CSIC, Barcelona. Spain), C. Guillerm (INSU/CNRS Division Technique, Brest, France), A. El Gindy (Alexandria University Department of Oceanography, Alexandria, Egypt) and M. Said (National Institute for Oceanography and Fisheries, Alexandria, Egypt).

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WATER MASSES INFLUENCING THE HYDROGRAPHIC PROPERTIES OF SAROS BAY

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Abstract

The water properties of the Saros bay are investigated considering the influences of several water masses: The warm and highly saline Levantine waters (LSW and LIW), the cold and fresh Black Sea Water (BSW), and the intermittently formed cold and dense upwelling water off the northern coast of Gelibolu Peninsula. The analysis was made using cruise data collected between 1991 to 2004. The Levantine waters were observed especially in spring periods, and penetrate into the Saros bay, influencing the water column from 40 m to 350 m. All water masses, including North Aegean Deep Water (NAeDW) were compared with each other in time and space. *Keywords : Aegean Sea, Upwelling.*

Saros bay is situated at the northern coast of the Gelibolu Peninsula in the North Aegean Sea. The bay is roughly "V" shaped; its length is about 61 km, and the width that connects it to Lemnos basin (Aegean Sea) is about 36 km long, reaching a depth of 700 m. Saros bay is under the influence of northerly winds most of the year. Northeast wind affects the northern coastal area of Gelibolu Peninsula, and cold and dense water can be observed as a result of upwelling processes taking place in the area.

In order to examine the physical features of Saros bay, CTD data sets obtained from expeditions between 1991 to 2004, and hourly wind data from Gökçeada Meteorological Centre between 1991-2001, were studied. A numerical model (Killworth's Ocean Model) was used to calculate the general circulation patterns of Saros bay.

Four types of water masses can be determined in the bay: 1) LWs (Levantine waters, LSW, Levantine Surface Water and LIW, Levantine Intermediate Water), 2) BSW (Black Sea Water), 3) NAeDW (North Aegean Deep Water), and 4) SBSW (Saros Bay Surface Water). Although the bay is widely open to the North Aegean Sea, the water exchange between Saros bay and the open basin is limited. The renewal time, which was calculated using Killworth numerical model, is approximately more than 10 years because of the currents weakness.

Physical properties of the SBSW are mainly affected by the pronouncedly blowing northerly Etesian winds that cause upwelling over Saros bay. Upwelling frequently occurs along the northern coast of Gelibolu Peninsula and brings cold and dense water to the surface. Therefore, a distinguishable surface water (SBSW) is formed with characteristics different (colder and saltier) from the North Aegean Surface Water (NAeSW). Surface water temperature in the upwelling area is 1 or 2 °C lower than the temperature of surrounding waters.

BSW is characterized by its very low salinity compared to Aegean Sea waters. BSW was detected by its low salinity (36.12) and temperature (13.25 $^{\circ}$ C) values in the Saros bay surface layer in winter 2002.

The relatively warmer and more saline waters of Levantine origin propagate northwards along the Eastern Aegean, encounter the less saline and colder BSW over the Lemnos plateau, and form a strong permanent thermohaline front [1, 2]. The Levantine water masses can be determined in the intermediate layer by their relatively higher salt and heat content in the North Aegean Sea [3]. Vertical temperature profiles measured during the spring cruises of R/V Piri Reis in Saros bay show that the intermediate layer is filled by warm LWs that occasionally enter the bay. In addition, the effect of LWs can be determined from winter and spring T-S diagrams with their specific water characteristics down to a depth of 350 m. In the profiles obtained in spring 2001, LWs are observed between 50 m and 200 m with salinity of 38.7 and temperature of 14.9 °C (Figure 1).

The deep layers of the North Aegean Sea are occupied by very dense waters with density values greater than 29.40 [4]. According to their characteristics, these waters should have their origininside the Northern Aegean.We concluded that the physical properties of Saros deep water are not affected by seasonal changes, and their values are nearly constant having similar characteristics to NAeDW. Typical water properties of the deep water under the depth of 500 m are as follows: 13.4 °C, 38.9 psu and 29.4 kg/m³.



Fig. 1. Spring 2001 T-S diagram

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137 CS AS A TOOL FOR WATER MASSES DYNAMICS IN THE WESTERN MEDITERRANEAN SEA

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Abstract

¹³⁷Cs measurements were conducted in the western Mediterranean Sea in order to examine the relationship between its distribution and water masses circulation. From the results this correlation is clearly evidenced. The minimum concentration in the Algero-Provençal basin seems to identify the horizontal and vertical extent of the Tyrrhenian Deep Water (TDW). *Keywords : Radionuclides, Western Mediterranean, Hydrology.*

It is well known that ¹³⁷Cs is a useful long term radiotracer for water mass transport in the Mediterranean Sea [1]. Its major sources are fallout from nuclear weapon testing in the early 1960s and the Chernobyl accident in 1986 that produced a marked input in the Eastern Mediterranean, re-distributed in the water column and transferred to the Western Mediterranean in the intermediate waters flowing through the Sicily Straits [2]. This work presents the ¹³⁷Cs distribution in the water column in the western Mediterranean basin and discusses its relationships with convection processes and thermohaline circulation.



Fig. 1. Sampling stations in the western Mediterranean sea, May 2005.

Sea water samples were collected in seven station (Fig 1) during a sampling campaign in the western Mediterranean sea in May 2005. ¹³⁷Cs was pre-concentrated on board by AMP method and measured in laboratory by gamma spectrometry with high purity germanium detectors.

Figure 2 shows the vertical profiles of 137 Cs in the study area. A relative maximum is present in the salinity maximum of the LIW with concentration ranging from 3.3 mBq/l in the Sicily Straits (St.C02) to 1.7 mBq/l in the Gulf of Lions (St. LX). This decrease is due to the LIW mixing with adjacent water masses during its spread along the basin.

The ¹³⁷Cs profiles reach a minimum (1-1.5 mBq/l) at depths around 1000-2000 m. The concentrations in the minimum, furthermore, are lowest close to the Sardinian coast (St. 241) and increase farther to west. According to Rhein [3] the variation and range of water mass properties in this layer can be explained as a mixture between deep water from the Tyrrhenian (TDW) and the Western Mediterranean Deep Water (WMDW).

The deep water below 2000 m in the Algero-Provençal basin (St S12) and in the Algerian basin (St. D7) shows an increase in Cs Activity (2.1-2.4 mBq/l). This is a clear signal of the new WMDW formed by deep convection in the Gulf of Lions during the winter 2004-2005 [4] that rapidly spread to the central part of the western Mediterranean.

The 137 Cs distribution in the water column has a clear relationship with the water masses in all basins. In particular the minimum values at mid depth seem to be a tool to identify the horizontal and vertical extend of the

TDW in the Algero-Provençal basin.

The sigma - tetha charactheristic of the TDW, infact, do not allow one to detect its presence in the Algero-Provençal basin, because its features could also be a local mixing product [5].



Fig. 2. ¹³⁷Cs vertical profiles in the seven stations

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REGIONAL MODEL PREDICTIONS OF 21ST CENTURY MEDITERRANEAN SEA LEVEL

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Abstract

Sea level projections for the Mediterranean Sea derived from the temperature and salinity fields of a high resolution regional model are presented. The projections are based on the differences between the periods 1961-1990 and 2070-2099 as simulated by the model on the basis of the SRES (Special Report on Emission Scenarios) A2 scenarios. *Keywords : Sea Level, Models.*

Climate models suggest that sea level rise is expected to increase during the 21st century mainly due to continuing thermal expansion of the oceanic water mass but with an additional contribution by melting ice sheets [1]. Spatially the various global models are inconsistent, indicating differences in the atmospheric and/or oceanographic models used. Thus, downscaling and the development of regional models have become a necessary tool for policy making and planning for climate change impacts.

The Mediterranean Sea is a semi-enclosed deep sea with its own, locally forced thermohaline cell separated from the Atlantic Ocean with a very dynamic hydraulically controlled regime. As a result past sea level changes in the Mediterranean did not always match those at the Atlantic Ocean. Sea level trends for the three longest tide-gauge stations in the Mediterranean are presently in the range 1.1-1.3 mm/yr, thus lower than the estimated global value for sea level rise [2].

An Atmosphere-Ocean Regional Climate Model coupled over the Mediterranean basin and forced by river runoff and influxes from the Atlantic Ocean and the Black Sea is used to obtain estimates of sea level rise in the region during the 21^{st} century. Sea level rise in the Mediterranean over the next century is expected to be at most 25 cm, plus any sea level rise due to mass addition from ice sheet. The mean sea level rise value predicted is around 13 cm with lower values in the Eastern Mediterranean and higher values at the western Mediterranean. Warming and salinification of the intermediate waters are expected to occur simultaneously, thus partly compensating each other. These are driven by intermediate water formation in the Adriatic Sea rather than the presently dominant Levantine Intermediate Water. Atmospheric pressure over the basin is also expected to increase by up to 2 mbars, thus also compensating some of the thermal expansion. There is no seasonal bias in the sea level rise indicating that the seasonal cycles will remain unaffected.



Fig. 1. Steric sea level rise estimated as the difference of the mean sea levels between 2070-2099 against the reference period 1961-1990

The most important missing contributor from the model is expected to be the water mass addition from melted ice. This is expected to dominate sea level rise in the second part of the century [1]. About 30% of the total sea level rise will be caused by this factor. In the worst case scenario that is about 27 cm of sea level rise. This needs to be added to the model predictions together with the atmospheric pressure effects. Clearly near the coasts this will correspond to most of the expected sea level rise.



Fig. 2. Differences of temperature and salinity profiles between the two periods

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TWO-DIMENSIONAL STRUCTURE OF THE TIDAL FLOW AT THE STRAIT OF GIBRALTAR

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Abstract

We present the analysis of current data obtained during an intensive vessel-mounted ADCP survey carried out on November 2003. The analysis include the assimilation of the data into a 2D tidal model, the interpretation of mean currents, semidiurnal and fortnightly variability, along with the estimation of the exchaged water transports and the interpretation of the hydraulic state of the exchage by mean of the Froude number of the flow.

Keywords : Strait Of Gibraltar, Currents, Tides, Water Transport.

The Strait of Gibraltar is the only connection between the Mediterranean Sea and the Atlantic Ocean .It is roughly a channel 50-70 km long with a minimum width of around 13 km (Tarifa Narrows) to the west of the minimum depth of 280 m at the main sill of the Strait (Camarinal Sill). An intensive vessel-mounted ADCP survey was carried out on November 2003 at Tarifa Narrows and Camarinal Sill (figure 1.a), to investigate the cross-strait structure of the flow. The survey was made during two one-day periods, at different stages of the spring-neap tidal cycle (figure 1.b).



Fig. 1. (a) Bathymetry of the Strait of Gibraltar with the location of the sections occupied with the vmADCP shown as black lines. (b) Sea level at the nearby harbour of Ceuta (upper panel) with the time location of the across strait intensive surveys.

A 2-D tidal model has been used to assimilate the measurements to a synoptic dataset. This dataset allows for a description of the two-dimensional structure of mean and semidiurnal tidal currents of both the Atlantic inflow and Mediterranean outflow. As anexample, figure 2 shows the mayor axis output from the 2D tidal model. The observations are in good agreement with the known characteristics of tidal and fortnightly variability of the flow. It has been recently shown [1] that the fortnightly variability is the consequence of two contributions, the tidal rectification and the subinertial current fluctuations. These authors have found that the fortnightly variability of these two contributions is much larger at the Carmarinal than at the East part of the Strait (Algeciras-Ceuta section, which is not far from the Tarifa section). We have found that both contributions are significant in the upper layer in Camarinal section. The subinertial currents in Camarinal are stronger on the neap tidal period than on the spring one. On the other hand, a smaller fortnightly variability is found in the subinertial currents in Tarifa section. Some interesting patterns can be observed at the northern shore of Camarinal Section. The zonal mean velocity in the uppermost 75 m shows three cores, named as shelf, shelf-break and outer cores. The shelf-break and outer cores have negative meridional velocities, that is, they show a negative inclination of the mean currents. On the contrary, the shelf core has small meridional velocities, what implies a nearly zonal flow there. This type of topographic constriction of the mean currents have not been previously reported. The exchanged transports have been estimated using the model velocities. The upper and lower layer transports, and the net transport are defined as in [2]. However, a problem arises in the estimation of the interface depth, as simultaneous hydrological (salinity) data are not available. The instantaneous alongstrait zero velocity surface is not adequate since one or both layer flow reverse with tidal periodicity, and a zero velocity interface does not always exist. The interface was estimated by using the zero velocity interface and defining its upper and lower bounds with the help of historical salinity data. Finally, Froude number estimations give subcritical conditions at Tarifa Narrows, pointing to the fact that during the survey the exchange was submaximal.



Fig. 2. Example of the output of the 2-D tidal model for the M_2 tidal currents: semimajor axis at the five sections, in m/s.

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TEMPERATURE, HEAT CONTENT AND SEA LEVEL CHANGES IN THE WESTERN MEDITERRANEAN: LONG-TERM TRENDS AND NATURAL OSCILLATIONS

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Abstract

We analyze temperature, salinity and sea level time series in Málaga Bay, extending from October 1992 to October 2005, and series of temperature and sea level at L'Estartit, extending from 1974 to 2005. In both areas a warming trend is detected, but it is also observed a reversal during the initial years of the twenty first century. This reversal is just a fraction of the total accumulated temperature and heat content change in the case of L'Estartit time series not being able to obscure the general trend. Nevertheless it is different in the shorter Málaga time series. These results prevent from extracting conclusions from short time series as natural oscillations superimposed on long term changes can alter the results

Keywords : Global Change, Western Mediterranean.

Previous Works reported an intensification of warming trends in the Mediterranean Sea for the second half of the XX century, and an even more intense increase of these trends during the last decade of the XX century. Vargas-Yáñez et al [1, 2] reported an increase of an order of magnitude (0.02° C/yr) for warming rates in continental shelf waters of the Málaga Bay (Alboran Sea) and this was coincident with a similar acceleration detected in the North western Mediterranean shelf waters [3], in Tyrrheniann deep waters [4] or in the main thermocline of the nearby subtropical North Atlantic [5]. These data suggested that the rate at which the sea was absorbing heat was continuously accelerating.

The analysis of updated time series extending to the end of 2005 has shown that these trends have been interrupted for the last part of the 90s decade and initial part of the XXI century, being also coincident with a recently interruption of warming at intermediate and deep waters in the Catalano-Balearic Sea due to severe winters during the first years of the twenty first century [6].

Temperature and heat content trends in Málaga bay have decreased considerably when considering the 1992-2005 period $(0.007^{\circ}C/yr, 0.28 Wm^{-2})$, if compared with those trends reported for the 1992-2001 period $(0.02^{\circ}C/yr, 1.2 Wm^{-2})$. It is important to note that temperature trends during 1992-2005 are only marginally significant and the heat content trend is not significant. In the case of L'Estartit, there is a 0.24 Wm⁻² trend, being it significant, for the 1974-2005 period. Nevertheless we would get a heat loss of -0.4 Wm⁻² if only the 1997-2005 was considered.

These changes have a clear influence on the thermosteric sea level. Although this is the result of the thermal expansion of the whole water column and it can not be calculated using only the upper 200 m (in Málaga Bay case) or 80 m (L'Estartit case) it is interesting to note that the heat content decrease in the initial part of the XXI century is coincident with an interruption of the sea level rise trend in both Málaga Bay and L'Estartit. Nevertrheless, this reversal is just a fraction of the accumulated change and there is a 3 mm/yr trend when the 1974-2005 period is analyzed in the L'Estartit station. In the case of the Málaga tide gauge, where a longer time series is available (from 1943), we get a 0.9 mm/yr long term trend. This could suggest that as longer time series are analyzed, pentadal and decadal oscillations, as those evidenced in this work, are removed in the trend estimation, and real long term changes arise. On the other hand, it has to be taken into account that changes in the Mediterranean seem to be stronger than in the Atlantic, probably due to a higher thermal inertia of the latter. This is confirmed by a West-Est and up to bottom (Atlantic to Mediterranean) gradient observed in the trends estimated in the Málaga Bay grid of stations.

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SUMMER BREAKOUT OF TRAPPED BOTTOM DENSE WATER FROM THE NORTHERN ADRIATIC

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Abstract

An unusual drop of the bottom temperature coupled with southeasterly currents has been observed in August 2004 in the open northern Adriatic. It is hypothesised to be a result of a leakage of bottom dense water generated in the previous winter and blocked by the cyclonic Adriatic circulation. The breakout has been initiated by a storm appearing violently over the open northern Adriatic and lasting for a couple of hours. The storm has been reproduced using COAMPSTM atmospheric model. The physical generator of the breakout (wind stress, wind stress curl and divergence, fluxes) is being currently investigated through process-oriented ocean modelling studies. *Keywords : Adriatic Sea, Air-sea Interactions, Models.*

The northern Adriatic shelf is a complex dynamical area, characterized by large seasonal changes in surface heat and water fluxes, Po river discharge (annual average of 1500 m³/s) and advection of middle/south Adriatic and Levantine water masses [1]. During cold and dry winters it is a place where dense water is being generated, spreading to the southeast and filling most of the Adriatic bottom layers [2]. Part of it may however be blocked in the generation area and reside there up to the following autumn, when it becomes mixed up with surface water during pycnocline destruction [1, 3]. Nevertheless, it can be also advected towards southeast in specific meteorological or oceanographic conditions. That is the topic of our study.

The breakout of the residing dense waters towards the southeast in summer 2004 has been suspected first from thermistor and current-meter data obtained at the Ivana gas field platform (lat = 44° 44.8' N, lon = 13° 17.7' E, depth = 41 m). A sudden temperature drop of more than 2°C has been observed near the bottom on 9/10 August 2004 (Fig. 1). At the same time, bottom currents were directed to SE with a speed of 10 cm/s. The temperature and salinity data collected in July and August 2004 on the Po-Rovinj profile (30 km north of the platform) clearly depicts the presence of a 5-10 m thick pool of cold water (13-14°C) near the bottom, being obviously a source for the observed breakout. However, the generative force remained unknown after inspection of coastal meteorological time series and estimated surface heat and water fluxes, which showed no significant changes at that time.



Fig. 1. Low-pass filtered temperatures measured by thermistor chain near the Ivana gas field platform.

The breakout lasted for about 3 days, being relaxed after the weakening of the bottom currents. A phase lag of about one day occurred between the appearance of southeast currents and the temperature drop. Thus,

assuming southeasterly current speed of 10 cm/s and bottom thermohaline front being perpendicular to the currents (or parallel to the Po-Rovinj profile as documented in [4]), the distance between the bottom front and the platform may be estimated to about 9 km.

Fortunately, satellite images in the visible frequency band gave us a clue, as a storm was observed in the morning hours of 8 August 2004. The storm occurred almost entirely over the open northern Adriatic, therefore discarding the usefulness of the coastal surface fluxes in our analyses. Atmospheric conditions have been reproduced by COAMPS^{TM} mesoscale atmospheric model [5], being set up at 3-km resolution in horizontal, and forced by ECMWF (European Centre for Medium-range Weather Forecasts) fields at the open boundaries. The model has been initiated a day before, on 7 August 2004 at 00 UTC. Surface wind convergence occurred over the open northern Adriatic in early hours of 8 August, resulting in the generation of a storm at approx. 05 UTC with the centre very near the platform. A few hours later modelled surface winds reached 12 m/s at the storm front, diverging from the centre, which was still located over the platform. Therefore, one may suspect that the surface divergence and wind stress curl is responsible for the breakout. However, the effects of wind stress itself and also fluxes should be investigated by an oceanographic model. These studies are currently being carried out through targeted numerical experiments using the Princeton Ocean Model [6] forced by the $COAMPS^{TM}$ surface fields.

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IMPLEMENTATION OF THE PIECEWISE PARABOLIC METHOD (PPM) FOR ADVECTION OF A PASSIVE SUBSTANCE IN POM

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Abstract

A Piecewise Parabolic Method (PPM) advection type scheme for a variable grid size has been implemented in the Princeton Ocean Model (POM). Preliminary tests for a tracer dispersion in the Adriatic Sea are presented. *Keywords : Adriatic Sea, Air-sea Interactions, Models.*

An advection scheme for the Princeton Ocean Model (POM) was constructed based on the papers by van Leer [1] and Colella and Woodward [2]. Such numerical scheme is conservative and keeps sharp gradients, two requirements that is quite difficult to meet with the existing POM advection schemes. Since POM's grid spacing in vertical is nonuniform we had to use a slightly more complicated variant of PPM designed for the case.

In the first figure we present simple examples of the scheme behavior in advecting a Gaussian shaped concentration with constant speed, and a variable velocity case (sinusoidal shape) advecting an initially constant concentration.



Fig. 1. The initial distribution of a passive substance with Gaussian shape, and its position after about 10 days of integration (A), velocity variation in space (B), concentration distribution after 4 days of integration (C).

The first experiment concludes that sharp gradients, if exist, will be preserved during the integration. The second experiment shows that very sharp gradients will be created if such situation arises. Once we were convinced that the scheme works as expected, we have implemented it in a fully coupled atmosphere-ocean model EBU-POM [3] (NCEPS' Eta is the atmospheric component, [4-7] while POM [8-9] is the ocean component). The model was integrated for 17 days, staring from the 11th of February, 2003. That particular situation was characterized by strong bora, a cold wind that blows down the Dianaridis mountains from land to sea.



Fig. 2. Initial position of the patch and it's final position after 12 days of simulation. The dotted line is a 12 days trajectory of a point originating on the edge of the initial patch.

The second figure shows a snapshot of the tracer field from the 12th day of integration. A black line near the Croatian coast designates the initial position of the patch. Denoted by a dotted line, we show the trajectory of a point positioned at the edge of the initial concentration. This serves as a verification of the advection scheme.

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CLIMATE CHANGE IMPACTS ON ECOSYSTEMS: THE RHODES GYRE CASE

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Abstract

The 15 years (1986-2001) hydrographic (temperature, salinity, density), hydrochemical (nutrients, dissolved oxygen) and biological (chlorophyll-a as phytoplankton biomass, primary production) data collected during Turkish and Greek cruises in the Rhodes cyclonic gyre region, northern Levantine are presented. These two data sets were combined and interpreted together and the aim was to understand the interactions between meso-scale physical dynamics and ecosystem processes, and impacts of observed climate changes. *Keywords : Eastern Mediterranean, Upwelling, Primary Production.*

The findings obtained during the last two decades have shown that, although the Mediterranean is oligotrophic, locally and temporarily very high planktonic biomasses can be found at some locations. In the cyclonic regions in the Northern Levantine basin, e.g. the Rhodes gyre, where the nutricline ascends to the base of the euphotic zone, phytoplankton biomass and primary production are higher than those in the anticyclonic regions, where the nutricline is situated at greater depths, thereby limiting the nutrient input to the surface waters during winter mixing [1, 2, 3]. Other reasons for the relatively high productivity in such regions are intensive convective mixing during severe winters leading to vertical homogenisation, and upwelling of waters from intermediate and deep layers to the euphotic zone. Re-evaluation and processing of the long-term (1986-2001) Turkish and Greek nutrient and phytoplankton biomass (as chlorophyll-a) and primary production data in the Rhodes Gyre and its peripherals confirmed these findings.

The major nutrient source for the biologically active euphotic zone of the open sea is the input from the nutricline. New production in the open waters of the eastern Mediterranean is therefore dominated by the input from the nutricline through vertical mixing, contribution from riverine input via surface circulations and atmospheric transport being of secondary importance [3]. The permanent nutricline is located between specific density surfaces (29.00-29.05 and 29.15) throughout the eastern Mediterranean basin even though it appears at different depths (at shallower depths in the cyclonic gyres and far below the euphotic zone in the anticyclonic regions) with region and season. The eastern Mediterranean waters are very clear and ultra-oligotrophic with PO₄<0.02 μ M and NO₃<0.3 μ M in the upper mixed layer in summer and chlorophyll-a is below 0.5 μ g L⁻¹ [1, 3]. In this sea, primary production is as low as 45 mgC m⁻²d⁻¹, and bacterial production corresponds to about half of algal production.

The homogeneous water column formation in the Rhodes cyclonic gyre due to strong overturning during 1992, 1993 and 1995 winters resulted in uniform profiles of nutrients down to at least 1000 m. The surface nutrient concentrations reached those of deep water concentrations, e.g. $0.16\pm0.02 \ \mu\text{M}, 4.7\pm0.4 \ \mu\text{M}, 7.8\pm0.4 \ \mu\text{M}$ for phosphate, nitrate and reactive silicate respectively (Figures 1 and 2). The relevant changes in the molar ratios of nitrate to phosphate, silicate to nitrate and silicate to phosphate in the surface layer between the pre-, post and chimney formation periods reveals that the area is phosphorus limited. NO₃/PO₄ molar ratio was as low as 5-10 at the surface layer for pre- and post-chimney formation periods while it was relatively higher (26-29) at the surface layer and constant in the whole water column down to 1000 m at chimney formation period. The efficient nutrient pumping from aphotic to euphotic zone in the Rhodes Gyre center and its peripherals caused unusually high biomass accumulation and an increase in primary production rates. The highest chlorophyll-a concentration was measured as 3 mg/m³ and the primary production rate was as high as 1.1 g C/m²/d, which were very similar to those observed in the productive Black Sea waters. Such events observed in the Rhodes cyclonic gyre represents good and unique examples of climate change impacts on the dynamical processes and consequent changes in the marine ecosystems.



Fig. 1. Long-term variation of Air Temperature and Sea Surface Temperature (SST, $^{\circ}$ C) in the Northern Levantine. ERA-15 re-analysis monthly averages satellite data set produced by the European Center for Medium-Range Weather Forecasts (ECMWF) are presented.



Fig. 2. Surface (the top 20m) nutrient concentrations in the center of Rhodes Gyre. Turkish data are presented by filled symbols and Greek data are presented by open symbols.

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CIRCULATION OF THE MARMARA SEA

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Abstract

The circulation of the Marmara Sea is studied using data-driven primitive equation simulations. The data are drawn from basin wide cruises carried out during 1991-1995 by R/V Bilim of the Institute of Marine Sciences of Middle East Technical University. *Keywords : Aegean Sea, Black Sea, Circulation, Hydrology, Marmara Sea.*

The general water movement characteristics are given by Killworth's Ocean General Circulation Model (OGCM) based on the primitive equations as described by [1] and [2]. The main modification is to explicitly include a free surface. The horizontal resolution is about 1 km with 89 and 261 grid points in the latitudinal and longitudinal directions, respectively. The vertical is discretized with 13 levels. The grid spacing in the upper layers is finer than in the layers below.

The BSW (Black Sea Water) enters to the Marmara Sea from north through the Bosporus as a surface water, due to the sea level difference between the Black Sea and the Marmara Sea. The ASW (Aegean Sea Water) enters to the Marmara Sea from west through the Dardanelles strait as an intermediate water, due to the density difference between the Aegean Sea and the Marmara Sea [3] (Figure 1 and Figure 2).



Fig. 1. Dardanelles - Bosporus potential temperature cross section for February 1993

During high discharge from the Bosphorus (e.g. March 1992), the currents at the surface were predominantly directed southward and concentrated on the left of the downstream flow. At the exit section of the Strait into the Sea of Marmara, current velocities reached 300 cm/s, due to the small extent of the upper layer. Away from the Bosphorus-Marmara junction region, the velocities were of the order of 20 cm/sec. These measurements also reveal the presence of the anti-cyclonic circulation of the Bosphorus outflow in the Marmara Basin.



Fig. 2. Barotropic circulation pattern for February 1993

During the low discharge periods (e.g. October 1991), the upper layer flow exiting from the Bosphorus is not as well defined and contrary to the

direct southward flow. A right-hand attachment of the outflow, i.e., to follow the Thracian coast was observed. Outflow velocities were measured to be about 30 cm/s even in the exit region of the Bosphorus. The mean flow was the basin scale anti-cyclonic circulation. The model sensitivity studies show that the upper layer circulation patterns are set up by the sea-level differences between the Black Sea and the Aegean and modified by the winds.

Mediterranean water coming through the Dardanelles sinks to the deeper layers of the Marmara Sea and moves to the east. The sinking depth of the Mediterranean water is controlled by buoyancy.

Modelled circulation patterns of the Marmara Sea are found to be consistent with ADCP measured currents.

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THE SUCCESSFUL APPLICATION OF THE MEDITERRANEAN OIL SPILL MODEL IN ASSISTING EU DECISION MAKERS DURING THE OIL POLLUTION CRISIS OF LEBANON IN SUMMER 2006

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Abstract

The Mediterranean oil spill model (MEDSLIK) was applied during the Lebanese oil pollution crisis in July and August 2006 in order to assist the decision makers in Europe and the Eastern Mediterranean. MEDSLIK is coupled operationally to the high resolution flow model of the Cyprus Coastal Ocean Forecasting and Observing System (CYCOFOS), using the SKIRON winds. The MEDSLIK simulations showed that the oil moved northward from the Jieh power station along the Lebanese and Syrian coast. The displacement of the dispersed oil and the affected coastal areas were validated by local observations and satellite remote sensing images. *Keywords : Petroleum, Pollution, Models, Remote Sensing, Levantine Basin.*

The risk of oil spill pollution in the Mediterranean Sea is high due to the heavy traffic of merchant vessels for oil transportation and to the many coastal installations related to the oil industry. Oil spills are a matter of concern due to the damaging effect they can have on various coastal resources. To mitigate such damage as much as possible, it is common to combat a spill by deploying equipment such as booms and skimmers or to spray chemical dispersants. In order to make optimal use of such devices it is common to employ a computer model to predict where the spill will most likely move to, in particular what resources are threatened, and how soon it will get there. Such models often predict the expected state of the oil when it arrives, that is, how much will have evaporated, the degree of emulsification of the remainder, how much will remain on the surface and how much will be dispersed as fine droplets throughout the water column. In the case of the Lebanese oil pollution crisis in mid July-August 2006, there was no possibility for the responsible agencies to act as long the war actions continued. The Jieh power station spill is considered as the biggest so far in the Eastern Mediterranean. There was an urgent request to the Cyprus Oceanography Centre to provide predictions regarding the displacement of the oil that was spilled into the sea from the oil tank installations of the Jieh power plant, from several European and regional agencies (REMPEC-Regional Emergency Centre for Response to Oil Spill Pollution in the Mediterranean, the Cyprus Ministry of Environment and the European Commission Civil Protection co-operation Mechanism through the Cyprus Civil Protection Agency). MEDSLIK [1] was designed to predict the transport, fate and weathering of an oil spill, and has been applied operationally using the high resolution forecasting products of the Cyprus Coastal Ocean Forecasting and Observing System (CYCOFOS). CYCOFOS [1] is nested within the Mediterranean Forecasting System (MFS), using the high frequency SKIRON winds. MEDSLIK constitutes one of the oil spill models of the Marine Environment and Security in the European Areas (MERSEA) project [2], that aims at establishing the Marine Core Services of the Global Monitoring for Environment and Security (GMES) of the European Union.

Results and discussion

According to the input information provided by REMPEC, the MEDSLIK oil spill model was applied using the operational CYCOFOS forecasting products, in order to predict the dispersion and the movement of the oil spill in the NE Levantine. After the bombing of few of its oil tanks, which are located right on the coast, early on the morning of the 13^{th} and 15^{th} July 2006, 10,000-20,000 tons of a very heavy oil (with API around 20) were spilled in the sea. The CYCOFOS forecasts showed a strong (20-30 cm/s) northward current along the Lebanese and Syrian coast. This flow pattern remained throughout the examined period, from mid-July to the end of August, 2006. The same period the SKIRON forecasts showed winds 2-7 m/s varying between Southwesterly - Southerly in the area of interest. Consequently the MEDSLIK simulations showed that the spilled oil was pushed northward by the currents and the winds (Fig.1). Significant amounts of oil were deposited on the coast adjacent to the Jieh power plant and on the coast northward between there and Beirut, especially on the headland of South Beirut. Much of this coastal oil was subsequently washed off the coast and moved northwards by the northward currents and winds. Within 3 days of the start of the incident, evaporation was complete and a little less than 20% of the original oil had evaporated. The model predicted that after 15 days almost 80% of the original oil was on the coast, while about 0.035% of the oil remained into the sea. Coastal impact remained heaviest south of Beirut. There was a ignificant impact between Beirut and Chekka and northwards to the Syrian border, and on the Syrian coast from the border to Tartus with lighter impact up almost to Latakia. The results of the oil spill simulations, regarding the affected coastal areas, were validated from observations of the Lebanese Ministry of Environment and satellite remote sensing images. The results of the MEDSLIK simulations assisted the European and Mediterranean agencies to obtain a first overview of the area covered by the spilled oil during the period of the war in Lebanon.



Fig. 1. MEDSLIK predicted slick positions after 5 days from the Lebanese oil spill incident.

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- 1 http://www.oceanography.ucy.ac.cy/cycofos
- 2 http://www.mersea.eu.org

THE ATLANTIC WATER IN THE LEVANTINE BASIN (1995-2006)

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Abstract

New in-situ data sets obtained from different observing platforms between 1995-2006, within the framework of the CYBO, CYCLOPS, HaiSec projects and the CYCOFOS observing system, provide the most recent evidence about the spatial and temporal displacement of the Atlantic Water (AW) and of the Mid-Mediterranean Jet (MMJ) in the Levantine Basin. These data confirm that the MMJ is an offshore cross-basin flow transferring the AW, as it was first depicted in 80s within the framework of the Physical Oceanography of the Eastern Mediterranean (POEM) experiment.

Keywords : Water Transport, Circulation, Levantine Basin.

Preface

The most variable water mass of the Eastern Mediterranean Levantine Basin is the surface and subsurface Atlantic Water (AW). The inflow of the AW in the Mediterranean is the result of the water volume compensation for the high rates of sea water evaporation in the Levantine Basin and the outflow of Levantine Intermediate Water (LIW) into the North Atlantic [1]. The AW, after its entry into the Mediterranean through the Gibraltar, spreads as far east as the Levantine Basin. The general circulation in the Eastern Mediterranean as inferred in the 1960s and 70s [1] shows an anticlockwise flow with sub-basin features in the Levantine basin. In the 80s, during the Physical Oceanography of the Eastern Mediterranean (POEM) mesoscale field experiments [2,3], it was documented that AW is transferred within the Levantine by the MMJ. This offshore cross-basin jet is generated as a result of the interaction between the cyclonic (Rhodos gyre) and the anticyclonic (Mersa Matruch and Shikmona gyres) flow features during the eastward spreading of the surface and subsurface waters of Atlantic origin, after passing the Cretan passage.

Discussion and results

The seasonal and inter-annual variability of the AW distribution in the Levantine Basin, particularly in its south-eastern part, is examined based on new in-situ data collected during the Cyprus Basin Oceanography (CYBO), Cycling of Phosphorous in the Mediterranean (CYCLOPS) and HaiSec (Long-term Haifa Section) projects, carried-out between 1995-2006 [4]. Moreover, high frequency in-situ data were collected in the near surface layer from the Cyprus Coastal Ocean Forecasting and Observing System (CYCOFOS) ocean observatory, from 2004 to 2006. These data sets highlight the spatial and temporal variability of the AW in the region, while in addition provide strong evidence about the existence of the Mid-Mediterranean Jet (Fig.1). During the summer periods studied (1995-2006) the minimum salinity layer, attributed to AW, is well defined at a depth of about 40-50 m (below the seasonal thermocline) and with a value as low as 38.65-38.75 (Fig.1). During winter (as in January 1999) it can be found with similar or higher salinities. However, during severe winter weather conditions the presence of AW is difficult to trace, and is most likely modified due to strong winter mixing processes. The AW, transferred by the MMJ along the northern periphery of the Cyprus warm core eddy, is most well defined southwest and south of Cyprus. However, AW has also been observed close to the Egyptian coast, as a result of a westward re-circulation (Fig.1). In-situ data from the CYCOFOS ocean observatory, located in the open deep sea southwest of Cyprus, provide unique evidence for the high frequency (half-hourly) variability of AW in this particular area. The MMJ is considered to be the main flow pathway for transferring AW eastward within the Levantine Basin. From June through October 2004, the 38 m sensors indicate the presence of AW. The salinity at this depth was nearly always below 38.8, whereas the salinity in the upper layer (17m) was greater than 39. In winter 2004-2005, the mixed layer deepened beyond the deepest (38 m) sensor. Salinities in the mixed layer were greater than 39. From May to June 2005 the salinity at 38 m showed again the intrusion of the AW with values fluctuating between 38.8-38.98. The sensors at the depth of 17 m showed the salinity to increase gradually during the same period, reaching values greater than 39.

The analyses of these new in-situ data sets collected from different observing platforms, with different sampling time and spatial scales, provide strong new evidence that the MMJ transfers the main volume of the AW in the SE Levantine basin. These new data confirm that the MMJ, after crossing the basin from the offshore southwestern part of the Levantine, meanders eastward between offshore Cyprus and the northern periphery of the Cyprus warm core eddy or the Shikmona gyre (when present). Moreover, at a certain times the in-situ data closer to Egypt provided evidence of a westward re-circulation off the coast of Egypt.



Fig. 1. Salinity section (a), salinity profiles (b) and geostrophic velocities (c) along the N-S Cyprus- Egypt section (d) in early September 2005, show the AW and the MMJ in the study area. The dynamic height topography (e) and SST image (f) show the prevailing flow patterns during the same study period.

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Comité 3

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# **Biogéochimie marine**

Président : Nicholas Fisher

# SUIVI TEMPOREL DU PHÉNOMÈNE D'IMPOSEX CHEZ *HEXAPLEX TRUNCULUS* CONTAMINÉ PAR LE TRIBUTYLETAIN (TBT)

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## Résumé

Des spécimens femelles d'*Hexaplex trunculus* ont été collectés dans un milieu à faible trafic maritime. Ils sont répartis en un lot témoin et deux lots traités avec le TBT (5 et 50 ng/l) pendant cinq mois. L'examen du phénomène d'imposex montre une différence significative entre les trois lots. Le taux d'imposex, la longueur du canal déférent et du pénis varient en fonction de la concentration en TBT. *Mots clès : Bio-indicators, Ecotoxicology, Fouling, Gastropods.* 

Certains gastéropodes femelles développent, en présence de TBT, des caractères sexuels masculins (un canal déférent et/ou un pénis). Les premières observations du phénomène d'imposex chez *H. trunculus* ont été fournies par [1] et plus tard par [2]. En Tunisie ce phénomène a été étudié *in situ* par [3-4]. *In vivo*, les travaux de contamination par le TBT sont rares. Le but de la présente étude est de suivre, dans le temps, l'évolution du tractus génital mâle chez les femelles contaminées au laboratoire. Des spécimens adultes d' *H. trunculus* ont été collectés à pied, au mois de février 2006, dans une station à faible trafic maritime (lac nord de Tunis-Fig.1).



Fig. 1. Station de plélèvement dans le Lac Nord de Tunis.

Le taux d'imposex enregistré est de 12,12%. Les femelles anormales montrent une ébauche du canal déférent près de l'ouverture vaginale. Au laboratoire, 274 femelles ont été triées. Le lot témoin 1, constitué de 74 spécimens, est placé dans un aquarium contenant de l'eau de la station de collecte. Deux autres lots, de 100 spécimens chacun, sont placés dans deux aquariums contenant de l'eau contaminée par une solution de TBT à raison de 5 et 50ng/l. L'eau, maintenue à une température de 20 °C±1 est renouvelée tous les deux jours et les animaux sont nourris de palourdes provenant de la station d'origine. L'état de développement du phénomène d'imposex a été déterminé mensuellement après examen, sous loupe binoculaire graduée, de la partie molle séparant l'emplacement du pénis et l'orifice de ponte. La comparaison des taux d'imposex et des longueurs moyennes du canal déférent et du pénis, entre les trois lots, a été testée par X<sup>2</sup>et le test de Student (*t*).

Le taux d'imposex enregistré passe de 12,12% à 100% après cinq mois pour le lot 2 et trois mois pour le lot 3. Les variations mensuelles enregistrées, pour le lot témoin, sont insignifiantes (P>0,05). Pour ce qui est de la longueur du canal déférent (VDL), les résultats ont montré que l'écart moyen entre les valeurs initiale et finale est élevé, il est respectivement de 9,28 mm pour le lot 2 et 11,48mm pour le lot 3. Par contre, la longueur moyenne du canal déférent du lot témoin passe de 1,2mm à 1,53mm. Les tests statistiques ont montré une différence significative entre les lots comparés deux à deux. Quant au développement pénial, les femelles témoins ne montrent pas de pénis tout le long de l'expérience. Par contre, 12,5% des femelles contaminées à 5ng/l développent une ébauche puis un bourgeon pénial à partir du troisième mois. Ce taux s'élève à 37,5% au mois de juillet, la longueur moyenne du pénis atteint 0,3mm. A forte concentration, le bourgeon pénial apparaît à partir du deuxième mois. Le taux de spécimens, de 12,5% en avril passe à 37,5% en mai, 75% en juin et 87,5% en juillet. La longueur moyenne du pénis, à la fin de l'expérience est de 0,58 mm. Les tests statistiques de Student et de  $X^2$  ont révélé une différence significative entre les valeurs comparées deux à deux.

L'étude écotoxicologique réalisée sur H. trunculus a montré que l'imposex s'installe plus précocement chez les femelles traitées à 50ng de TBT/l que chez celles traitées à 5ng /l. En comparant nos résultats avec ceux enregistrés par [5] qui ont travaillé sur Nucella lapillus, nous constatons que H. trunculus est plus sensible au TBT. Pour une concentration de 50ng/l et une exposition de 3 mois, le taux d'imposex s'élève de 30% chez Nucella lapillus[5] contre 87,8% chez H. trunculus. Chez Ilyanassa obsoleta, le taux d'imposex est passé de 2,5 % à 28 % après 6 mois d'exposition dans une solution de 10 ng/l de TBT [6]. Le degré de développement du tractus génital mâle, chez la femelle, est dépendant également de la concentration en TBT. La longueur moyenne du canal déférent enregistrée chez H.trunculus s'élève avec la concentration en TBT. Des résultats similaires ont été relevés chez Nucella lapillus après une contamination de trois mois par une solution de 50 ng/l de TBT [5]. Pour ce qui est du pénis, Nos résultats sont proches de ceux enregistrés par [5] chez Nucella lapillus. Après trois mois de traitement dans une solution à 50ng/l, la longueur moyenne du pénis passe de 0,02 mm à 0,23 mm.

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# DISSOLVED INORGANIC MATTER AND NUTRIENT ENRICHMENT BIOASSAY IN THE GERENCE BAY, (TURKEY)

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### Abstract

The Gerence Bay is the enclosed bay of .Izmir. Excess nutrient inputs from aquaculture fish farms and domestic wastewater are the main antropogenic pollution source. In this study temperature, salinity,  $NH_4^+$ -N,  $NO_3^-N$ ,  $PO_4^{-3}$ -P, Si, Chl- *a* are measured. To determine the variation of the parameters and to assess the dynamics between the nutrients and the microplankton of the Gerence Bay, nutrient enrichment bioassays were performed. During the summer of 2006 two exceptional blooms and one cladoceran swarming were observed. The first one appears as bloom of *Rhizosolenia* mats. The second growth was the increasing of filamentous algae. The thirth one was the cladocer *Penilia avirostris*. Then the members of ctenophora were seen.

Keywords : Aegean Sea, Phytoplankton, Growth, Pollution, Coastal Processes.

### Introduction

The aquaculture fish productions are generally initiated in the closed basins in Türkiye. Gerence Bay is a well known fish production area of .Izmir. The Gerence Bay is the enclosed bay of .Izmir subjected to a variety of human influences such as tourism, aquaculture, and fisheries, together with agriculture and farming practice in the surrounding area.

In this study temperature, salinity,  $NH_4^+$ -N,  $NO_3$ -N,  $PO_4^{-3}$ -P, Si, Chl*a* are measured of this area. To assess the dynamics between the nutrients and the microplankton of the Gerence Bay, nutrient enrichment bioassays were performed. Nutrients were added as known concentrations to find out growth curves and kinetic parameters. The obtained data were ploted as growth curves and chl-*a* based exponential growth rates were calculated.

#### Materials and Methods

Water for nutrient samples were collected in 100 ml polyethylene. (Nitrate+Nitrite)-Nitrogen (NO<sub>3</sub>+NO<sub>2</sub>)-N, Reactive Phosphorus (RP), reactive silicate (RSi) were measured spectrophotometrically according to Strickland and Parsons, 1972 [1]. During the sampling periods bioassay samples were collected from Gerence Bay station were transported to the laboratory by 20 L PET Carboys covered by wet white cloths to reduce light intensity to keep their temperature. Water samples in pet carboys were filtered from 300 micrometer ( $\mu$ m) plankton net to remove mesozoo-plankton and distributed to the experimental bottles.

In situ conditions were simulated in the laboratory by using constant temperature and light room. (600 ft-Cd light intensity). Experiments were performed October 2005 and April 2006 to find out nutrient limitation and to asses phytoplankton community. Nutrients such as N, RP, RSi were added to the one liter bottles contained seawater sample. This known nutrient concentration enrichments help to find out growth rate. The obtained data were plotted as growth curves and chl-a based exponential growth rates were calculated. Growth rates as a function of nutrient concentrations were fitted to monod equations.

### Result and Discussion

The surface waters of the main station are poor in chl- *a* for most of the year. In October 2005, the depth-averaged values were 8.76  $\mu$ M for (NO<sub>3</sub>-N + NO<sub>2</sub>-N) and 0  $\mu$ M for RP. The values ranged in ( $\mu$ M) for the analyses of this main station sample were as follows: (NO<sub>3</sub>-N + NO<sub>2</sub>-N (10.18 - 14.39), RP (0-1.68), RSi (3.79-5.76)  $\mu$ gat/l. The values ranged in ( $\mu$ M) for the analyses in May 2006 (NO<sub>3</sub>-N + NO<sub>2</sub>-N( 6.41 - 12.27), RP (0), RSi (1.19-9.83). The surface molar ratios ofnitrogen to phosphate (N/P) were calculated as 24.65 in October. Thismolar ratios not calculated because lack of the RP in May 2006.Salinity values ranged 37- and 39.6 psu in October and May respectively.

During the summer of 2006 two exceptional blooms and one cladoceran swarming were observed. The first one appears as bloom of *Rhizosolenia* mats. The second growth was the increasing of filamentous algae. The thirth one was the cladocer *Penilia avirostris*. After all of these observations the members of ctenophora was seen in the bay.

Bioassays experiments can be summarized as followed. Phytoplankton of mostof the experimental bottles reached exponential phase immediately,while some of bottles stayed in lag phase (for RP up to 0.3  $\mu$ M). Variation of Chl-  $a_{max}$  concentrations consistent with RP concentrations. Growth rate and the carrying capacity werecalculated by respectively;  $\mu = \mu_{max}$  extperiodcentered S /(S+K<sub>s</sub>) and Chl-  $a_{max} =$ P[Chl-  $a_{max}$ ] extperiodcentered S /(S+K<sub>s</sub>)

Results of the growh rate and potansiyel chl-  $a_{max}$  for RP were calculated as  $\mu = 0.07 \text{ d}^{-1}$  and Chl-  $a_{max}$  in sinu= 0.05  $\mu$ g/L. Minimum growth rate was calculated by RP. Growth andbiomass accumulation were low, similar to the control, then it waslikely that RP was limiting phytoplankton growth. The results of thelimiting factor shows that the watermass of the bay is similar toMediterranean Sea [2]. Data are presented for water column from surface(0.1 m) to bottom waters (60 m) from 0, 5, 10, 20,40, 60 m monitoring.Chl-  $a_{max}$  values ranged from 37.1 to 0.14  $\mu$ g/L for the period of this study. The chlorophyll *a*concentrations at that time of the experiments were generally in thelow. Total inorganic nitrogen values ranged 6.2 to 21.79  $\mu$ M.

Thisstudy is not complicated yet. We are planning to take more biochemicaldata from pollutant sources as well as sediment samples. Also modellingstudy will be help to find out the effects of loading.

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# <sup>210</sup>PO AND HEAVY METAL (ZN, CU, FE, CD, MN, NI, PB, CR) CONCENTRATIONS IN MUSSELS (*MYTILUS GALLOPROVINCIALIS*) AND SEDIMENTS IN DIDIM

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### Abstract

The trend of marine pollution levels to increase worldwide requires control strategies and routine monitoring of radionuclides and heavy metals in the marine environment. Estimation of marine pollution levels is based on measurements of the abundance and bioaccumulation of metals and radionuclides in water, sediment and selected marine organisms. In this study, concentrations of <sup>210</sup>Po and heavy metal (Zn, Cu, Fe, Cd, Mn, Ni, Pb, Cr) have been measured in mussels (*Mytilus galloprovincialis*) and sediments collected from Didim (Aegean Sea) monthly. Our obtained results were higher than the literature.

Keywords : Aegean Sea, Bio-indicators, Pollution, Radionuclides, Sediments.

In the marine environment <sup>210</sup>Po ( $t_{1/2}$ = 138.4 d) is mainly resulted in the decay of <sup>210</sup>Pb deposited from the atmosphere. These radionuclides are daughter products of <sup>222</sup>Rn, which is released from the earth's crust to the atmosphere. <sup>210</sup>Po can be also introduced by radioactive decay of <sup>226</sup>Ra and <sup>222</sup>Rn that diffuse from the sediment. Part of it is scavenged from the water by particles and removed to the sediment (1, 2).

Most of the particle-reactive radionuclides released into the aqueous phase eventually reach the sediments. The accumulation, retention and transport of particle reactive radionuclides is strongly associated with sediment and sedimenting particles (3).

 $^{210}\mathrm{Po}$  becomes highly concentrated in marine organisms and can contribute significantly to human radioactivity exposure through seafood consumption.

It is well known that, many organisms have the potential to bioaccumulate heavy metals from ambient waters to extremely high levels. In previous studies with mussels, mainly the soft tissue of *Mytilus* spp has been considered as a potential *biomonitor* for monitoring metallic contamination in marine ecosystems (4, 5, 6, 7).



Fig. 1. The map of sampling location.

In our project supported by IAEA, <sup>210</sup>Po concentrations of mussel and sea water samples obtained from Didim station, on the coast of Aegean Sea, were found higher than the other stations. Therefore, our research has been emphasized on Didim station and <sup>210</sup>Po concentrations of marine samples are measured monthly to determine the sources of marine

pollution in this area.

Sampling for mussels (*Mytilus galloprovincialis*) and bottom sediments has continued at Didim in Aegean Sea indicated in Figure 1.

For mussel (*Mytilus galloprovincialis*) samples, in order to minimize the effect that size (age) exerts on the radionuclide concentrations; specimens of standard size in groups were selected.

Sediment samples were taken by bottom-grap. Each sample is oven-dried to constant weight and was sieved before analysis.

Concentrations of <sup>210</sup>Po and heavy metal were determined monthly in sediments and the edible muscle tissue of mussel samples. After applying chemical procedure with some acids, polonium was spontaneously plated onto a copper discs. Measurements of <sup>210</sup>Po were realized through its 5.30 MeV alpha particle emission, using <sup>209</sup>Po (4.88 MeV alpha emission,  $t_{1/2}$ = 109 a) as the internal tracer. <sup>210</sup>Po was measured by alpha spectrometry using a Passivated Implanted Planar Silicon detector (PIPS). Heavy metal concentrations (Zn, Cu, Fe, Cd, Mn, Ni, Pb, Cr) were measured by ICP-OES.

According to obtained results until now, the concentrations of  $^{210}$ Po in mussels (*Mytilus galloprovincialis*) and sediments were come up to 2002  $\pm$  60 Bq kg<sup>-1</sup> and 79  $\pm$  8 Bq kg<sup>-1</sup>.

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# METAL POLLUTION IN THE MUSSEL (MYTILUS GALLOPROVINCIALIS) AT THE BOSPHORUS

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### Abstract

Between the years 2003-2004, mussel samplings were performed seasonally from the six different stations located at the Istanbul Strait. The samples were classified in two classes according to their sizes (bigger and smaller than 5 cm). Their Pb, Cd, Hg, Cu contents had been measured by using the device of Absorption Spectrophotometers (AAS). As a result of the researches that Asian Side of the Istanbul Strait had been subjected household wastes much more than the European Side of the Istanbul Strait and there had been determined to exceed the Water Corps Instructions of the values limits.

Keywords : Trace Elements, Mollusca, Toxins.

### Material and Method

For the mercury measurements they had been applied to nitric acid solubility in the 60 °C water bath, and the solubility of the strong acid (HF+HNO<sub>3</sub>+HCLO<sub>4</sub>) at 120 °C was used for the Pb, Cd and Cu analysis [1]. Hg measurements were made by the Cold Stream method in the Hydrure unit of the Shimadzu 6701 F model atomic absorption spectrophotometer. The other metal measurements were performed on the flames of the acetylene air-gas mixture.

### Results and Discussion

The seasonal average values of Cd, Cu, Pb and Hg elements for each station are depicted in figures 1. In the figure, the limit values determined by the Water Corps Instructions are also given.



Fig. 1. a) The metal contents measured in the big sized mussels. b) In the small sized mussels  $(\mu g/g)$ .

Generally Cadmium (Cd) contends had been found in big mussels at Asian side much more than the European side. But at both size of the mussels (big and small sizes) the Water Corps Instructions of the values limits had been exceeded at every stations without the Baltalimaniand Büyükdere stations. Copper (Cu) contents exist at the same level in big size and small size mussel groups. The values are higher at Asian Side like in Cadmium (Cd). Also at all the stations, the values are under the limit values determined by the Water Corps Instructions. Lead (Pb) contents are higher in big size mussels at Asian Side. For both size of the mussels the limit values had been exceeded at every stations. Mercury (Hg) contents are at the same level at the either sides. Also at all the stations, the values are under the limit values. Examined elements had been amountly arranged as follows Cu >Pb >Cd >Hg at both the Asian Side and the European Side. Another result of this research is that Asian Side of the Istanbul Strait had been subjected household wastes much more than the European Side. Especially Lead (Pb) and Cadmium (Cd) contends limits had been exceeded too much due to the Küçüksu and Göksu rivers which carry anthropogenic pollution into the Istanbul Strait. The final report of the water quality monitoring program handled in 2003 and 2004 also supports this situation [3].

Consumption of the mussels in Istanbul is rising rapidly and this will threaten the human health seriously.

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## HEAVY METAL DISTRIBUTION IN THE SUPERFICIAL BOTTOM SEDIMENTS OF THE NORTHERN CONTINENTAL SHELF OF CRETE

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### Abstract

This study examines the dispersion of heavy metals (Cu and Ld), as pollutant indicators, in the surface sediment of the inner shelf of the north coast of Crete (Gulfs of Heraklion and Malia) on the basis of their source points, in land, and the general circulation of surface shelf waters. Increased values of Cu and Ld have found at the western part of the Heraklion Gulf, close to their terrestrial source, whilst increased values in the Gulf of Malia have been attributed to the presence of an anticyclonic circulation. *Keywords : Cretan Sea, Lead, Metals, Sediments.* 

#### Introduction

The major contribution of anthropogenic metals in a marine coastal area is of terrestrial origin, (mining, industrial, and urban developments) and other human practices near rivers and estuaries [1]. The scope of this work is to investigate the dispersion of trace metals in the sea floor sediments and to correlate their spatial abundance to offshore water circulation patterns and the location of their sources.

Study area and sampling procedure

The study area is located in the northern coast of the Island of Crete (South Aegean) including the Gulfs of Heraklion (to the west) and Malia (to the east). Sediment samples for all analyses were collected on a seasonal basis along 93 stations, which were located from the continental shelf and in depths from 30 m to 100 m (Fig. 1).



Fig. 1. Study area, sampling stations, bathymetry, schematic circulation, pollutant sources (1:Fuel and cement silos, 2:Power plant, 3,4:Biological waste treatment plant), major torrents (a:Almiros, b:Gazanos, c:Xiropotamos, d:Giofiros, e:Karteros, f:Aposelemis).

The local coastal circulation depends weakly upon the prevailing wind conditions and is mainly dictated by the bottom topography and the general circulation of the Cretan Sea. From re-analysis of existing current meter records in the region, we conclude that local currents appear to be relatively weak ( $\sim$ 10 cm/s). The main direction of variability is along isobaths. Although during spring and summer flow exists in both directions, during the rest of the seasons currents propagate towards east. Moreover this is the sense of flow of the residual circulation. Finally, within the gulf of Malia, an anti-cyclon is present and influences the local circulation.

The area under investigation receives urban sewages and industrial wastes from the nearby coastal zone, including the influxes of 6 torrents, and in particular from the harbor and airport of the city of Heraklion. Besides, in the western section there are petrol, oil and cement storage silos, whilst at its central and eastern part has gathered the majority of the tourist industry in Crete Island.

### Methodology

For the quantitative analysis of the trace metals, the sediment from each station was separated with a plastic sieve in two fractions: sand (>63 $\mu$ m) and the silk-clay (<63 $\mu$ m) to achieve satisfactory degree of normalization of the results; this is for the comparison between concentrations of different stations with non-homogeneous sedimentological characteristics [2].

The trace metals analysis was made by humid digestion with dense  $HNO_3$ and  $H_2O_2$  and the engagement of the metals with nitric ions. The concentrations of the metals (copper, zinc) were determined with the method of atomic absorption (AAS, PE4100ZL) and correction at Zeeman. Subsequently, the total stockings of metals were determined and the seasonal average of their concentration has been calculated.

#### Results

The measured concentrations of Copper and Lead show that there are high values for both metals (Cu: 40-117ppm and Pd: 20-60ppm) in the eastern part of the study area and in depths 30-40m. For the Lead there are even higher values in the area seawards of the Heraklion harbor. Their values then reduce eastwards until the Malia gulf where there are some stations with relatively higher values H9.3 (29.50ppm), H9.4 (17.02ppm), H10.3 (19.32ppm)-H10.4 (16.09ppm), He.3 (16.91ppm), He4 (13.42ppm), H12.2 (11.18ppm) and H12.5 (25.32ppm) for Cu and H9.3 (25.79ppm) H9.4 (23.10ppm), H9.5 (19.73ppm), H10.3 (12.13ppm), H10.4 (15.08ppm), He.2 (15.48ppm), He4 (16.98ppm) and H12.5 (17.42ppm) for Pd (fig2).



Fig. 2. Copper and Lead concentrations in ppm.

This distribution pattern is explained by the offshore circulation that incorporates an eastward water movement that transport trace metals eastwards away of their sources, reducing their concentrations. On the other hand, the presence of an anticlockwise gyre in the Malia gulf entraps the trace metals and increases, therefore, their concentrations are increased.

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# THE SPATIAL DISTRIBUTION OF HEAVY METALS IN SURFACE SEDIMENTS FROM THE SOUTHERN BLACK SEA SHELF

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### Abstract

The surface sediments were collected at sixty-three stations from the southern shelf area of the Black Sea. Spatial distribution of the heavy metals in southern shelf is mainly controlled with the geochemical differences in the southern hinterland. Southwest shelf sediments contain low values. Relatively high metals (Cu, Pb, Zn, Fe, Mn, Cr and Ni) values are found mainly in the southeast Black Sea shelf, indicating the great influence of metallic ore deposits transported by rivers. However, local anthropogenic influences are also detected from the high enrichment factors of Pb, Zn and Hg.

Keywords : Metals, Black Sea, Sediments.

The Black Sea is the largest anoxic basin in the world and connected to the Mediterranean Sea via the Marmara Sea and its narrow straits; Istanbul and Çanakkale). It receives a huge amount of riverine inputs which transport both the natural and anthropogenic loads to be accumulated in the basin. The southern shelf off the Anatolian coasts is narrow (2-25 km) and dissected by numerous submarine canyons. Hence, the shelf sediments are not preserved extensively but are immediately transported via these canyons beyond the shelf edge and into the deep Black Sea basin. However studies dealing with the heavy metal content of the southern shelf sediments are very few [1].

In this study, sixty-three surface samples were collected on board of R/V Arar (Istanbul University, Institute of Marine Sciences and Management) from 20, 50 and 100 m water depths in the southern shelf. In general, the mean metal contents of surface sediments from the southern shelf of the Black Sea are comparable to average crust's composition and to the ranges of sediments from adjacent seas, regardless of local elevations (Table 1).

Tab. 1. Total metal content found in this study and other studies.  ${}^{a}$ [2], ${}^{b}$ [3];  ${}^{c}$ [4].

|        |      | This study | Marmar | a Sea shelf areas * | Shale Average b | Black Sea (NW shelf) |
|--------|------|------------|--------|---------------------|-----------------|----------------------|
|        | Mean | Range      | Mean   | Range               | Mean            | Range                |
| Al (%) | 6.4  | 2.6-9.1    | 6.7    | 1.1-11              | 9.2             |                      |
| Fe (%) | 3.5  | 0.8-5.2    | 3.7    | 0.6-7.7             | 4.7             | 0.5-7                |
| Mn (   | 654  | 244-1155   | 448    | 101-2,610           | 850             | 8-1,321              |
| Cr (.  | 110  | 25-390     | 127    | 11-654              | 100             | 1-135                |
| Ni (   | 49   | 8-141      | 64     | 8-173               | 80              | 1-207                |
| Cu (   | 51   | 23-109     | 31     | 3-107               | 50              | 2-108                |
| Pb (.  | 29   | 10-63      | 33     | 10-85               | 20              | 0.5-50               |
| Zn (   | 103  | 61-215     | 118    | 33-410              | 90              | 1-185                |
| Hg (   | 0,13 | 0,0-0,6    | 0,5    | 0,04-0,7            | 0,3             |                      |

Relatively high Cu, Pb and Zn values occur in samples collected from the eastern part of the study area (between Yeşilırmak and Hopa). Cu and Zn clearly indicate increments at the deeper stations, and locally in front of Kızılırmak River. Although Hg is generally lower than the "average Shale", it is relatively high (100-300  $\mu$ g/mg) at the western Black Sea shelf and also off the rivers Yeşilırmak and Kızılırmak. Spatial distribution pattern of Cu, Pb, Zn, Fe, and Mn is similar, being high in the southeast, and low in the southwest shelf sediments. Ni, Cr and Hg have different pattern. They are higher off the Kızılırmak and Yeşilırmak Rivers and lie within low and narrow range of values in the rest of the study area. Relatively strong positive relationships can be seen between Pb and Zn (r=0,62), Ni and Cr (r=0,77), Mn and Fe (r=0,76), and Cu and Fe (r=0,59). This indicates that these elements are enriched with a common mechanism. To assess the origin of each element, the enrichment factors (EF) relative to 'average crust' were calculated. EF values of Pb and Zn indicate enrichment in the southeast (>2), whereas EF values of Cu are mostly around 1 and locally exceeds 2. EF values of Ni and Cr are significantly high (>5) in the samples collected off the Kızılırmak and Yeşilırmak rivers. EF of Fe and Mn do not exceed 2. Hg has EF values mostly lower than 1 in the study area, however values between 2,5 and 3 are found locally in the southwest and southeast shelf. The variability of the metal contents of the Black Sea shelf sediments is primarily governed by the geochemical differences in the southern hinterlands, except local anthropogenic sources. There are Cu-Pb-Zn mines in the eastern Black Sea between Artvin and Ordu. Besides from the natural high background in the southeast shelf, some anthropogenic influences are evident from EF values of Pb, Zn and Cu. The accumulation of these metals in the sediments results from both natural processes (weathering products from geological formations) and anthropogenic processes, such as mining activities, industrial and domestic discharges. Pb, Zn and to a lesser extend Hg, unlike to other metals, appear to be also enriched in southwest shelf sediments, based on EF values.





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# VARIATIONS SPATIO-TEMPORELLES DE L'INDICE DE CONDITION DE *MYTILUS GALLOPROVINCIALIS* EN ÉLEVAGE ET RELATIONS AVEC LES TENEURS EN HYDRATES DE CARBONE DE LA GONADE

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### Résumé

L'indice de [1] varie dans le secteur aquacole du lac de Bizerte selon un gradient spatial et temporel. Il est démontré dans cette étude que cet indice ne reflète pas l'activité de reproduction de manière fidèle. La connaissance préalable de cette dernière, associée à une étude de la variation des hydrates de carbone, métabolites fournissant une grande partie de l'énergie nécessaire à l'activité de reproduction et donc de croissance, indices de performances aquacoles, met en évidence dans ce travail les limites de l'utilisation de cet indice qui est en fait essentiellement sous l'influence de la charge organique des tissus de réserve elle-même dépendante de la richesse trophique du milieu. *Mots clès : Aquaculture, Bivalves, Growth, Reproduction.* 

### Introduction

*Mytilus galloprovincialis* présente de nombreuses adaptations aux conditions environnementales. L'étude de l'indice de condition est l'une méthodes retenues pour l'évaluation des potentialités de croissance pondérale liée au cycle reproducteur, bien que [2] considère que seules les variations brusques sont indicatrices d'une évolution gonadique. La présente étude se base sur des données histologiques en microscopie photonique et électronique acquises sur la reproduction de l'espèce afin de définir les limites de fiabilité de cet indice en tant que paramètre d'estimation de l'activité sexuelle.

### Matériel et Méthodes

L'étude a porté sur le secteur conchylicole du Lac de Bizerte (Tunisie). L'indice de condition de [1] est calculé au niveau de 3 stations et deux effets principaux sont évalués par une analyse de variance :

- temps : effet des variations mensuelles

- station de prélèvement : situation géographique de la table conchylicole. Le dosage des hydrates de carbone a été effectué selon la méthode de [3].

### Résultats et discussions

La courbe de l'évolution des moyennes observées dans les 3 stations confondues (intervalle de confiance de 95 %), met en évidence 3 phases de décroissance correspondant aux émissions gamétiques suivies par une remontée de la valeur de l'indice de condition corrélative à la restauration gonadique. L'influence du temps évaluée statistiquement à l'aide du test F, montre un niveau de significativité élevé (N= 4463, P = 0,000 ; 11 ddl). Le test F montre un effet de la station hautement significatif (P = 0,000 ; 2 ddl) malgré le fait que le cycle soit identique [4] dans les 3 stations. La station 1 présente nettement la meilleure valeur d'indice (16,31 ± 1,54). Les moyennes des stations 2 et 3 sont respectivement de 13,53 ± 1,38 et 12,05 ± 1,346.

Le taux des hydrates de carbone passe par un maximum en août (75.29  $\pm 19.5$  mg glucose/g) et atteint une valeur minimale en janvier (2 $\pm 0.05$  mg glucose/g). Le repos sexuel (Mai-Août) est caractérisé par une accumulation des réserves glucidiques dans la gonade, ce qui a pour conséquence directe l'augmentation de la valeur de l'indice de condition. On observe une accumulation, dès le mois de mars, de métabolites glucidiques dans le tissu de réserve qui est à son maximum en été. Au cours de cette période, une accumulation de glycogène a lieu dans les cellules vésiculeuses [5]. A cela s'ajoute le fait que les cellules conjonctives interfolliculaires se chargent en phospholipides et en graisses neutres [6], [7]. Les lipides sont visibles au niveau des coupes effectuées en microscopie électronique. L'accumulation massive de cellules qui forment l'essentiel du manteau pendant la période de repos sexuel ont pour conséquence directe l'augmentation de la valeur de l'indice de condition mais n'explique pas la chute observée en juillet et août alors que les métabolites énergétiques et les lipides [8] sont à leur maximum d'accumulation et qu'ils engendrent de ce fait une augmentation notable du poids. Cette contradiction est confirmée durant la phase d'activité gonadique (septembre à février) durant laquelle aucun lien direct n'a pu être établi entre les gains ou perte de poids liées à la gamétogenèse ou à l'utilisation des réserves et les valeurs de l'indice de condition.

### Conclusion

L'indice de condition n'est pas un paramètre fiable d'estimation des varia-

tions de poids en liaison directe avec le cycle reproducteur. Les variations de poids observées sont liées à l'accumulation des composés biochimiques qui sont sous l'influence directe de la richesse trophique du milieu [9] ce qui explique l'effet significatif de la station au niveau de notre site d'étude. L'utilisation de l'indice de condition reste toutefois intéressante en tant que paramètre de performance aquacole et d'évaluation pondérale du produit.

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# MONITORING CHEMICAL CONTAMINATION LEVELS IN THE MEDITERRANEAN BASED ON THE USE OF MUSSEL CAGING

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### Abstract

A bioindicator monitoring network (RINBIO) was deployed all along the French Mediterranean coast (1,800 km), using man-made cages containing mussels (*Mytilus galloprovincialis*) to assess contamination by heavy metals, persistent organic products and radionuclides. The caging technique compensated for the scarcity of natural shellfish stocks in significant parts of the coast and enabled comparison between sites regardless of their physico-chemical and trophic characteristics. Models linking a biometric parameter from each of 103 mussel samples to pollutant levels make it possible to adjust raw data on contamination for a reference individual, by making a clear distinction between physiological (growth) and environmental factors. *Keywords : Bio-indicators, Coastal Waters, Monitoring, Pollution.* 

Introduction

Under the aegis of the Water Management Master plan of the French Mediterranean coastal zone and the recent EU Water Framework Directive, a monitoring programme was established to document a coherent and comprehensive overview of the different water masses and inform on progresses towards the achievement of high quality water status. Most monitoring programmes now include the use of biological indicators. In the Mediterranean Sea, the species Mytilus galloprovincialis is widespread, but in some locations natural populations are rare or absent. The transplantation method compensated for this scarcity and allows the control of the source, age, and stage of sexual maturity of the samples. Although concentrations measured in the tissue are a function of bioavailable pollutant levels, the bioaccumulation factor depends on mussel growth. Comparison of raw data on tissue concentration between sectors of different trophic potential may be misleading. A biometric parameter representing growth must be used to correct initial data and to produce reliable comparison at a large spatial scale.

#### Material and Methods

Mediterranean mussels, Mytilus galloprovincialis, were transplanted from a unique cultivated population located in a low contamination area and selected in a narrow size range. Mussels were immersed in plastic cages at the end of March and hauled out in July 2003, along 1,800 km of French Mediterranean shoreline, including coastal lagoons. In the open sea, the stations were immersed between 20 m and 30 m in the mean field of dilution of land-based contamination sources. The monitoring network includes 103 transplantation sites and evaluate various trace-contaminant levels: heavy metals, organic pollutants (pesticides, PCBs, PAHs) and radionuclides for which 41 stations were selected. During this sexual resting period, the condition index (CI), defined as the ratio of soft tissue dry weight over shell weight, appears to be a good indicator of growth rate. The use of linear regression analysis for each contaminant statistically infers that tissue concentration under steady state conditions can be a function of the CI. These regression lines allow normalization of the concentrations measured to a reference CI, based on the hypothesis of equal slopes. The contaminants levels are then comparable at a large spatial scale, independently of the trophic conditions prevailing around the sampling sites [1].

### Results

The recovery rate of samples is above 98% and mean mortality of mussel is less than 20%. The condition index (CI) ranges from 0.05 to 0.21, growth being greater in samples west of the Rhone river mouth. For each contaminant, adjustment parameters calculated on the basis of the raw data (concentrations per dry weight) allows tdetection of contaminated locations with outlaying values. Cadmium concentrations are in the same order in the open sea and in lagoons (mean value:  $1.1 \ \mu g \ g^{-1}$ ), with the exception of one lagoon with concentrations up to 4.5  $\ \mu g \ g^{-1}$ . Mercury background level is stable and below 0.1  $\ \mu g \ g^{-1}$  with high levels in some lagoon (0.15  $\ \mu g \ g^{-1}$ ). High concentrations were also observed in the waters of Toulon (0.25  $\ \mu g \ g^{-1}$ ). Zinc and copper are stable at about 150  $\ \mu g \ g^{-1}$  and 6  $\ \mu g \ g^{-1}$ ). Lead background level is 1.13  $\ \mu g \ g^{-1}$  with extreme values in one lagoon (4.86  $\ \mu g \ g^{-1}$ ) and in coastal waters of large urban

areas (3.5  $\mu$ g g<sup>-1</sup>). Levels of nickel and chromium contamination are equivalent, in lagoon and open sea (1.2 and 1  $\mu$ g g<sup>-1</sup>). However, a peak is observed off an old asbestos mine in northwest part of Corsica (3.2 and 3.28  $\mu$ g g<sup>-1</sup>). Arsenic concentrations are homogeneous (20  $\mu$ g g<sup>-1</sup>). For PCBs, only CBs 138 and 153 were observed at measurable levels; they are uniformly distributed. CB 153 peaks were observed in the waters off Toulon (18 ng g<sup>-1</sup>), off Marseille (15 ng g<sup>-1</sup>), and in one lagoon (41.5 ng g<sup>-1</sup>). DDT contamination peaked in the plume of the Rhône (2.0 ng g<sup>-1</sup>), but low values were recorded in lagoons. Conversely, the lagoons showed high levels in the by-products of DDT degradation, such as DDE (73.26 ng g<sup>-1</sup>). Among the PAHs, only fluoranthene is present at measurable levels that fluctuate significantly, with peaks in the Languedocian lagoons, Toulon harbour and the Marseille area (23 ng g<sup>-1</sup>).

Anthropogenic radionuclides of environmental concern exhibit very low levels in 41 stations along the French Mediterranean coast: <sup>137</sup>Cs is the only artificial radionuclide regularly detected in mussels with low and stable values (mean value 0.17 Bq kg<sup>-1</sup> dry weight corresponding to the baseline levels found in the northwest part of the Mediterranean basin. <sup>60</sup>Co is sporadically measured at levels from 0.12 to 0.19 Bq kg<sup>-1</sup> dry weight. <sup>60</sup>Co is clearly originated from releases of nuclear facilities along the Rhone River, and is considered as a reliable tracer to picture the extent of the Rhone river plume along the coast [2].

### Discussion and Conclusions

The condition index distribution also provides some clues on the levels of chemical contamination, especially in the case of trace metals and radionucleides. Tissue growth is likely to mask or dilute the levels measured in the case of metals like cadmium, nickel, and chrome, which are essentially present in the structural tissues of mussel. Under these conditions, levels of metals measured in natural populations sampled on the coast are nearly identical to those obtained from transplants of mussels immersed in the open sea. However, the open-sea dilution effect is greater with organic compounds. Levels measured in mussels in artificial stations are much lower than values observed in organisms sampled directly on the coast. This phenomenon may be related to the uptake kinetics of these molecules, which are exclusively accumulated from food, adsorbed on suspended particles and stored in reserve tissues. The transplantation of mussels in caged devices is now a well-tested technique, reliable for large spatial monitoring. The method requires some training of the operating team but could be easily extended to most Mediterranean coastal waters.

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# MYTILOS AND MYTIMED PROJECTS MONITORING CHEMICAL CONTAMINATION IN THE MEDITERRANEAN SEA

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## Abstract

Main objective of Mytilos and Mytimed projects is to assess the level of chemical contamination for the Western and Eastern Mediterranean coastal waters, using a standard protocol developed since 1996 by Ifremer using man-made cages containing mussels (*Mytilus* galloprovincialis).

Keywords : Monitoring, Bivalves, Eastern Mediterranean, Western Mediterranean.

Mytilos and Mytimed projects are supported by the Interreg IIIB MEDOCC program. They take place within the frame of the MEDI-CIS program from Ifremer. MEDICIS is a targeted research program which objectives are to improve knowledge of inputs, fate and to reduce chemical contamination of the Mediterranean Sea.

Mytilos project (2004 to 2006) was developed for the whole Western Mediterranean basin (with 120 mussel cage stations). The geographical areas are Spain coasts with Balearic islands, French coasts (including Corsica island), West Italian coasts (including Sicily and Sardinia), Morocco, Algeria and North of Tunisia (figure 1). Mytimed project (2006 to 2008) concerns Eastern Mediterranean coastal waters (about 120 stations). The geographical areas are Aegean sea (Greece and Turkey), Coasts of South Turkey, Syria, Lebanon and Cyprus, East of Tunisia, South-east of Italy and Western coast of Greece (linked to Mytilos project).

### Methodology

Active biomonitoring consists in putting mussel cages in targeted locations for a desired duration (about 3 months) while mussels accumulate contaminants. Sea stations were located by means of combined use of DGPS, panoramic sonar, and depth-sounding systems. Samples were recovered either by divers or by grappling hooks. After recovery, contaminants levels in organism flesh are measured.



Fig. 1. Study area and sampling site for Mytilos project.

Caging method enables to control the age and sexual condition of samples. Mytilos/Mytimed/Rinbio methodology is based on the computation of a condition index for every location. Using this condition index, a correction is applied to raw data in order to get homogeneous and comparable contaminant concentrations. The field methodology and data management has been thought in order to limit interferences with effects of trophic level on bio-accumulation. Using this method at a large scale allows to get data independent from physicochemical and trophic variability of study sites.

Considered contaminants : Trace metals (Lead, Cadmium, Copper, Mercury, Zinc, Chromium, Nickel, Arsenic, Organic compounds (PCBs, Dioxins, PAH, DDTs, Hexachlorocyclohexan, Detergents, Bromine compounds).

Exploitation of results will be performed through an Internet site with an

automatic data processing software (statistics) and advanced data display (graphics, classification, GIS links $\hat{a}$ Åę).

### Contributors

France (TVT program coordination, IFREMER technical coordination), Italy (ICRAM, PSTS Sicily), Spain (IEO, IMEDEA-UIB Balearic islands and IIQAB-CSIC), Morocco (INRH, MATEE and University Ibn Zohr), Algeria (ISMAL), Tunisia (INSTM), Greece (HCMR, ANEM S.A), Turkey (IMS / Middle East Technical University), Syria (HIMR / Tishreen University), Lebanon (NCMS).

MAP/MED POL in relation with regional monitoring programs will contribute to the project through supporting coordination and organization at different levels and also will be the end-user of the project as an international organization.

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# METAL POLLUTION FINGERPRINTS IN SEDIMENTS OF DEEP WESTERN MEDITERRANEAN SEA

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### Abstract

A survey in the deep Western Mediterranean Sea sediments (depth 2,850 m) revealed relatively enhanced concentrations of Cd, Pb and Zn at the surface (2 cm) in comparison to deeper layers. Lead isotope analysis indicated that this surface enhancement is not caused by an in-situ diagenetic migration of natural metals towards the surface but to an anthropogenic input associated to land-based pollution in the Western Mediterranean Region.

Keywords : Western Mediterranean, Deep Sea Sediments, Metals, Pollution.

Anthropogenic influence on the metal content of near-shore sediments is detectable in large parts of the Western Mediterranean littoral zone. However, anthropogenic impact on deep Mediterranean sediments is not well documented, although it is recognized that atmospheric pathway and lateral transport from continental margins are important modes of metal transport from land to the sea [1-3]. Increased metal concentrations have already been found in surface layers of western deep Mediterranean sediments [4], but it is not always clear whether they reflect pollution processes or diagenetic up-wards movement of naturally occurring metals. In the present study, using metal analysis combined with lead isotope analysis on dated sediment cores, it was attempted to investigate evidences for metal contamination in deep Mediterranean sediments. Isotopic lead signature allows discriminating the origin of lead (anthropogenic vs natural) independently of any variations in their contents. This work was part of the European project ADIOS, aiming to study the impact of atmospheric deposition in the open Mediterranean Sea.

A sediment core of 37 cm depth was collected in the Western Mediterranean Sea (station WB, 39° 29.51' N and 06° 10.88' E). For dating purposes, <sup>210</sup>Pb activities were measured by alpha spectrometry of its granddaughter <sup>210</sup>Po. Total metal concentrations were determined by AAS and GFAAS, after decomposition in a mixture of aqua regia and HF. Samples for lead isotopes analyses were oxidized using HNO3, HF, HCl and purified through AG1X8 resins in clean dust laboratory. Isotopic ratios were determined by thermo-ionisation mass spectrometry (FIN MAT 262). The core WB shows a regular profile of excess <sup>210</sup>Pb decreasing exponentially with depth, but restricted to the first three centimetres. Using a CFCS model, maximum sedimentation rate was estimated to be 0.0227 cm  $y^{-1}$  or 0.0225 g cm<sup>-2</sup>  $y^{-1}$ . These rates are high compared to those obtained from <sup>14</sup>C in the same area and the <sup>210</sup>Pb distribution is probably entirely due to mixing. Assuming negligible sedimentation rates (S=0 cm/yr) the maximum mixing rate is 0.016 cm<sup>2</sup>/y, which is probably representative of the mean sedimentation-bioturbation processes occurring in this abyssal plain. Increased concentrations of Cd, Pb (and to a lesser extend Zn) were recorded in the upper 2 cms of the core (maximum values 0.165 mg/kg, 38.4 mg/kg and 82.6 mg/kg, respectively), while metal concentrations were relatively stable in deeper layers (Cd 0.067-0.107 mg/kg, Pb 14.1-24.8 mg/kg, 50.5-74.7 mg/kg). Copper concentrations did not show any increase in the surficial sediments. According to the <sup>210</sup>Pb profile, the upper 2 cms represent the more recent (and important) anthropogenic influence related to industrial development and increased leaded gasoline utilization in Western Europe after 1950. The profile of <sup>206</sup>Pb/<sup>207</sup>Pb ratio in the core is plotted in Figure 1. In the Mediterranean Sea 206 Pb/207 Pb ratios higher than 1.195 generally reflect natural lead, whereas lower ratio is typical of anthropogenic origin from gasoline and industry emissions [5-6]. Our isotope ratio profiles show a decrease from an anthropogenic value in surface layers to natural values at 6 cm depth, i.e. deeper than the <sup>210</sup>Pb. However, we observed a sudden shift in the isotopic ratio between 3 and 4 cm depth. This shift occurs just below the surface layer where excess <sup>210</sup>Pb is observed and is not due to local mixing processes (ingestion of subsurface sediment at 2 cm and rejection at 3,5 cm) since no <sup>210</sup>Pb excess was observed at this depth. This shift could be explained by turbidite type dynamics in the area. It was concluded that the enhancement of metal concentrations in the upper sediment layers of deep Western Mediterranean sediments are caused by recent anthropogenic contamination due to increasing land-based human activities (industry and traffic).

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Fig. 1. Profile of  $^{206}\mathrm{Pb}/^{207}\mathrm{Pb}$  in core WB from the Western Mediterranean.

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# ÉVALUATION DE LA POLLUTION PAR LES HYDROCARBURES DE L'ÉCOSYSTÈME MARIN DU LITTORAL DE GABES

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### Résumé

Dans le cadre du diagnostic de l'état de pollution marine du littoral de Gabès, nous avons effectué une compagne d'échantillonnage pour le prélèvement des sédiments de surface, eau de mer ainsi de rejets industriels. L'objectif étant d'évaluer la contamination par les hydrocarbures en séparant les différentes fractions et analyser la fraction saturée et insaturée non aromatique par chromatographie en phase gazeuse. Les résultats montrent que les teneurs les plus élevées en hydrocarbures totaux ont été mesurées aux alentours de deux ports et à l'embouchure de rejets de phosphogypse.

Mots clès : Pollution, Gulf Of Gabes, Petroleum, Coastal Systems.

### Introduction

La ville de Gabès occupe une place de choix dans la stratégie du développement économique de la Tunisie, compte tenu de ses richesses biologiques, de ses atouts touristiques et agricoles, de ses activités portuaires et pétrolières et de l'importance de ses complexes industriels.

Toutes ces activités socio-économiques, engendrent diverses atteintes à l'environnement marin ce qui a nous mené d'évaluer quantitativement et qualitativement la pollution marine par les hydrocarbures du littoral de Gabès.

#### Matériel et Méthodes

Une campagne d'échantillonnage de sédiments de surface, de l'eau de mer et de rejets industriels a été réalisée au mois de mars 2005 au niveau du littoral de Gabès. Au total 10 échantillons d'eau et 4 échantillons des sédiments ont été prélevés entre la zone supratidale et la zone infratidale. Les échantillons de sédiments et de l'eau ont été conservés pendant deux semaines à -20 °C pour arrêter toute activité bactérienne. La fraction fine de sédiments (<à 63 $\mu$ m) lyophilisée est utilisée pour l'extraction chloroformique de la fraction lipidique au soxhlet et on a utilisé l'eau filtrée pour l'extraction chloroformique liquide-liquide [1].

La séparation de fractions de l'extrait chloroformique total est réalisée par chromatographie en phase liquide (CPL) alors que l'analyse de ces fractions est assuré par chromatographie en phase gazeuse (CPG).

### Résultats et discussion

L'étude Géochimique des sédiments superficiels montre que la distribution des teneurs en extrait chloroformique total varient entre 65 et 725 ppm (en moyenne 273 ppm).

Les fortes proportions ont été observées à l'exutoire de rejet de phosphogypse et à l'embouchure de Oued Cheninni. Ces valeurs sont très élevées attestent d'une contamination par les hydrocarbures.

La distribution des hydrocarbures totaux montre une forte contamination d'eau de mer par des résidus pétroliers. En effet, les teneurs en extrait chloroformique total varient entre 20 ppm et 94 ppm avec une moyenne de l'ordre de 54 ppm. Cette forte contamination peut être expliquée par l'intense activité portuaire ainsi que les rejets urbains et industriels ( phosphogypse 12800 t /j).

L'analyse quantitative des fractions constituant l'extrait lipidique dans l'eau que dans les sédiments montre une richesse en hydrocarbures totaux par rapport aux composés lourds [2].

Les chromatogrammes concernant l'eau et les sédiments montrent une distribution unimodale régulière des n-alcanes allant de  $C^{14}$ à  $C^{31}$ sans prédominance d'atomes de carbone pair ou impair (Fig. 1). UCM présente une bosse importante et CPI est voisin de l'unité.

Tous ces paramètres prouvent bien que les hydrocarbures ne sont pas d'origines biogènes mais d'origines exogènes [3] et les fortes activités bactériennes attestent la présence des résidus pétroliers dans les échantillons [4].



Fig. 1. Chromatogramme type des hydrocarbures saturés et insaturés non aromatiques des sédiments du littoral de Gabès.

### Conclusion

Ces résultats nous permettent de conclure que l'extrait chloroformique total présente dans les sédiments de surface et de l'eau du littoral de Gabès n'est pas héritée en totalité de la biomasse originelle, mais provient pour la plupart d'une pollution par des résidus pétroliers.

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# HEAVY METAL POLLUTION OF THE TURKISH SHORES OF THE BLACK SEA

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### Abstract

This study aims to investigate the effects of the terrestrial originated (natural+industrial) inputs on the heavy metal distribution. For this reason sampling procedure at the depth of 10 m was accomplished along the shore from the Iğneada to Hopa. Overall trace metal content of the water body (dissolved+adsorbed in the suspended material) was investigated in two different periods; in September 2004 and in April 2005. Along the shelf, the amount of dissolved metals (Fe, Mn, Pb, Cd, Hg,and Cu ) and the suspended solid matters (Fe, Mn, Pb, Cd, and Cu ) are found above the average shelf values [1].

Keywords : Black Sea, Metals, Surface Waters.

### Results and Discussion

Water dissolved cadmium (Cd) contents in the southern Black Sea shelf are generally higher. This arises from the high water solubility of Cd. The highest values were in front of the Samsun Harbour. The values above the shelf average show the terrestrial originated anthropogenic inputs. Whereas the dissolved iron (Fe) content was higher in April 2005, however it was lower in September 2004 (Table 1). This is because of the presence of the dissolved Fe mineral brought together with the humic material by the rivers as a consequence of the melting snow and increasing rainfall during April. The higher values of the manganese (Mn) content in the eastern shelf originated from the transports from the manganese mineral zones in Trabzon, Rize and Hopa [2]. However, it is thought that the high values in front of Samsun Harbour are due to the heavy traffic. The high copper (Cu) contents values in mid-end of the eastern parts of the shelf are originated from the metal zones present in this region which also indicates the influence of the Danube River [2].

### Tab. 1. Water dissolved metal and metal in TSS contents at 10 m depth

|           | Ward         | ( g1)       | Or I         | 19.         | Fel           | <i>p</i> %   | Ma           | (g))         | Car          | 120          | 25           | gt)          | Hgt          | 80           | T85' C       | 01.14        | 0            |              | Fe           | (10)          | Ma           | 61           | Ort          | a%        | 291          | 1 <sup>1</sup> 2 |
|-----------|--------------|-------------|--------------|-------------|---------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|---------------|--------------|--------------|--------------|-----------|--------------|------------------|
| Biseyes   | Apr.<br>2005 | 5µ.<br>2004 | Apr.<br>2005 | 5µ.<br>2004 | .4pt.<br>2005 | 5pt.<br>2004 | Apr.<br>2005 | 5pt.<br>2004 | Apr.<br>2005 | 5pt.<br>2004 | Apr.<br>2005 | 5pt.<br>2004 | Apr.<br>2005 | 5pt.<br>2004 | Apr.<br>2005 | 5µ8.<br>2006 | Apr.<br>2005 | Spt.<br>2004 | Apr.<br>2005 | 5µ8.<br>21014 | Apr.<br>2005 | 5pt.<br>2004 | Apr.<br>2015 | Spt. 2004 | Apr.<br>2005 | 5µ.<br>2004      |
| 0 neada   | 0,01         | 0.61        | 0.04         | 1.32        | 32,68         | 1,22         | 0.29         | 2,83         | 0,37         | 2,66         | 0,01         | 1,20         | 0,94         | 4,84         | -0,01        | <0.01        | -0,01        | -0.01        | 11,91        | 23,39         | 0.55         | 0.58         | 0,54         | +0.01     | 0.45         | 1,90             |
| Zonguklak | 0,01         | 0,40        | 0.01         | 3,19        | 26,74         | 1,10         | 1,04         | 3,51         | 0,11         | 2,51         | 0,01         | 1,10         | 0,01         | 0,04         | 0,01         | 0,10         | 0.52         | 0,30         | 0,22         | 22,30         | 0,20         | 0,85         | 0,42         | 0,60      | <0,01        | 1,00             |
| Bath      | 0,01         | 0.50        | 4.83         | 1.38        | 27,27         | 0.87         | 0.80         | 2,66         | 1,12         | 1,14         | 0,01         | 0,70         | 2,87         | 0.86         | <0.01        | <0.01        | 0,45         | <0.01        | 1,90         | 19,87         | 0,80         | 0,70         | 0,32         | 0.40      | <0.01        | 1,70             |
| Sincp     | 0,02         | 0.38        | 0.04         | 0,45        | 65,67         | 0,79         | 3,17         | 2,02         | 0,29         | 1,64         | 0,01         | 0,01         | 0,01         | 0,95         | 0,13         | 0,10         | 0,35         | 0,50         | 6,20         | 35,84         | 0,74         | 0,85         | 0,295        | 0,40      | +0,01        | 1,90             |
| Sameun    | 0,01         | 1.15        | 2,17         | 0.56        | 6,15          | 0,82         | 1,19         | 14,09        | 0,23         | 1,11         | 0,01         | 0,42         | 0,01         | 2,71         | +0,01        | <0,01        | 5,00         | 0,40         | 6,27         | 103,54        | 1,70         | 8,54         | 0,45         | 0,90      | <0.01        | 0,80             |
| Ordu      | 0,02         | 0,44        | 3.53         | 1.85        | 54,74         | 1,37         | 1,21         | 3,04         | 0,50         | 1,26         | 0,01         | 0,17         | 2,45         | 0,45         | 0,37         | 0,20         | 0,59         | 0,70         | 2,28         | 40,27         | 0.58         | 1.36         | 0,01         | 0,50      | <0.01        | 1,90             |
| Gresun    | 0,01         | 0.58        | 0.01         | 2,86        | 17,29         | 1,27         | 1,82         | 1,95         | 0,24         | 1,10         | 0,01         | 0,01         | 2,38         | 0.83         | 0,30         | 0,10         | 1,38         | 1,00         | 2,34         | 30,56         | 0.96         | 1,08         | 0,29         | 0,40      | +0,01        | 1,40             |
| Trabeon   | 0,01         | 0.55        | 0.35         | 4.26        | 19,17         | 1,15         | 2,29         | 1,28         | 0,47         | 0,98         | 0,01         | 0,01         | 0,56         | 1,51         | 0,06         | 0.10         | 1,80         | 0.60         | 3,57         | 99,21         | 1.52         | 6,54         | 0,36         | 0,60      | <0.01        | 1,30             |
| Ras       | 0,01         | 0,65        | 3,53         | 2,13        | 20,67         | 0,95         | 2,37         | 0,89         | 0,17         | 1,05         | 0,01         | 0,01         | 0,45         | 0,01         | -0,01        | <0,01        | 0,79         | 0,70         | 4,50         | 18,28         | 0.64         | 0,96         | 0,28         | 0,30      | 2,13         | 1,10             |
| Hope      | 0,01         | 0.76        | 0.01         | 3.03        | 20.30         | 0,81         | 2,14         | 1,83         | 0.59         | 2,27         | 0.01         | 0.01         | 0,20         | 0.37         | 0,15         | <0.01        | 0.27         | 0,30         | 6,83         | 21,15         | 0.94         | 0.95         | 0.25         | 0,60      | <0.01        | 1,00             |
| Seauther  |              |             |              |             |               |              |              | 1.5          |              | <i>m</i>     |              |              |              |              |              |              |              |              |              |               |              |              |              |           |              |                  |

The lead (Pb) contents both in dissolved form and in suspended solid form are higher in September 2004 period (Table 1). High values in mid and eastern parts of the shelf showed the presence of industrial and mine originated inputs. Water dissolved chromium (Cr) contents are higher. The values are especially higher in Bartin, Zonguldak, Samsun, Trabzon and Rize where the river inputs (inflows) are dense (Table 1). Inputs are related particularly with the terrestrial anthropogenic (industrial inputs). It is known that Cr is used in Steel, Textile and Tanning Industries and in the production of stainless steel householdings. Mercury (Hg) contents are higher in fronts of Samsun where there are heavy sea traffic and dense urbanization. And again it is higher in the Igne Island which is under the influence of the Tuna River. In the coastal region which is saturated between Inebolu and Sinop in the southern Black Sea, Hg mining zone is present [2]. The values in this zone are related with the coastal erosions from the Hg mineral zone. As a result, the metal contents in the southern Black Sea water are generally higher than the average [1]. Besides the values in the west side of the shelf showed a good correlation with the previous studies.[3] High values are the signs of the increasing metal pollution due to the dense urbanization, industrial activities, sea traffic and the river transports from the mineral zones.

Dedicated to sainted Prof. Dr. Erdoğan Okuş who sacrificed his life for marine sciences.

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# A PROTOTYPE BENTHIC CHAMBER FOR THE DETERMINATION OF NUTRIENT FLUXES AT THE WATER - SEDIMENT INTERFACE

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### Abstract

The quantification of nutrient fluxes between sediment and water is important for the designing of proper environmental management plans in any coastal marine zone where anthropogenic activities play a significant role. This work presents a prototype benthic chamber which allows the study and calculation of benthic fluxes based on laboratory simulations. *Keywords : Coastal Management, Sediments, Sampling Methods.* 

Nutrient elements' speciation in the water - sediment interface is a difficult achieved task, due to space and time fluctuations continuously present in an open system such as a coastal area. The water currents and the sea waves continuously affect the surface sediment, the particulate matter and the water masses. The *in situ* benthic chamber techniques initially employed to study these phenomena [1-2], present an inherent difficulty in handling the overall experiment, in addition to a series of disadvantages deriving from the lack of a regulatory system for oxygen supply, and thus the redox conditions, in the chamber.

In order to overcome these disadvantages, we introduced a prototype portable benthic chamber, capable of sampling surface sediment along with its overlying water column, which can be transported undisturbed from the study area to the laboratory where simulation experiments are carried out. The benthic chamber (Fig. 1) is made of a stainless steel ring with properly attached "knives" embedded in a lidded Plexiglas cylinder (typical dimensions: 120 cm long, 40 cm diameter) with sprung Plexiglas plates covering the top and the bottom of it. The chamber, placed by scuba divers into the seabed can capture sufficient sample quantities (30 to 50 cm) of sediment along with its overlying sea water column.



Fig. 1. The benthic chamber.

The watertight chamber is specifically connected with an electronic system using an oxygen meter an electronic valve, a Teflon oxygen supply tubing and a Teflon coated magnetic stirring, in order to retain the oxygen concentration at any set value from 0.0 mg/l to 20.0 mg/l (Fig 2A). The chamber is also equipped with a second electronic system using a cooling/thermal spiral, a digital thermometer and a circulator capable of retaining the water temperature constant at any set value (Fig. 2B).



Fig. 2. Electronic control of dissolved oxygen (A) and temperature (B).

This benthic chamber allows the full and fine control of the dissolved oxygen concentration - and thus of the redox potential - as well as the water temperature, while sub samples of both water and sediment can be easily obtained and analysed for a series of chemical substances. The simulation technique employing the chamber is capable of investigating most of the coastal water sediment interfaces.

Concerning the determination and the distribution of nutrient fluxes, a series of experiments took place near fish farm installations and coastal lagoon areas. The calculated fluxes ( $\mu$ M/d) inside the benthic chambers can be used as first approximations of the actual natural conditions. The results showed that even minor changes in the redox conditions at a relatively narrow zone near the water-sediment interface have significant impacts on the concentrations of dissolved nitrogen, phosphorus and silicate compounds [3]. The use of this type of benthic chamber, in combination with in situ studies, can achieve a realistic assessment of the consequences of marine pollution in coastal embayments and improve the design of environmental management plans.

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# STUDY OF THE N, P AND SI FLUXES UNDER ANOXIC CONDITIONS BETWEEN FISH FARM SEDIMENT AND SEAWATER. RESULTS OF A SIMULATION EXPERIMENT

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### Abstract

Over the last decade cage fish farming has expanded rapidly particularly in the Mediterranean where Greece is currently the main producer. The aim of this paper is to explore the behaviour of such an affected area under anoxia by measuring the fluxes of ammonium, nitrite, nitrate, TDN, phosphate, TDP and silicate between the surface sediment and the overlying waters. To achieve this goal we used a prototype benthic chamber capable of sampling considerable quantities of affected undisturbed sediment along with its overlying water. The concentrations of ammonium, nitrite, TDN, phosphate, TDP and silicate rapidly increase, those of nitrate decrease. DON and DOP exhibit remarkable fluctuations.

Keywords : Anoxia, Coastal Management, Oxygen, Redox, Sediments.

The operation of cage fish farms is not free from environmental consequences, the most important of which is related to significant redox reactions connected with the formation of an organic rich, loose "nepheloid" sediment layer below or near the cages, consisted mainly of the food-remains together with the pellets and metabolic products from fish [1]. The aim of this work is to explore the behaviour of such a system. To achieve our goal we constructed a portable benthic chamber, capable of sampling surface sediment along with its overlying water column. After sampling, the chamber was transported from the study area to the Environmental Chemistry Laboratory of the University of Athens. The chamber allows for the water temperature and the dissolved oxygen concentration to be continuously and automatically controlled [2]. The study area is located in a coastal site near the Acheloos river estuary at the Aquaculture Center of Acheloos SA (ACEA SA). The simulation experiment lasted 9 days under set anoxic conditions where the dissolved oxygen concentration decreased rapidly from 5.0 mg/l to 0.4 mg/l, (Fig. 1a) where it remained constant.Ammonium, nitrate, nitrite, phosphate and silicate concentrations in sea water samples were determined with standard spectrophotometric methods [3]. Total Dissolved Nitrogen (TDN) and Total Dissolved Phosphorus (TDP) were determined following a persulfate oxidation [2]. Dissolved Organic Nitrogen (DON) was calculated as the difference between TDN and Dissolved Inorganic Nitrogen (DIN - sum of nitrate, nitrite and ammonium). Dissolved Organic Phosphorus (DOP) was calculated as the difference between TDP and phosphate.During anoxia we observed some remarkable changes. The concentration of NH4+ (Fig. 1b) increases in an impressive way. Nitrate concentration falls rapidly to near zero values (Fig. 1c) while  $NO_2^-$  (Fig. 1d) concentration fluctuated widely before reaching near zero values. From the inorganic forms of nitrogen NO<sub>3</sub><sup>-</sup> was the prevailing species at the beginning, falling rapidly with simultaneous increase of  $NH_4^+$ , which becomes progressively the dominant species. The concentrations of PO43-(Fig.1e) and SiO44-(Fig. 1f) also increased significantly. The DON was the dominant form at the end of the experiment compared to inorganic nitrogen forms which dominated at the beginning.



Fig. 1. The evolution of (a) dissolved oxygen, (b) ammonium, (c) nitrate, (d) nitrite, (e) phosphate and (f) silicate concentrations in the benthic chamber throughout anoxia, n=9 days.

The rapid decrease of dissolved oxygen concentration and predominance of anoxic conditions is an indication of the death of micro biota that prevailed in the ecosystem of the benthic chamber and degradation of biomass by anaerobic bacteria releasing water soluble forms of organic nitrogen and phosphorus and eventually some silicates originating from the autolysis of cells of diatoms. The release of  $PO_4^{3-}$  through the reduction mechanism of insoluble FePO<sub>4</sub> into soluble Fe<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> [4] probably contributes to the increase of the concentration of phosphates, while dissolution of silicate depositions from the sediment contributes significantly to the increase of the silicate concentration. Statistical analysis of the concentrations of  $PO_4^{3-}$ ,  $SiO_4^{4-}$  and  $NH_4^+$  (*sest* :the standard deviation about the regression line, and p value: determines whether the association between the variables is statistically significant) are shown in Figure 1 and the consideration of their ratios support the above mentioned hypotheses.

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# HEAVY METAL CONCENTRATIONS IN RED MULLET *MULLUS BARBATUS* (L. 1758) FROM THE IBERIAN PENINSULA COAST (NORTHWESTERN MEDITERRANEAN)

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### Abstract

In this paper we present the concentrations of heavy metal (Hg, Cd, Pb, Cu, Zn and As) in *Mullus barbatus* from seven areas of the Iberian Mediterranean coast under different degree of anthropogenic pressure. Hg, Cd and Pb levels obtained are compared with those found in specimens caught from the same areas during the period 1984-87.

Keywords : Bio-accumulation, Coastal Systems, Fishes, Metals, Western Mediterranean.

### Introduction

Pollution of the marine environment with heavy metals from land-based sources (industrial, agriculture, mining, etc.) is one of the specific problems to be addressed in the Iberian mediterranean coast [1]. Red mullet is a demersal fish [2], associated with muddy bottoms, used as bioindicator in the Mediterranean Pollution Monitoring Programme (MED POL). The degree of exposure of *Mullus barbatus* populations to heavy metals was measured by the analyses of muscle tissue in specimens from each sampling site. Data obtained should help to establish the baseline concentrations of heavy metal in this specie along Iberian Mediterranean coast.

### Material and Methods

Specimens of *Mullus barbatus* (n = 10; length interval: 12-18 cm.) were collected from seven areas (Santa Pola, Mar Menor, Cartagena, Mazarrón, Aguilas, Almería y Nerja) (Figure 1) using commercial bottom-trawler or gill net fisheries during Autumn 2004. Once collected, the specimens were identified, their length measured and immediately frozen at -20  $^{\circ}$ C.



Fig. 1. Map of the study area and sampling sites.

Preparation of the samples included muscle tissue dissection, freeze drying, homogenization and wet digestion using microwave oven. The quantitative analyses were carried out by A.A.S (Perkin Elmer Model 4110 ZL) through graphite furnace (As, Pb, Cu, Cd), flame (Zn) and cold vapour (Hg). The accuracy of the analytical procedures was tested and controlled using certified reference material (CRM-422) and participating in the intercomparison exercise QUASIMEME. Statistical differences between mean metal concentrations in different areas were evaluated using parametric or non-parametric test (Kruskall-Wallis), in function of the nature of data obtained (Normality and Homogeneity in Variances). Post-hoc comparisons were also performed to test differences among areas (Tukey b or Tamhane tests).

### Results and Discussion

Mean metal concentrations from the study areas are shown in Table 1. Cu concentrations ranged from 0.332 to 0.448 mg/kg of wet weight and they were similar in all study areas (1-way ANOVA, p=0.054). Hg concentrations ranged from 0.001 (Mar Menor lagoon) to 0.170 mg/kg w.w. (Mazarrón) and significant differences were observed among areas (1-way ANOVA, p=0.000). High Hg concentrations were also found in Aguilas and Cartagena areas. Cd levels ranged from 1.550 (Cartagena) to 1.059

mg/kg w.w. (Nerja). Pb concentrations ranged from 0.121 (Cartagena) to 0.038 (Nerja). For Cd and Pb, significant differences were also observed among areas (1-way ANOVA, p=0.000; Kruskall Wallis, p=0.000;). In the case of Zn and As, its levels were significantly higher in Mar Menor lagoon than in rest of the areas (1-way ANOVA, p=0.000). These high levels of As and Zn in the coastal lagoon could be explained by the inputs from the old of mine activities and the present intensive agricultural that is taking place into its drainage area.

If we compare the Hg, Cd and Pb concentrations measured in red mullet caught in the same areas during the period 1984-1987 (IEO, unpublished data), it can be observed a general increase of Hg mean concentrations and a strong decrease of Cd and Pb concentrations (Table 1), especially in the case of specimens caught in Cartagena area.

Tab. 1. Concentrations of metals (mean  $\pm$  standard error of the mean) in muscle tissue of *Mullus barbatus* from areas sampled in 2004 and during the 1984-1987 period. Asterisks means pooled samples.

| Area | Year      | N   | Hg                | Cd            | Pb                |  |
|------|-----------|-----|-------------------|---------------|-------------------|--|
|      |           |     | mg#kgw.w.         | mg/kg w.w.    | mg/kg w.w.        |  |
| 1    | 2004      | 10  | $0.056 \pm 0.006$ | 1.359 ± 0.065 | 0.048 ± 0.005     |  |
|      | 1984-87   | 15* | 0.085 ± 0.010     | 2.21 ± 0.28   | 0.071± 0.015      |  |
| 2    | 2004      | 10  | 0.001 ± 0.001     | 1.122 ± 0.045 | 0.051± 0.008      |  |
|      | 1984-1987 | 57  | 0.035 ± 0.010     | 7.2 ± 2.58    | 0.028 ± 0.006     |  |
| 3    | 2004      | 10  | 0.137 ± 0.021     | 1.550 ± 0.040 | 0.121 ± 0.027     |  |
|      | 1984-87   | 17* | 0.080 ± 0.013     | 3.38 ± 0.72   | 0.618 ± 0.017     |  |
| 4    | 2004      | 10  | 0.170 ± 0.022     | 1.281 ± 0.097 | 0.097 ± 0.016     |  |
|      | 1984-87   | 12* | 0.136 ± 0.025     | 2.80 ± 0.36   | 0.084±0.019       |  |
| 5    | 2004      | 10  | 0.147 ± 0.016     | 1.157 ± 0.062 | 0.068 ± 0.009     |  |
|      | 1984-87   | 12* | 0.048 ± 0.007     | 2.20 ± 0.033  | 0.070 ± 0.015     |  |
| 6    | 2004      | 10  | 0.101 ± 0.011     | 1.257 ± 0.053 | $0.051 \pm 0.003$ |  |
|      | 1984-87   | 13* | 0.053 ± 0.013     | 2.31 ± 0.28   | 0.076 ± 0.015     |  |
| 7    | 2004      | 7   | 0.025 ± 0.004     | 1.059 ± 0.046 | 0.038 ± 0.001     |  |
| Area | Year      | N   | Cu                | Zn            | As                |  |
|      |           |     | mg/kgw.w.         | mg/kg w.w.    | mg/kg w.w.        |  |
| 1    | 2004      | 10  | 0.332 ± 0.015     | 3.30 ± 0.86   | 11.28 ± 0.83      |  |
| 2    | 2004      | 10  | 0.434 ± 0.036     | 5.06 ± 0.30   | 23.71 ± 2.59      |  |
| з    | 2004      | 10  | 0.386 ± 0.019     | 4.16 ± 0.15   | 11.97 ± 1.67      |  |
| 4    | 2004      | 10  | 0.414 ± 0.027     | 3.62 ± 0.15   | 15.01 ± 1.42      |  |
| 5    | 2004      | 10  | 0.435 ± 0.033     | 4.02 ± 0.24   | 17.44 ± 2.35      |  |
| 6    | 2004      | 10  | 0.448 ± 0.023     | 3.77 ± 0.22   | 16.10 ± 1.49      |  |
| 7    | 2004      | 10  | 0.427 ± 0.049     | 4.16 ± 0.32   | 10.35 ± 1.10      |  |

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# HEAVY METAL LEVELS ALONG THE IBERIAN PENINSULA AND BALEARIC ISLANDS COAST (NORTHWESTERN MEDITERRANEAN) USING CAGED MUSSELS: AN ACTIVE BIOMONITORING APPROACH (MYTILOS PROJECT)

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# Abstract

Within the framework of the INTERREG III B/MEDOCC MYTILOS Project, the heavy metal (Hg, Cd, Pb, Cu, Zn and As) concentrations in cage mussels (*Mytilus galloprovincialis*) were determined. The purpose of the MYTILOS project is the development of an interregional costal water quality monitoring network in the western Mediterranean basin based on active biomonitoring through caged mussels. In this paper, we present the preliminary results obtained during the period 2004-2006 from 36 stations located in the wastewater dilution zone along the Iberian Mediterranean and Balearic Islands coast. In general, all the levels obtained can be considered as baseline or low, except for Pb in the section of coast between Portman (Murcia) and Cabo de Gata (Almería) where the levels found were higher than 6.81 mg/Kg d. w

Keywords : Bivalves, Bio-accumulation, Metals, Monitoring, Western Mediterranean.

#### Introduction

In the last decades, the use of the mussel has become a general method to evaluate the environmental quality of coastal waters [1]. Until now, the developed strategies are two: passive biomonitoring (using indigenous populations of wild mussels) and active biomonitoring (using individual transplants from a reference site). The MYTILOS project (http://mytilos.tvt.fr/) is based on the advantages of the active biomonitoring: a known period of exposure, stations selected regardless of the existence of natural populations and their distance from the coast, and the possibility of to adjust raw concentration data to a reference condition index [2], making a clear distinction between physiological factors (growth) and environmental ones.

### Material and Methods

Each 3 Kg-sample was made up of adult mussels (*Mytilus galloprovincialis*) 18-24 months old of standardized shell size (50 mm) coming from a reference site (Languedoc-Rousillon). The cages were immersed between 20 and 30 m at different stations along the Iberian Mediterranean coast and Balearic Islands (Fig. 1) during several surveys (2004, 2005 and 2006).



Fig. 1. Map of the study area and sampling sites.

After two months, the cages were recovered and pre-processed according to standardized procedures: the mortality and some biometric parameters were recorded, the soft tissue was cut out of the shells parts, weighed and frozen at - 20 °C. The condition index (ratio of dry flesh weight to dry

shell weight) was measured on 10 animals for each cage. The following techniques were used to analyses heavy metals: Pb, Cd, Cu, Zn: oven or flame Atomic adsorption spectrometry. Hg: Cold vapour. As: hydrides technique. For metals, tissue concentration is inversely proportional to the condition index.

#### Results and Discussion

Results are expressed in mg/Kg of dry mussel flesh. Hg concentrations ranged from 0.002 (Tabarca I.) to 0.279 (Cartagena-Palomas I.), with a mean level of  $0.151\pm 0.005$ . Cd levels ranged from 0.714 (Besòs river) to 3.351 (Fornells), with a mean level of  $2.151\pm 0.068$ . Pb concentrations ranged from 1.029 (Cabo de Palos) to 8.714 (Cartagena-Palomas I.), with a mean level of  $2.831\pm 0.21$ . Cu levels ranged from 3.222 (Ebro river) to 5.539 (Alcudia) with a mean level of  $4.284\pm 0.049$ . Zn concentrations ranged from 38.966 (Cabo de Palos) to 272.781 (Cabrera), with a mean level of  $176.323\pm 4.62$ . As levels ranged from 2.004 (Fornells) to 29.591 (Tabarca I.), with a mean level of  $12.742\pm 0.52$ . Figure 2 presents raw and adjusted data of Hg concentrations in the soft parts of transplanted mussel. On the whole, mean levels of Hg, Cd, Cu y Zn were higher in the Balearic Islands stations than in the Peninsula ones. On the contrary, the average concentrations of Pb and As were higher in the Peninsula coast that in Balearic Island.



Fig. 2. Raw and adjusted data of Hg concentrations in the soft parts of transplanted mussel (Mean  $\pm$  standard error of the mean).

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# ESTIMATION OF PHYTOPLANKTON CARBON (PHYTO C) BY USING VARIABILITY OF CHL A VERSUS PARTICULATE ORGANIC CARBON (POC) AND THEIR RELATIONSHIPS WITH NITROGEN (PON) ALONG THE SALINITY GRADIENT IN THE MOUTH OF THE GEDIZ RIVER, IZMIR BAY, AEGEAN SEA

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### Abstract

In order to determine accurate estimates of phytoplankton biomass, Phytoplankton Carbon (Phyto C) values were computed by using Chl-a and Particulate Organic Carbon (POC) data. Particulate Organic Nitrogen (PON), POC and Chl a distributions in the mouth of the heavily polluted Gediz River through the salinity gradient showed that the river acts as a source for the plume area but as a sink for the Outer Izmir Bay regardless the alterations in its flux. The linear regressions of POC vs. Chl a and POC vs. PON showed that the spatial variations in POC:Chl and POC:PON were within the ranges of 3000-300 and 4-0.3, respectively. The former seems to be related with the variatons in detrital carbon (about 1500 mg/l-100 mg/l) along the salinity gradient.

Keywords : Aegean Sea, Brackish Water, Coastal Processes, River Input, Phytoplankton.

Berger et al. [1], Falkowski, [2] and Antoine et al. [3] have drawn attention to the fact that phytoplankton may fix between 35-45 Pg (peta-grammes=1015 g=gigatonnes) of carbon per year, i.e. no less than 30-60 % of the global annual fixation of carbon on Earth, despite these organisms account for only 1-2% of the global biomass [1]. The amount of Chl a is generally used as an index of the living photosynthetically active phytoplankton biomass. But it has an inherent error because of cell size and photoacclimation. Therefore, the reach of phytoplankton carbon (Phyto C) is essential for obtaining more accurate and precise information on their biomass. Direct measurement of Phyto C in nature is impossible because it is inseperable from non-phyto C by any convenient and reliable approach [4]. Therefore, in the present study Phyto C values were estimated by using POC and Chl a data.

The study area, Gediz river is heavilly polluted due to agricultural drainage water, industrial waste water and virtually all domestic waste water from the entire provincial area. It is the second largest river flowing into the Aegean Sea from Anatolia through Izmir Bay. During the study period (August 2004- August 2005) samples were taken 7-8 stations in the mouth of Gediz river through the salinity gradient. POC, PON and Chl a together with the physical parameters of seawater.In order to estimate Phyto C, POC and Chl a data collected through the salinity gradient which could be classifed into five different salinity ranges as: 0-5, 8-20, 20-30, 30-38, 38-40 psu's, were used as described by Wienke and Cloern (1987) [5].



Fig. 1. Distribution of POC, Chl a and Phyto C through the salinity gradient.

Significant correlations were found among the particulate materials (POC, PON, TSS, Chla, Phyto C and salinty). POC, Chl a and PhytoC distribution through the salinity changes from the Gediz River to the Outer Izmir Bay were shown in the Figure 1. Phyto C ranged from 70 mg/l (43% in POC) in November'04 in the outer bay to 3700 mg/l (73% in POC) in April'05 in the mouth of Gediz river. As the salinity increases, Phyto C decrese as well as other particulate materials i.e. POC, PON, Chl a. This indicates that POC is mainly determined by phytoplankton.

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# THE PARTICULATE TRACE METAL (CU, ZN, CR, FE, MN, NI, PB AND HG ) LOAD CARRIED BY GEDIZ **RIVER INTO THE OUTER IZMIR BAY; THE AEGEAN SEA**

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### Abstract

In the surface water in the mouth of the Gediz river, the concentrations of particulate Cu, Zn, Cr, Fe, Mn, Ni, Pb and Hg measured for determining their loads to the outer section of the Izmir Bay. Excluding Mn and Hg, the temporal variations of the particle trace metals showed significant correlations with the river flow. With their independence from the flow, the transport patterns of Mn and Hg indicated that the Gediz River was a non-point source for these metals. There were also significant correlations between the suspended particulate matter (SPM) and the particulate metal concentrations except for Hg. The highest flow since 1999, had been recorded on February 18, 2005 exactly which one of the sampling surveys was carried out.

Keywords : Aegean Sea, Trace Elements, Particle Flux, River Input.

#### Introduction

Macro (N, P, Si and organic C) and micro (Fe, Mn, Co, Ni, Cu, Zn) nutrient inputs from the rivers influence the biogeochemical processes in the coastal seas and affect the quality and quantity of material accumulating in marine sediments. Changes in salinity brought about by fresh water and the introduction of river-derived nutrients have been found to promote the growth of siliceous plankton which increased the fluxes of biogenic opal and organic matter [1]. Among the micronutrients, Fe, Mn, Co, Ni, Cu and Zn are important metals. It is important to understand antagonist and synergic interactions between metals and the effects of these interactions on primary productivity in the coastal zone. These trace nutrients are required in metabolic processes for both marine and fresh water phytoplankton [2]. However, the some of these micronutrients are hazardous to aquatic life and human health when their concentrations are higher than the natural levels. For example, there is evidence that trace metals might also have been involved in the development of certain harmful species [3] in addition to the pollution in the sediment.

### Material and Methods

Analysis of these metals in SPM (suspended particulate matter) was carried out by flame AAS (Varian Spectraa-300 plus). Prior to the determinations, the samples were microwave-digested (Milestone 1200 Mega) in Teflon bombs using a mixture of HNO3-HF-HClO4-HCl. Since this study was the first effort for taking the sample on particle flux of trace metals in the mouth of Gediz River, the very first data set were finally obtained and preented. There were four sampling surveys over a 1-year period for the particle trace metals, i.e., November 04, February, April and August 05. The main strategy in the determination of the sampling timing was the matching the periods of river's low and high flows. The relationships between metal concentrations, SPM, flow, dissolved oxygen, pH, and temperature were examined. Metal loadings were estimated by using the metal concentrations and river's flow.

#### Results and Discussion

The specific objectives of the research were the following: (i) Collect reliable analytical data on the concentrations of particle Cu, Zn, Cr, Fe, Mn, Ni, Pb and Hg in the mouth of the river entering to the outer Izmir Bay, (ii) Obtain particle metal data at both high and low stream flows, (iii)Use particle metal concentration and flow data to generate metal loading data for the Gediz River as a first step in understanding the effects of particle metal input on the water quality of the outer Izmir Bay.

Metals in the river is transported principally by suspended sediments. A large proportion of the suspended sediments are discharged to the outer Izmir bay during high flow events and are deposited into bottom sediments when the flow rate of water carrying them is decreased. The flux during the study period had seasonally changed in the range of 5 to 123  $m^3 s^{-1}$ . The freshwater discharges to the outer Izmir bay are generally low, an overall mean annual freshwater contribution to the outer Izmir bay of approximately 33 m<sup>3</sup> s<sup>-1</sup> when the monthly averaged values since 1962 were considered. The period of trace metal deployment in the plume coincided with the period of high water discharge of the river. Maximum fluxes of biogenic and lithogenic components coincided with maximum discharge of the Gediz River during February 05. Freshwater SPM was deposited near its source, and the small amount that is exported to the outer Izmir Bay is probably subject to successive resuspension. The river act as effective sediments traps. Then sediments are behaving as an important diffuse source, being reservoir of trace metals from continental discharges, which are released to the water column due to resuspension.

Large seasonal variations of fluxes were observed for Cu (about 300.000 times), Pb (about 300.000 times), Fe (about 2.000 times), Cr (about 500 times), Zn (about 500 times), Mn (about 350 times), Ni (about 300 times) and Hg (about 50 times) when the maximum particle metal flux values were compared with their minimum values.

At the end of the present study, the following recommendations are made: i)Metal concentrations should be studied at more stations and at all seasons even daily sampling to determine to what extent metals are transported and recirculated from sediment into overlying waters, ii)Organisms at all trophic levels should be examined over a period of several years for bioactive metals.

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# LEAD BIOACCUMULATION IN THE MEDITERRANEAN MUSSEL MYTILUS GALLOPROVINCIALIS

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### Abstract

Uptake and loss kinetics of waterborne Pb, using radiotracer <sup>210</sup>Pb, were investigated in the mussel *Mytilus galloprovincialis*. Pb was readily taken up (concentration factor up to 300 after 14 days of exposure) and was relatively strongly retained (biological half-life: 23-28 days). Bioconcentration and retention efficiency of Pb in the mussel tissues were found to be independent of its ambient dissolved concentrations.

Keywords : Bio-accumulation, Bio-indicators, Bivalves, Lead.

#### Introduction

Among metal contaminants, Pb is an element of particular concern due to its widespread occurrence in the marine environment and its welldocumented toxicity for biota [1,2].

Although severely regulated in the industrialised countries, global emissions do not show a significant downward trend and Pb will continue to cause problems [3,4]. It is thus important to develop tools to monitor its occurrence and abundance in coastal waters, particularly in less-developed regions of the world where the legislation on its uses and disposal are often weakly enforced.

Bivalve molluscs, particularly the genus *Mytilus*, are well known to bioaccumulate metals up to several orders of magnitude with respect to the levels found in their environment and to fulfill the additional criteria as being ideal biomonitors since they are sedentary and easy to sample [5,6]. The aim of this work was to investigate Pb bioaccumulation using <sup>210</sup>Pb radiotracer under controlled laboratory conditions in a widely distributed and abundant mussel species along the Mediterranean coasts, *viz. Mytilus galloprovincialis*, and to evaluate its potential as a bioindicator species to be considered for biomonitoring Pb contamination in the coastal marine environment of North Africa.

#### Material and methods

In order to minimize the effect that size (age) may exert on metal concentrations, 40 specimens of *Mytilus galloprovincialis* of uniform size (30-35 mm length; 5.0-6.5 g wet wt) were collected in Corsica in September 2002. Upon return to the laboratory, the shells of the mussels were cleansed and tagged and animals were then acclimated for two weeks under laboratory conditions (temperature  $19^{\circ}$ C; salinity 37 p.s.u.).

After acclimation, the mussels were exposed for 14 days to 4 different concentrations of waterborne  $^{210}$ Pb (0.25, 0.5, 1.25 and 2.5 Bq ml<sup>-1</sup>). Each specimen was gamma-counted on a daily basis using a NaI detector to determine  $^{210}$ Pb uptake kinetics. In order to ensure a constant  $^{210}$ Pb activity in each of the 4 aquaria, the seawater and the radioactive spike were renewed each day; seawater samples were collected and gamma-counted before and after each seawater renewal.

Following the uptake phase, organisms were dissected in order to assess the body partitioning of the radioactivity and the remaining animals were placed into running-seawater aquaria for 22 days in order to study their depuration kinetics.

#### Results and Discussion

The results of the seawater exposure experiments indicate that *M. galloprovincialis* readily took up <sup>210</sup>Pb according to a linear uptake-kinetic model (Fig. 1a). Uptake efficiency (with respect to the dissolved <sup>210</sup>Pb concentration in the surrounding seawater) was similar (p = 0.35) for the 4 exposure conditions (0.25 to 2.5 Bq <sup>210</sup>Pb ml<sup>-1</sup>). At the end of the exposure period (14 days), calculated concentration factors for the different exposure conditions reached values ranging between 210 and 300.

Following the exposure period, non-contaminated conditions were restored (clean flowing sea water) for 22 days and loss of  $^{210}$ Pb from mussel tissues was determined (depuration phase) during that time.

*M. galloprovincialis* was found to eliminate <sup>210</sup>Pb according to monoexponential loss kinetics (Fig. 1b). Mussels displayed similar loss kinetics (p = 0.25) regardless the <sup>210</sup>Pb activity (0.25 to 2.5 Bq ml<sup>-1</sup>) to which they were previously exposed: the estimated biological half-life (Tb<sub>1/2</sub>) of <sup>210</sup>Pb ranged between 23 and 28 d. The experimental results presented here indicate that *M. galloprovincialis* bioconcentrates waterborne Pb efficiently in its tissues, and that concentration factors are independent of the dissolved metal concentration in the seawater, i.e. bioconcentration of Pb in the mussel tissues is proportional to the metal concentration in the surrounding seawater. The mussel also displayed a relatively long retention time of incorporated Pb (Tb<sub>1/2</sub> from 23 to 28 days), and the elimination kinetics in relative units are independent of the dissolved <sup>210</sup>Pb concentration in the environment.



Fig. 1. Uptake (a) and loss (b) kinetics of  $^{210}$ Pb in *Mytilus galloprovincialis* exposed to 0.25 Bq  $^{210}$ Pb ml<sup>-1</sup> via sea water (n = 5).

These findings are very promising as they indicate that the Pb concentration in the edible tissues of *M. galloprovincialis* would actually reflect the Pb contamination level in its environment, and that this bivalve would be able to preserve the information related to contamination events for several weeks in its tissues.

The results of our experimental work strongly support the usefulness of *M.galloprovincialis* as an excellent bioindicator species for Pb contamination monitoring in North African waters.

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# ÉVALUATION DE LA RADIOACTIVITÉ PRÉSENTE DANS LES MOULES LE LONG DU LITTORAL ALGÉRIEN

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## Résumé

Dans le cadre du projet de la CIESM pour la mise en place d'un réseau de bio-surveillance radiologique en Méditerranée, des moules ( *Mytilus galloprovincialis*) provenant de 3 stations (Centre, Est et Ouest de la côte algérienne) ont été analysées en spectrométrie gamma puis, après séparation radiochimique, en spectrométrie alpha (<sup>210</sup>Po). Les résultats indiquent que les moules ne présentent aucune trace de <sup>137</sup>Cs et que les concentration des radioéléments naturels sont faibles.

Mots clès : Bio-indicators, Radioactivity, Bivalves.

### Introduction

Outre la radioactivité naturelle, des radionucléides artificiels sont introduits dans le milieu marin par l'intermédiaire de différentes sources de contamination anthropiques. Ces radionucléides sont notamment accumulés par les organismes marins et, parmi ceux-ci, les moules qui sont reconnues comme d'excellents indicateurs biologiques. Le but du projet est la mise en place d'un réseau de surveillance couvrant la Méditerranée à l'aide de bioindicateurs de l'état de la contamination du milieu. La première phase du projet concerne les contaminants radioactifs ; l'extension du projet à d'autres polluants conventionnels est prévue ultéruement. Ce travail permettra l'élaboration d'une stratégie de surveillance appropriée, le suivi des variations spatio-temporelles de la bioaccumulation des radionucléides par les moules, l'harmonisation et la standardisation des procédures appliquées, la compilation et la comparaison des résultats présentés par les pays membres de la mer Méditerranée.

#### Matériels et Méthodes

Prélèvement des échantillons :

Des moules *Mytilus galloprovincialis* (longueur : 4 à 11 cm) ont été récoltées en pêche à pied au cours du premier semestre 2003 dans 3 stations : Bouharoun (station 1), El-Kala (station 2) et Oran (station 3) (Fig. 1). La quantité collectée en poids frais total est de 675g pour la station 1, 3.480g pour la station 2 et de 465g pour la station 3 (viz. 28, 147 et 17g poids sec, respectivement). L'indice de condition a été déterminé et varie de 0.052 à 0.079.



Fig. 1. Localisation de trois stations: 01-Bouharoun; 02-El-Kala; 03-Oran

# Analyse en spectrométrie gamma et détermination de la concentration du $^{210}Po$

Une fois les échantillons séchés et homogénéisés, ils ont été analysés en spectrométrie gamma (détecteur germanium hyperpur ; efficacité relative: 30%). Une aliquote de 1g a ensuite été prélevée pour en extraire le <sup>210</sup>Po selon la procédure décrite dans [1]. Le <sup>208</sup>Po a été utilisé comme traceur interne et les comptages ont été réalisés à l'aide d'un détecteur à barrière de surface. Le matériel de référence "Cockle Flesh - AIEA 134" a été analysé dans le cadre d'un exercice d'inter comparaison (AIEA-LEM, Monaco).

### Résultats et Discussion

Les concentrations en Bq/Kg poids sec obtenues et les concentrations minimales détectables (CMD) sont présentées au Tableau 1. Les résultats montrent que les moules prélevées dans les trois stations n'ont fixé que la radioactivité naturelle, notamment les descendants des familles de l'uranium et du thorium et le 40K. La radioactivité artificielle, caractérisée principalement par le <sup>137</sup>Cs, est inférieure aux limites de détection. Les concentrations en Bq/Kg sec sont obtenues à partir des rendements de détection déduits de l'échantillon AIEA-134. Sur la base de travaux similaires effectués en mer Méditerranée, on constate que les concentrations en <sup>210</sup>Po sont dans la même gamme de valeurs [2-4].

Tab. 1. Activité des radioéléments (Bq/kg PS) dans Mytilus galloprovincialis.

| Station      | 212Pb           | 214Pb           | <sup>214</sup> Bi | *ºK              | 210Po      | 137Cs |
|--------------|-----------------|-----------------|-------------------|------------------|------------|-------|
| 01 Bouharoun | 1               | $0.65 \pm 0.13$ | $1.28 \pm 0.11$   | $313.5 \pm 15.9$ | 107 ± 7.4  | < L.D |
| 02 El-Kala   | $0.84 \pm 0.06$ | 1               | $1.29 \pm 0.13$   | 217.3 ± 11.3     | 267 ± 16.4 | 1     |
| 03 Oran      | 1               | $3.22 \pm 0.28$ | $5.03 \pm 0.36$   | $184 \pm 10.02$  | 158 ± 11.2 | 1     |
| CMD          | $0.05 \pm 0.01$ | $0.09 \pm 0.02$ | $0.20 \pm 0.02$   | $2.52 \pm 0.29$  | 1          | 0.04  |

#### Conclusions

Les résultats montrent l'absence totale de radioactivité artificielle ( $^{137}$ Cs) dans les moules du littoral algérien. Les conditions de collecte, de transport et de conservation des échantillons doivent cependant encore être optimisées afin d'améliorer la représentativité de l'échantillon. Une collaboration avec d'autres partenaires serait bénéfique pour assurer la récurrence des prélèvements nécessaire à l'étude des variations spatiale et temporelle de la contamination radioactive dans le milieu marin.

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# UTILISATION D'UN MOLLUSQUE BIVALVE : *DONAX TRUNCULUS* (LINNÉ, 1758) COMME INDICATEUR DE LA QUALITÉ DES EAUX LITTORALES DANS LE GOLFE DE TUNIS

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### Résumé

Dans le présent travail, nous avons donné une importance particulière à un biomarqueur de pollution, l'Acétylcholinestérase (AChE), mesurée chez une espèce de bivalve sentinelle *Donax trunculus* récoltée au niveau du Golfe de Tunis. L'étude a permis de montrer que l'activité cholinestérasique au niveau du manteau diminue significativement (p<0.05) pendant la saison estivale dans les deux stations de Radés et Kalâat El Andalous et que le niveau d'activité de l'AChE chez les individus de Radès est inférieur à celui des individus de Kalâat El Andalous durant toute l'année.

Mots clès : Bio-indicators, Bivalves, Ecotoxicology.

### Introduction

L'agriculture intensive employée dans certaines régions nécessitent l'usage de pesticides (insecticides, herbicides, fongicides, etc.) pour une meilleure rentabilité du secteur. Toutefois, l'application de ces produits, de manière abusive et non contrôlée peut entraîner des conséquences néfastes sur l'Homme et sur son environnement. Pour cela, une attention particulière a été portée sur l'étude de l'activité de l'AChE ; inhibée essentiellement par les pesticides Organophosphorés et Carbamates ; chez une espèce de bivalve "*Donax trunculus* "choisie comme espèce bioindicatrice de la qualité des eaux littorales des plages sableuses de Kalâat El Andalous (KA) et de Radès (R) qui sont respectivement sous l'influence des apports d'Oued Medjerda et Oued Méliane.

### Matériel et Méthodes

Nous avons réalisé un échantillonnage mensuel qui couvre la période allant de juillet 2004 à juin 2005. Le dosage de l'activité cholinestérasique chez *Donax trunculus* est déterminé par la méthode d'Ellman *et al* [1]. Le dosage des protéines est effectué selon la méthode de Lowry *et al.* [2]. La signification des différences entre les moyennes a été analysée par ANOVA.

#### Résultats et discussion

La variation saisonnière de l'activité enzymatique (figure 1) montre que cette activité suit une évolution similaire au niveau des deux stations.



Fig. 1. Variation saisonnière de l'activité de l'AChE chez le flion au niveau R et KA.

En effet, les valeurs les plus faibles de l'activité de l'AChE sont enregistrées pendant l'été 2004 et les plus élevées durant le printemps 2005. Les niveaux d'activité enzymatique seront plus ou moins stables durant l'automne et l'hiver. Les analyses statistiques montrent qu'au niveau d'une station les différences de niveaux d'activité sont significatives (p<0,05) entre la saison printanière et les autres saisons et ceci pour les deux stations; R et KA. Notons bien que les niveaux d'activité les plus faibles correspondent aux sites les plus contaminés [3]. L'activité de l'AChE dans la station R. parait être la plus faible lorsqu'elle est comparée à celle de KA. Des niveaux d'inhibition de l'activité enzymatique de l'ordre de 81 % sont observés dans la station R aux mois de juillet et août 2004 comparé à la valeur maximale de l'activité observée en mai 2005, ce pourcentage d'inhibition assez élevé est supérieur à 20 % durant la période estivale (2004) donc il sera considéré comme étant un effet toxicologique de l'exposition aux xénobiotiques [4]. La station de Kalâat El Andalous quand à elle, présente une baisse du niveau d'activité pendant l'été 2004 correspondant à 74 % par rapport à la valeur enregistrée au mois de juin 2005.

En conclusion, nous pouvons dire que les résultats de la variation saisonnière de l'activité AChE trouvés chez *Donax trunculus* montrent que ce bivalve pourrait être utilisé dans les programmes de biosurveillance comme un bon bioindicateur de la qualité des eaux marines des côtes sableuses.

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# INVESTIGATING THE MUTAGENIC EFFECTS OF MEDITERRANEAN COASTS OF TURKEY

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### Abstract

In the current study, mutagenicity experiments without metabolic activation using mutant TA98 strain of *Salmonella typhimurium* were performed on sediment samples of 8 stations chosen from Mediterranean Coastline of Turkey between September 2005 and October 2005. The study showed that sediment samples from selected stations were not mutagenic for the TA98 strain. The study is of importance in that it is the first one alming at screening mutagenicity in the region.

Keywords : Pollution, Ecotoxicology, Sediments.

### Introduction

Mediterranean Sea, of which coasts are shared by 21 countries, is regarded as an ecological inheritance for the world. According to the reports presented in the meetings held by United Nations Environmental Program (UNEP) and Mediterranean Action Plan (MAP), actions should be started immediately for Mediterranean Sea; because, it is bearing a load exceeding its capacity for a long time. Blue Plan Report in the context of MAP contains a scenario for situation of Mediterranean by 2005. Accordingly, riches of Mediterranean Sea will be run out if energy and water sources are not used well and terrestrial pollutants are continued to be discharged in Mediterranean Sea. Mediterranean Sea constitutes 0.7% of all sea water on the world and 7% of world population lives on the countries o its coasts. A total of 425 million people live in Mediterranean Region with 150 million of them living on its coastline. Mediterranean is most affected by load of tourism and marine transportation. Annually, about 200 million tourists come to Mediterranean coasts and population in the region doubles during tourism season. 30% of international marine traffic is performed on Mediterranean Sea with waters carried into Mediterranean Sea by ships alters the environmental balance in it. Solid wastes and waste waters must absolutely be prevented to be discharged into Mediterranean Sea. Annually, about 40 million ton of solid waste and 80% of waste waters as well as 150.000 ton of oil are being discharged into Mediterranean Sea. The nations should start actions on waste waters and solid wastes. Unfortunately, work on this issue is far from being satisfactory. "We determined that chemical wastes are being discharged from some regions into the sea", says Paul Mifsud, Coordinator of UNEP-MAP [1]. Detecting these chemicals with environmental effects is an important study subject in terms of environmental and health science. This is, however, is a very difficult and practically impossible although not a truly impossible task because of complex molecular structure of organic chemicals in aquatic environments. Thus, short-term biological investigation methods make an accurate and practical tool in detecting toxic and/or mutagenic materials in the environmental samples [2]. Among them, Salmonella typhimurium/microsome assay (Ames test) is one of the most important tests [3]. Therefore, Ames's mutagenicity test was done with screening purposes in sediment samples from Fethiye, Antalya, Finike and Beymelek all located on coastal line of Mediterranean Sea.

Material and Methods

Sampling area

Sediment samples were taken from 8 stations September 2005-October 2005 in the context of study of project 104Y065 supported by TUBITAK Sampling area :

- Stat.1 Fethiye Bay, 36°37'46" N 29°06'32" E
- Stat.2 Fethiye Bay, 36°39'24" N 29°04'44" E
- Stat.3 Fethiye Bay, 36°37'47" N 29°04'39" E
- Stat.4 Beymelek Lagoon, 36°16'04" N- 30°02'57" E
- Stat.5 Finike Körfezi, 36°17'07" N- 30°10'02" E
- Stat.6 Finike Bay, 36°17'46"N- 30°09'18" E
- Stat.7 Antalya Bay 36°50'17" N- 30°36'31" E
- Stat.8 Antalya Bay 36°49'53" N- 30°37'08" E

Van-Veen grap sampler was used in obtaining sediment samples. Samples taken from surface layer (sampling an area of  $0.1 \text{ m}^{-2}$ ) with metal spatula were stored under cold-chain and then dried in the incubator at 60°C. Extracting the samples: Sediment samples from Mediterranean sea were crash to powder and sifted in the laboratory and then placed in portions of 1 gram into sterile teflon tubes and mixed with hexane/choloroform/acetone (1:1:1 v:v:v) using a vortex mixer [4]. Subsequently, the samples were centrifuged for 10 minutes at +4°C at 5600 g in Sigma K3 cooled centrifuge and supernatants were taken into sterile tubes. Organic solvent of

sediment samples was evaporated after this procedure had been repeated for 3 times and it was dissolved by adding 1 ml of Dimethylsulfoxide (DMSO). When testing for mutagenicity without metabolic activation, 100  $\mu$ l and 200  $\mu$ l of organic extract was mixed with 100  $\mu$ l of an overnight culture of bacteria and 2  $\mu$ l of melted agar containing 5mM histidine and biotin. The molten top agar was then poured onto a minimal glucose agar base plate and incubated at 37°C for 2 days. Mitomycin-C (0.5  $\mu$ g/plate) were used as positive controls. Each dilution of extract and controls were assayed in triplicate. Following incubation, the number of revertant colonies was counted (His<sup>-</sup>revertants)[3]. Salmonella mutagenicity tests were performed using the standard plate incorporation method with the TA98 strains of *Salmonella typhimurium*, [3].

#### Results and Discussion

No mutagenic results were obtained with TA98 strain of S.typhimurium in the current study using experiments with Ames test on sediment samples from 8 stations on Mediterranean coast (figure 1). However, results that will be obtained using TA 100 strain of *S.typhimurium* will be compared those of sediment extracts from 8 stations. In conclusion, it is pleasant that mutagenicity was not found in sediment samples from selected locations although pollution of Mediterranean by chemical wastes and tourism has been reported by UNEP and MAP.



Fig. 1. Mutagenicity analysis of sediment samples with S. typhimurium TA98

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# VOLTAMMETRY AS A TOOL FOR DETECTION OF METAL SULFIDE PARTICLES AND NANOPARTICLES

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### Abstract

In this work we investigated the possibility of reduction of metal sulfide particles (Ag, Cd, Hg, Pb, Zn and Fe) at the Hg electrode in electrolyte solutions containing  $\mu$ M levels of different metals and sulfide. In all investigated solutions metal sulfide particles are formed and subjected to the reduction at the Hg electrode resulting with voltammetric peaks situated between -0.9 and -1.7 V vs. Ag/AgCl, respectively. An electrochemical approach for detection of possible presence of metal sulfide species in anoxic natural samples was proposed.

Keywords : Electrochemistry, Metals, Anoxia.

It was shown that natural anoxic waters, containing Fe(II) and S(-II) and analogue model solutions, contain species which are reducible at the mercury electrode at -1.1 V vs. Ag/AgCl [1]. However, Ciglenečki et al. [2] have reported that in the solutions containing  $\mu$ M concentrations of copper and sulfide very similar reduction peaks can be observed (situated at the -0.9 to -1.0 V vs. Ag/AgCl) and can be assigned to the reduction of CuS solid phase particles.

In this study we investigated possibility of reduction at the Hg electrode of other metal sulfide particles as well as possibility of application of voltammetric measurements in detection of metal sulfide particles in natural samples. Proposed method was tested in measurements of samples collected from two meromictic, anoxic environments, seawater lake, Rogoznica Lake in Eastern Adriatic coast and Pavin Lake, crater lake in Central massife, France [3,4].

Cyclic voltammetric, CV, curves obtained in investigated metal sulfide electrolyte solutions are characterized by two reduction peaks: C2 situated at around -0.6 V and C3 situated between -0.9 and -1.7 V, respectively (Fig. 1A). The C2/A2 peak couple corresponds to the well documented HgS layer dissolution and formation processes [2] while C3 in comparison with our previously published data on CuS particles and nanoparticles [2], can be assigned to the reduction and dissolution process of the attached metal sulfide particles.



Fig. 1. CV curves for electrolyte solution containing: (A) 10.5  $\mu$ M Pb<sup>2+</sup> and 10.5  $\mu$ M HS<sup>-</sup>; Initial potential, E<sub>D</sub> = -0.2 V, scan rate 100 mV/s; accumulation period, t<sub>d</sub> = 60 s (solid lines), 100 s (dashed lines) and 220 s (dotted lines). LSV curves for (B) Pavin lake sample taken at 75 m depth. Initial potential, E<sub>D</sub> = -0.2 V (solid line) and E<sub>D</sub> = -0.8 V (dotted line) without accumulation, t<sub>d</sub> = 0 s.

Our investigations showed that different experimental conditions i.e. ageing of the particles, deposition potential and accumulation time can effect shape and position of the C3 reduction peak. C3 shifts with increased accumulation time and consists of two or more superimposed reducion peaks; which we marked as C3(1) and C3(2) (Fig. 1A). The same effect was observed with ageing of the solutions and aggregation of the particles.

In investigated natural samples, reduction peak similarly situated to C3,

already detected in model solutions, was observed (Fig. 1B). We ascribed the peak to the presence of metal sulfide particles.

The most interesting finding here is that in the case of ZnS, FeS and CuS similar voltammetric responses have been already reported for aqueous, soluble species of those metal sulfides in sulfidic environment. Evidence in this paper raises a cautionary flag regarding previous voltammetric studies of trace metal speciation in anoxic, sulfide rich marine environment. This implies that obtained voltammetric signal strongly depends on both solution i.e. solid and electrochemical conditions and therefore it should be interpreted with more caution.

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# SEDIMENT GEOCHEMISTRY ATLAS OF THE SEA OF MARMARA

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### Abstract

The Sea of Marmara has been subjected to organic and metal pollution sourced from municipal and industrial activities, the mineralized zones and high-background rocks in its drainage basin, and inputs from the Black Sea. The sediment geochemistry atlas of the Sea of Marmara consisting of the distribution maps of various major and environmentally important elements indicate the various sources and intensity of the pollution in different parts of the Sea of Marmara. The atlas is useful for the identification of the environmentally sensitive marine areas and selection of areas for benthic ecosystem studies, fisheries and otherrecreational and engineering activities. *Keywords : Metals, Geochemistry, Sediments, Mapping, Sea Of Marmara.* 

#### Introduction

The Sea of Marmara has been adversely affected by the high population density and industrial activity in its drainage area, and pollutant inputs from the Black Sea . For the *sediment geochemistry atlas of the Sea of Marmara*, a total of 378 surface sediment samples covering the entire Sea of Marmara is analyzed for grain size, organic carbon, carbonate, and 34 major and trace elements by the ICP-MS method . The data are presented in maps (Fig. 1) and basic statistical tables (Table 1) for different geomorphological areas. The maps are interpreted in terms of the scale and sources of organic and metal pollutants.

### Results and main conclusions

The results indicate that the İzmit Gulf and the shelf off the coast of Istanbul Metropolitan area are the most polluted in terms of organic carbon and metal contents, followed by Bandırma, Gemlik and Erdek bays on thesouthern shelf. The primary source of the organic and metal pollution is anthropogenic in most areas, with significant input in the southern shelf from the poymetallic mineralized zones and high-background utramafic, mafic and granitic rocks.



Fig. 1. Arsenic distribution in surface sediments.

The northwestern shelf, Çanakkale Strait and the shelf at its Marmara confluence are relatively less polluted than the rest of the Sea of Marmara. Compared to the average shale, Istanbul metropolitan shelf is enriched in Pb.Cr.Zn.As. Sn and Cu: İzmit Gulf in Mo. Pb. Zn.Cd veAs: nortwestern shelf in Cr, Cd, Pb and Ni; Çanakkale Strait and the shelf area at its Marmara Sea confluence in Pb, As, Cr, Zn, Ni, W and Sb; Erdek Bay in Pb, As, Sb, Zn, and W; Bandırma Bay in As, Pb, Cr, Sb, Ni, Zn and W; Gemlik Bay in As, Pb, Sb, Mo, Ni, Cr, Zn and W; southern shelf (excluding the bays) in Pb, Cr, As, Ni, Zn and W;and the deep basin and slope areas mainly in Mn ve Pb, and to a lesser degree in Cr, As,Ni, and Zn. In the deep basinal sediments, Mn is strongly enriched (enrichmentfactor= 5.2) by early diagenesis. Distribution of Pb and Cu indicate that at least a part of their source in the deep basinal areas could be the Black Sea waters. Element distribution maps indicate that the Kocasu, Gönen and Biga rivers in the southern catchment area of the Marmara Sea are very effective in transporting anthropogenic and natural organic and heavy metal contaminants as well as lithophile elements, such as K, Rb, Li, La and Nb, mainly as asuspended load. Furthermore, these maps show that the suspended load iseffectively distributed further from the inner shelf to the outer shelf, slopes and deep basinal areas.

The sediment geochemistry atlas can be used for theidentification of the environmentally sensitive marine areas and selection of areas for benthic ecosystem studies, fisheries and other recreational and engineering activities.

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# GENOTOXIC EFFECTS OF BISPHENOL A TO SEA URCHIN PARACENTROTUS LIVIDUS (LAMARCK, 1816)

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### Abstract

Bisphenol-a (BPA) is one of the most important industrial chemicals that are synthesized for diverse applications: BPA is, for instance, used in the manufacture of polymers, epoxy resins, polycarbonates, and packing industry. In this study, genotoxic effects of BPA (0.3-3.5 m/L), were evaluated using the embryos of the sea urchin *Paracentrotus lividus*. Results of cytogenetic analysis showed decreasing curve in mitotic index (number of mitosis per embryo) with increasing concentrations of BPA. *Keywords : Ecotoxicology, Echinodermata, Pollution.* 

### Introduction

Bisphenol-a (BPA) is one of the most important industrial compounds which belong to the bis (hydroxypheny) methane's. BPA is used primarily to make polycarbonate plastic and epoxy resins, both of which are synthesized for wide variety applications; for example, polycarbonate is used in eyeglass lenses, medical equipment. Because of the high production and widespread uses of BPA, it is entered in the environment in important quantities [1]. BPA is not naturally available in the environment therefore environmental concentrations result from diffuse sources (waste products, products in use) and point sources (industrial wastewater discharges). Several studies have been completed to determine the possible impacts of BPA [2]. The sea urchin bioassays are frequently used for determined the biological effects of pollutants on aquatic organisms [3].

#### Material and Methods

Analytical grade bisphenol-a  $[(CH_3)_2C(C_6H_4OH), Cas No: 80-05-7]$  purchased from Aldrich, Germany. Test chemicals were dissolved in dimethylsulphoxide (DMSO) as 100 mg-BPA/L. Test concentrations were 0.3, 0.5, 0.8, 4, 1.5, 2.3 and 3.5 mg/L of BPA. Adult sea urchins, were collected from the Aegean Sea coast (Seferihisar, Turkey), immediately transported dry to the laboratory. Sea urchin cytogenetic bioassays were carried out as described previously by Pagano et al. 2001. For cytogenetic analyses sea urchin embryos which exposed to BPA, were fixing in Carnoy's fluid (absolute ethanol: chloroform: acetic acid: 6:3:1) 5 hours after fertilization. Observations were carried out using a light microscope (using an immersion oil and 100x objective). Quantitative endpoints were evaluated according to criteria defined by Pagano et al (2001). Student-t tests were used to compare the differences in the frequency distribution of evaluated parameters between control and treatment groups by applying the logarithmic transformation to normalize distributions.

#### Results

The cytogenetic analysis was carried out in *P.lividus* embryos exposed to BPA. In test, mitotoxic effects were detected all tested concentrations which changes in the number of mitoses per embryo (MPE) (1) and increasing mitotically inactive embryos (IE) (p<0.0005).



Fig. 1. Mitotoxic effects of Bisphenol-a on number of mitoses per embryo (MPE).

Test results showed that the mean MPE were decreased with increasing concentrations of BPA ranging from 0.3 to 3.5 mg/L. In contrast, they caused an increase in IE ratios .The differences in Metaphase/Anaphase

was not statistically significant for each set of experiments. A few morphological aberrations (bridges, scattered chromosomes etc.) were observed at highest BPA concentrations.

### Discussion

Several studies have focused on the toxicity of BPA and a significant amount of literature is available at present especially on estrogenic activity. A lack of information about the toxicity of BPA to the developmental stages of the sea urchin P. lividus was observed. .Some previous reports focused on acute and chronic effects of BPA on aquatic organisms in both freshwater and saltwater by using several species and tropic levels. The LC50 has been determined for variety of aquatic organisms, including freshwater and saltwater algae, invertebrates (daphnids and mysid shrimp) and fish with reported values ranging from 1000 to 20.000  $\mu$ g/L [2]. In this study, genotoxicity of BPA was tested and adverse effects were observed on sea urchin embryos at concentrations of 0.3-3.5 mg-BPA/L. Our previous studies about same concentrations of BPA results show that its exert spermiotoxic effect on *P. lividus* fertilization. In this study results are consistent with other studies, Roepke et al., (2005) noted that estradiol and all EDCs including bisphenol-A (BPA) (250 to 750 ng/ml) inhibited normal development in two echinoid species Strongylocentrotus purpuratus and Lytechinus anamesus. It can be concluded that bisphenol-a affects the P. lividus during embryonic developmental stages. Therefore, to keep the environmental concentration of BPA under control is of great ecological importance in order to maintain sustainable ecosystems due to the hazard at the population level.

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# LONG-TERM MONITORING OF PCBS AND DDTS IN MUSSELS FROM THE EASTERN ADRIATIC SEA

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### Abstract

Mussels (*Mytilus galloprovincialis* Lam.) are collected along the eastern Adriatic coast over a period of 34 years (1972-2006). They were used as indicator organisms for monitoring levels of polychlorinated biphenyls (PCBs) and organohlorine insecticides (DDTs) [1,2]. Concentrations of these persistent organic contaminants have been determined using GC/ECD.

Keywords : Adriatic Sea, Ddt, Pcb, Monitoring, Mollusca.

The Adriatic Sea is an elongated basin  $(139\ 000\ \text{km}^2)$  of the northern Mediterranean, extending for 800 km into the heartland of the European continent. Croatian karstic region warrants particular attention because of its high ecological sensitivity and the unfortunate unscrupulous destruction during the warfare of 1991 - 1995.

Bioaccumulation of chemicals in biota may be a prerequisite for adverse effects on ecosystems. Mussels have been used in many parts of the world as indicator organisms because of their ability to sequester lipophilic contaminants such as PCBs and DDTs [1].

For the evaluation of a possible hazard from the pollution of the area of Adriatic with PCBs and DDTs, investigation of fish and mussels is implemented since 1972 [2]. The long-term monitoring of chlorinated hydrocarbons in mussels was carried out along the coastal waters of the east Adriatic [Fig 1]. In this region significant quantities of wastewater are discharged directly into the sea from the coastal regions, which are densely populated and have well-developed industrial and marine activities. Also, tourist population increases significantly during the summer period, raising the basic organic load and various pollutants.



Fig. 1. Map of the monitoring coastal area.

All sample analyses are performed by the Analytical group for organic pollutants at Rudjer Boskovic Institute; with uniformed methodology [3]. The following ranges of levels of chlorinated hydrocarbons are determined in mussels on the wet sample mass: PCB ranges from below method sensitivity (0.1) to 1510  $ngg^{-1}$ , respectively DDT ranges from 0.1 to 1088  $ngg^{-1}$ .

Due to non-normal distributions of the elaborated data, temporal trends are investigated through regression analyses and it was necessary to use log-transformation [Fig 2]. Concentration of PCBs is nearly sustained, slightly elevating throughout the investigated period, while DDT levels are significantly decreased since 1970's.



Fig. 2. Temporal trends of chlorinated hydrocarbons.

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# LONG-TERM MONITORING OF PCBS AND DDTS IN FISH FROM THE EASTERN ADRIATIC SEA

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### Abstract

The muscle tissue of fish was analysed for PCBs and DDTs between 1972 and 2006. These organic pollutants were monitored to trace the levels and to ascertain whether the concentrations exceeded the maximal allowed quantities in fish fixed by the regulations. Quantitative determination of DDTs and PCBs in the samples examined has been carried out using GC-ECD. *Keywords : Adriatic Sea, Ddt, Pcb, Monitoring.* 

Chlorinated aromatic molecules are one of the most significant mutagens in a sea environment. Chlorinated insecticides (DDT) and polychlorinated biphenyls (PCB) present a group of synthetic organic compounds, greatly used in different fields of a human activity. Monitoring of marine ecosystems has been typically made using widely distributed coastal organisms, such as inshore bottom fish, as bioindicators [1].

The long-term monitoring of chlorinated hydrocarbons in several fish species from coastal waters of the east Adriatic is performed with the aim for locating and determining a critical sea pollution points, as well as for tracking of PCB and DDT levels [2]. Mostly benthic and epibenthic fish was analyzed with exception of a few pelagic fish caught in the north Adriatic. Contaminants in these fish do not depend much upon relatively small distances from a dotted source of contamination, thus providing better contamination status of a site.

In the period between 1972 and 2006 intensive samplings have been carried out at the number of station along the Croatian sea coast (Istria, Kvarner and islands, area of Zadar, Šibenik, Split and Dubrovnik). All analyses are performed by the same laboratory of Rudjer Boskovic Institute; with uniformed methodology. Fish fillets were extracted with n-hexane using a high revolution blender. The analytical method used for the extracts included filtration through a column of Na<sub>2</sub>SO<sub>4</sub> anh., cleaning on an alumina column and the separation of the PCBs from organochlorine insecticides on a miniature silica gel column. After concentration down to 1 cm<sup>3</sup>, elutes were analyzed by EC gas chromatography [2].

The following ranges of levels of chlorinated hydrocarbons are determined in fish on the wet sample mass: PCB ranges from below the method sensitivity (0.1) to 2403 ngg<sup>-1</sup>, respectively DDT ranges from 0.1 do 1575 ngg<sup>-1</sup>.

PCB levels are higher compared to DDT, especially in last decade, and it could be said that they are comparable to the more contaminated areas of the Mediterranean, such as the coasts of Spain, France, Italy and Greece [3]. Although significant levels of PCBs and DDTs are observed in certain samples, it never exceeded the maximal allowed quantity for these substances in fish. The annual trends of PCB and DDT levels have been analyzed with a linear regression. The trend lines of the DDT and PCB levels, and of their ratio, as natural logarithmic values are presented in Fig. 1 and 2. Results of these trend analyses point to a significant decrease of DDT levels from 70's of last century to nowadays, while in the same period levels of PCBs increase in analyzed biota samples, but this increase is not statistically significant.



Fig. 1. Trend lines of DDT and PCB levels.



Fig. 2. Ratio of PCB/DDT as logarithmic natural values.

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# BIOACCUMULATION OF ORGANOCHLORINATED COMPOUNDS IN CAGED MUSSEL (*MYTILUS* GALLOPROVINCIALIS) AT THE IBERIAN MEDITERRANEAN AND BALEARIC WATERS. INFLUENCE OF LIPID CONTENT AND MUSSEL GROWTH

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### Abstract

Caged mussels were used as sentinel organisms of organochlorine (OC) contaminant bioavailability in the Iberian Mediterranean and Balearic waters, within the surveillance network developed by the Mytilos project in the western Mediterranean area. The mussels were collected from an uncontaminated site and transplanted to 30 stations. After 3 months, concentrations of PCBs and OC pesticides were measured in the mussel tissues. The distributions of OC compounds are showed herein, and the influence of two biological factors on the levels of these pollutants have been examined: lipid content and mussel growth. *Keywords : Monitoring, Bivalves, Chlorinated Hydrocarbons.* 

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### Introduction

The purpose of monitoring contaminant concentrations in bivalve tissue is based on the mussel capacity to integrate the bioavailable portion of contaminants in the water column over time. Two different strategies have been adopted in the Mussel Watch Programs; pasive biomonitoring, with indigenous populations, and active biosurveillance with transplanting individuals [1]. Active biomonitoring allows to control the bioaccumulation process. However, bioaccumulation in marine organisms could be influenced by several factors such us lipid content or the mussel growth [1]. In this work, the influence of lipid content, condition index and organochlorine compounds have been studied in transplanted mussel in the Iberian coast.We have used this method of active biomonitoring to evaluate chemical contamination by PCBs (IUPAC ns 28, 52, 101, 105, 118, 138, 153, 156 and 180), and pp'DDT and its metabolites.



Fig. 1. Map with sampling points.

#### Materials and methods

The mussel transplantation technique is described in details elsewhere [1]. The mussels were transplanted to 30 stations shown in the Fig. 1 (April-June 2004 and 2005). The ratio of dry flesh weight to dry shell weight was used to determine a condition index (CI) for each sample. Samples were freeze-dried and soxhlet extracted. An aliquot of extract was used to determine gravimetrically lipid content. After the chromatographies over alumina and silica, the extracts were analyzed by GC-ECD.

#### Results and Discussion

Distribution of the congener CB153 is shown in Fig.2. Most of PCBs concentrations were similar to the levels found in native mussel sampled in the Iberian coast, far from industrial and urban areas. These data showed the dilution of the land source pollution in the marine shelf waters. The highest concentrations CB153 were observed in El Portus and Palma Port, 7 and 9 ng/g dw, respectively. These levels reflect the high degree of industrialization and/or urbanization of the cities of Cartagena and Palma de Mallorca, respectively. The levels of pp'DDE and pp'DDD varied in the range of 0,3-4,0 and from nd -1,76, respectively, and the highest pp'DDE concentrations were found in Aguilas, C.de Gata, Almeria and Adra(Fig. 2). In contrast, pp'DDT was no detected in the samples.

Tissue concentrations of CB153, CB138 and pp' DDE were positively correlated with the lipid content (R=0,496, 0,456 and 0,936, respectively, N=30, p<0,01) and the CI (R=0,381, 0,379 and0,936, respectively, N=28, p<0,05), a biometric parameter related to the growth. From our results, it is deduced that the normalization of the organochlorine concentrations to the lipid content or the growth is necessary to reveal the real spatial bioavailability of the contaminants along the Iberian and Balearic coasts.



Fig. 2. Levels of PCB 153 and pp'DDE in the investigated stations (unit: ng/g dw).

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# MONITORING CHEMICAL CONTAMINATION LEVELS IN THE MEDITERRANEAN MUSSEL, *MYTILUS GALLOPROVINCIALIS*, OPTIMIZED BY THE USE OF DYNAMIC ENERGETIC BUDGET (DEB) MODEL

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### Abstract

Within the framework of the biointegrator network (RINBIO), 92 man-made cages containing mussels (*Mytilus galloprovincialis*), distributed over 1800 km of the French Mediterranean coast, and made it possible to assess chemical contamination by heavy metals. Bioaccumulation of contaminant within an organism results from interactions between physiological factors, chemical factors and environmental factors. To account for such interactions in the mussel *Mytilus galloprovincialis*, we combined accumulation and Dynamic Energy Budget models. Field experiments were conducted to measure contaminant (metals and organics) kinetics for contaminant in 3 Mediterranean sites with differences in contamination levels, and to calibrate the models. By combining environmental and biological data, the model provided an efficient bio-monitoring tool which can be applied to various coastal environments and enabled us to assess the real level of contamination in water on the basis of contamination measured in mussels.

Keywords : Bio-accumulation, Bivalves, Inverse Methods, Monitoring.

### Monitoring and interactions

Many monitoring programs are based on the concept of quantitative bioindicator, which uses the properties mussel to concentrate contaminants in their soft tissue with a relationship with the ambient level [1-2]. Nevertheless, interpreting bio-monitoring data reveals some difficulties related to the contaminant dynamics, possible changes in the environment (temperature, trophic conditions and contamination level) and interactions with the bioindicator physiology (size, reproduction stages, and seasonal growth cycles). The data obtained give only information on the bioaccumulation level without taking into account the contaminants dynamic. There is still a lack of knowledge about the significance of the concentration at time "t". Furthermore, comparing concentrations between different sites appears to be difficult because of the variations in environmental conditions, and subsequently variations in growth rate of the mussels among sites, may involve changes in the concentration level in the animals. Subsequently, modeling bioaccumulation of metals in mussels can be a pertinent tool to optimize the use of quantitative bioindicators.

### Dynamic Energy Budget (DEB) model

Uptake and elimination kinetics of metals in the mussel *Mytilus galloprovincialis* can be described by a dynamic energy budget (DEB) model (Figure 1). A multi-compartment-pharmaco-kinetic model has been used to describe metal kinetics [3]. The contribution of physiologically determined variables, such as body size and tissue composition, on its influence on the pharmaco-kinetics of the xenobiotics has been evaluated. The metal uptake / elimination model has been designed to account for change in the physiological conditions of the organism. The uptake is considered to be carried out directly from the environment and/or *via* food and the elimination is *via* reproduction and/or directly to the environment.



Fig. 1. Schematic representation of the energy flow through an organism in the DEB model (Kooijman, 2000), and contaminants bioaccumulation. 1: assimilation, 2: utilisation.

However, the uptake/elimination model proposed by Kooijman and Van Haren (1990) for organic micro contaminants and has been designed to account for changes in the physiological (feeding/lipid) conditions of the organism [3]. This modelling attempt suggests that bioaccumulation models could provide an appropriate tool to analyse bio-monitoring data. In this perspective, applications to heavy metals have been applied to *Mytilus galloprovincialis* to assess uptake-excretion kinetics, calibrated on *in situ* experiments [4].

#### Field validation

In order to couple growth and metal accumulation, it's essential to have complementary data: (i) physico-chemical variables of water, (ii) chemical variables of contaminant, and (iii) biological variables of mussels [4]. In this experiment, mussels originating from a same site have been transplanted for six months in two sites known for their contamination (Lazaret bay and Bages lagune). The two mussel sets were sampled fortnightly and allometric parameters and contaminant concentrations in the mussel tissues were measured. In addition, water conditions were recorded: temperature, suspended solids and dissolved and particulate metal concentrations. After these six months, mussels were transplanted to a clean site (Port-Cros Island) in order to examine the decontamination kinetics during three months. All these data have been integrated into the DEB model to adjust parameters and validate it [4].

### Monitoring application

The coupled DEB bioaccumulation model was used to assess the level of water contamination on the basis of the contamination measured in mussels by an inverse method. Unknown food and contaminant concentrations were determined by fitting simulated mussel growth and contaminant concentrations to measured values [4]. Application of the model by inverse analysis to monitoring data (RINBIO) showed the usefulness of the DEB model as an operational tool. The model linked concentrations in the living organism with those of the surrounding environment using an explanatory method. It provided an evaluation of the effective chemical contamination on sites which have different trophic conditions in the Gulf of Lions by accounting for differences in physiological response. The successful reconstruction of contaminant concentrations in surrounding water at different sites with concentrations in tissues and the measurement of growth encourage the implementation of the DEB-based model in scenario simulation studies for management purposes. After application to heavy metals, we are actually applying it to organic contaminants like PCBs, DDTs and PAHs.

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# MONITORING THE EFFECTS OF POLLUTION ALONG SARONIKOS GULF

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### Abstract

The paper deals with the simultaneous use of "biological effects" techniques in mussels (lysosomal destabilization, micronuclei frequency, stress on stress test), associated with the traditional one of the bioaccumulation of metals, in order to evaluate pollution impact on biota along Saronikos Gulf (Greece). Results were in accordance with the known pollution gradient in Saronikos gulf. *Keywords : Bio-accumulation, Bio-indicators.* 

Although the domestic effluents of the metropolitan area of Athens are the main pollution source of Saronikos gulf, chemical effluents from a variety of industrial installations scattered along its north coasts and the harbor of Piraeus contaminate sea water of Saronikos gulf.

The determination of contaminants in biota provides a good indication of ambient contaminant concentrations, while information about the biological harm of pollutants to the living organisms at the sub-cellular level, either the molecular or the chromosome level can be estimated with the use of "biological effects" biomarkers. The lysosomal membrane stability evaluation (LMS) has become widely accepted as a sensitive index of cellular health [1], while the increased frequency of micronuclei (MN) provide an indication of accumulated genetic damage throughout the life span of the cells and is suitable to monitor genotoxic damage [2]. Although both tests are considered as general, they are sensitive to metal impact. The stress on stress test (SOS) is based on the concept that stress is expressed by a reduced capacity of the individual to adapt to further environmental variations as the mortality in air that would presumably occur more rapidly in pollutant pre-stressed individuals than in animals coming from unpolluted areas [3]. The aim of the present study was to evaluate pollution impact on biota along Saronikos, combining different methodologies: LMS, MN, SOS and the traditional one of metals bioaccumulation.

Mussels were collected seasonally from 4 localities seasonally (March 2000 to December 2004). Station C3 located in Elefsis bay is consequently more contaminated than the others. Stations C8A and C8B are located at both sides of the wastes outfall; the station C8B presenting very variable status with temporally aggravating environmental conditions, contrary to C10 that is included as reference area.

For LSM and MN tests the haemolymph was sampled from the posterior adductor muscle of 10 specimens, mixed with saline, dispensed on a slide and incubated in order to allow the cells to attach. Following that for the LMS calculation, neutral red dye was added and the slides were then examined microscopically at 15 minutes intervals. The time at which 50%of the lysosomes in the haemocytes have leached out neutral red in the cytosol was determined for each slide and a mean value was derived for each sampling site. For micronuclei the slides were fixed in methanol: acetic acid (3:1), washed in distilled water, air dried and stained with Giemsa. Two thousand cells with preserved cytoplasm were scored per mussel (per slide) to determine the frequency of micronuclei. For the evaluation of stress on stress, 30 individuals were cleaned carefully in order to eliminate epiphytes and epizoans. The sample was then partitioned in two groups of 15 individuals, enveloped in humidified straining paper, put into plastic containers with cover and subsequently kept in chambers of constant temperature of 10  $^{\circ}\text{C}.$  Survival was assessed daily and dead animals were recorded and removed until 100% mortality was reached. The LT50 was calculated graphically. Finally the determination of metals the samples, during each sampling occasion, 6 pooled samples were performed from the soft parts of 20 individuals each. The analyses of the samples comprised lyophilisation, homogeneisation and digestion of about 1.5 g of dry tissue with 12 ml of HNO3 under pressure using a microwave furnace CEM MDS 2100. Metal measurements were effectuated by atomic absorption spectrophotometry.

The LMS stability varied during time according to sampling locality. At stations C3 and C8A lower neutral red retention levels were found, indicating that mussel populations are subjected to a higher environmental stress at these sampling areas. The low number of analyses accomplished for micronuclei scoring (MN) provided limited information and mainly at station C10 for which only one analysis was made. The  $T_{50}$  survive period during the mussels aerial exposure (SOS) showed that mussels from the reference area C10, survived longer than the specimens from the other sampling stations, while those from C3 shorter. ANOVA showed

significant differences in environmental stress among stations only for SOS. However we can observe a tendency of mussels from C3 and C8A to be more stressed than those from C8B and C10 (Fig.1) presenting lower retention times, lower aerial survive and higher micronuclei frequency. In the case of MN the difference between C10 and C3 was not clear due to the limited data(only one analysis in C10). These findings were in accord with the known pollution gradient in Saronikos gulf [4]. Additionally metal bioaccumulation showed higher metal levels in C3 and lower at the reference area C10. Bioaccumulated metals in C8A and C8B were intermediate.



Fig. 1. Differences in studied parameters among mussels collected at the 4 sampling stations.

In conclusion, the results from the biological effects techniques applied in mussels from Saronikos gulf seem to describe well the environmental state along its coasts. Moreover these techniques are faster and consequently they are suitable for the early detection of unfavorable changes in the marine environment.

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# NEW RESULTS CONCERNING ACCUMULATION FACTORS OF METALS IN THE BLACK SEACOAST ECOSYSTEM

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### Abstract

New original results concerning Ag, Cd, Cr, Cu, Ni and Pb accumulation factors in the Romanian Black Seacoast biota and sediment in 2003-2006 are reported. Metal were determined in green alga, mussels, shrimp, fishes and also in sediment and water using inductive coupled plasma - mass spectrometry (ICP-MS) technique.

Keywords : Black Sea, Trace Elements, Bio-accumulation.

### Introduction

Determination of the metal concentrations in marine ecosystem is considered to provide useful information about the levels of metal contamination, and also about the rates and mechanisms of metal contamination or bioaccumulation [1-4]. Cadmium, chromium, copper, lead, nickel and silver play an important role in marine ecosystems as pollutants or essential elements. These six metals, commonly classified as heavy metals, are a subset of a larger group of trace elements that occur in low concentration in the Earth's crust. The two main pathways for heavy metals to become incorporated into air-soil-sediment- water are transport by air (atmospheric) and water (fluvial).

The investigation was carried out in the Black Seacoast ecosystem. Original results of Ag, Cd, Cr, Cu, Ni and Pb accumulation in sediment, flora and fauna are reported. The used analytical technique, ICP - MS, is generally considered to be a high sensitive, interference free technique for analysis of trace elements in environmental samples.

### Experimental

Water, sediment, alga, shells, shrimp and two fish species samples have been collected in August 2003, 2004, 2005 and February 2006 from Mangalia Gulf, located in the southern part of the Romanian Black seacoast. The solid samples - biota (*Ulva sp., Mytilus sp., Crangon sp., Ponticola sp., Encrasicholus sp.*) and sediment - have been carefully prepared (washed, dried) and subjected to dissolution with nitric acid and hydrogen peroxide in a Digesdahl device [5]. Water samples were filtered on quantitative filter paper, then nitric acid has been added for preservation and stored at 4°C in plastic bottles. Metal concentrations have been measured by atomic emission spectrometry with an Agilent 7500a ICP-MS apparatus [6]. The concentration factor was calculated as the rapport between ppm metal in organism or sediment and ppm metal in water.

### Results and discussions

The assessment of bioaccumulation (defined as association of a metal with an organism) may help to elucidate the role of trace elements in the ocean geochemistry.

Some toxic metal species are soluble in water and can be readily absorbed into plant or animal tissue. After absorption, these metals tend to bind to biomolecules such as proteins and nucleic acids, impairing their functions. The obtained results concerning concentration factors of studied metals in sediment and marine flora and fauna evolution in 2003, 2004, 2005 and 2006 can be sumarized as follows (in parenthesis the mean values are presented):

- in marine sediments: cadmium 57-200 (149), chromium 115-559 (317), copper 33-164 (83), lead 64-270 (163), nickel 129-1694 (839), silver 12-313 (91):

- in alga *Ulva sp.*: cadmium 71-333 (206), chromium 114-274 (217), copper 44-386 (166), lead 61-507 (222), nickel 127-1389 (610), silver 25-104 (53);

- in mussels *Mytilus sp* : cadmium 186-3461 (1175), chromium 127-156 (141), copper 88-521 (260), lead 64-1477 (466), nickel 149-4768 (1750), silver 37-298 (160);

- in shrimp *Crangon sp.*: cadmium 178-308 (236), chromium 112-547 (264), copper 53-3857 (1092), lead 75-279 (157), nickel 205-2697 (930), silver 79-250 (166);

- in hanos *Ponticola sp.*: cadmium 93-814 (334), chromium 111-135 (131), copper 63-307 (131), lead 43-277 (154), nickel 61-684 (298), silver

#### 37-134 (75);

- in anchovy *Encrasicholus sp*: cadmium 153-666 (294), chromium 146-196 (178), copper 50-221 (130), lead 34-300 (170), nickel 121-516 (352), silver 25-275 (97).

Aquatic organisms may take up trace metals mainly from solution and from food. For example mussels, as filter feeders effectively filter particulate matter out of suspension and therefore this suspended matter may be a source of trace metals. There is a large variation of concentration factors in each biota category. That may depend on the sample's collecting points, on the species, but also on the physiologic behavior of organism. It can be observed that Cd, Ni and Pb have the highest concentration factors in mussels and Ag, Cr and Cu in shrimps. Nickel has the highest concentration factors in all biota species from Romanian Black seacoast.

### Conclusions

The concentration factors of studied trace metals in the Black seacoast ecosystem increase as follows:

- for sediments Cu<Ag<Cd<Pb<Cr<Ni;

- for all studied biota categories Ag<Cr<Pb<Cu<Cd<Ni.

These new results confirm our previous researches [4].

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# SULPHUR SPECIATION IN TWO CONTRASTING ANOXIC ENVIRONMENTS

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## Abstract

Sulphur electrochemical speciation techniques were applied to understand the chemistry and cycling of sulphur in two meromictic lakes: seawater lake, Rogoznica Lake (Croatia) and crater lake, Pavin Lake (France). Using a cathodic stripping cyclic and linear sweep voltammetry we aimed to make distinguish between free and metal sulphide species in the anoxic deep layers. 90% of determined sulphur species in the anoxic bottom water of Rogoznica Lake are in the form of free sulphide, while opposite result was observed in the Pavin Lake. There was no presence of free sulphide detected; all sulphur was in the form of metal sulphide species, which regarding a prevalence of Fe can be ascribed to the presence of FeS.

Keywords : Anoxia, Electrochemistry, Chemical Speciation.

The stagnant deep layers of meromictic lakes (monimolimnion), which usually exhibits an accumulation of dissolved elements, is very suitable for studies of biogeochemical processes in anoxic conditions. Anoxic environment usually produces hydrogen sulphide that can be oxidized back to sulphate by oxygen, iron (III) and manganese (III, IV) compounds. The oxidation of sulphide frequently leads to intermediate oxidation state compounds, such as elemental sulphur, polysulphide and thiosulphate which may be used by bacteria or may react with metals and organic compounds. The biogeochemical/redox cycling of sulphur is important to the function of anoxic ecosystems and has a profound influence on the distribution and speciation of other substances amongst are the most important biologically active and redox sensitive elements such as Fe, Mn, Mo, Cu.

Reduced sulphur species (RSS), including sulphide, polysulphide, thiosulphate, and thiols (or sulphydryl compounds) have strong affinity to biologically active trace metals, changing their availability to living organisms. They could form stable complexes with most heavy metals of environmental concern. The complexation of metals with sulphide and/or polysulphide has been found to be able to control their solubility, mobility, and speciation in anoxic environments. In addition to acting as dissolved complexing ligands, RSS may exist in colloidal and particulate phases, and the interaction between trace metals and reduced sulphur may, therefore, influence the distribution of biologically active trace metals among dissolved, colloidal, and particulate fractions. On the other side  $H_2S$  is very toxic to living organisms and its removal by oxidation and/or precipitation is of great importance in maintaining the healthy state of environment.

Using different electrochemical methods it is possible to measure a variety of soluble sulphur compounds (1-3). In this work we used mercury electrode to measure different soluble and particulate sulphur species including H<sub>2</sub>S, polysulphide, thiosulphate, elemental sulphur, thiols and metal sulphide species in two contrasting anoxic environments: seawater lake Rogoznica Lake on the east Adriatic coast and Pavin Lake in French Massif Central. Both lakes present a stable anoxic deep layer which is in Pavin Lake situated from 62 m depth to the bottom (92 m) while in more shallower Rogoznica Lake this layer is from 10 to 15 m depth (4,5). At the boundary oxia-anoxia a stable oxic-anoxic interface can be find in both lakes. This interface usually is area where major biogeochemical processes are taking place.

In the interface layer, in Rogoznica Lake the presence of elemental sulphur in relative high concentrations (up to 30  $\mu$ M) as well as thiosulphate (up to 50  $\mu$ M) can be found. Elemental sulphur even in the higher concentration was also determined in the anoxic water layer (up to 140  $\mu$ M) where such high numbers can be explained by the presence of polysulphide. Anoxic layer in Rogoznica Lake is characterized by relative high concentration of free HS<sup>-</sup>, up to  $10^{-2}$  M which completely binds and precipitates almost completely metals from the water phase. In the interface layer of Pavin Lake, we found only presence of elemental sulphur (up to  $2\mu$ M), which was also in the similar concentrations determined in the anoxic deep water. Sulphur speciation in anoxic deep water of Pavin Lake was completely different than in Rogoznica Lake. A prevalence of Fe(II) in Pavin Lake, up to 1000  $\mu$ M, whereas dissolved Mn was only 25  $\mu$ M, indicates that Fe is the dominant metal involved in sulphur redox cycling and precipitation. Consequently, in anoxic deep layer of lake Pavin no presence of free HSwas found; all sulphur detected was in the form of FeS and soluble elemental S

In this paper for the first time the typical voltammograms of the Pavin

Lake samples with visible peaks of FeS species will be presented. Preliminary results on sulphur speciation in the interface and anoxic deep water of the Pavin Lake will be discussed.

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# DIAGENETIC AND PALAEOCEANOGRAPHIC ASPECTS OF SAPROPEL FORMATION IN THE EASTERN MEDITERRANEAN

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### Abstract

Organic-rich sediment units (sapropels) occur at an astronomically determined cyclicity. Their occurrence is related to relatively humid climatic periods, resulting in enhanced organic seafloor-arriving fluxes, whereas the intervening, arid periods are characterized by deposition dust fluxes (Ti/Al). The last "humid period", from 10-6 kyr <sup>14</sup>C, and was followed by a rapid increase in aridity (Ti/Al) coinciding with a peak of high Mn-oxide content. This peak occurs in response to an abrupt re-ventilation even which was followed by a progressively downward moving oxidation front. Proper recognition of initial versus secondary signals is vital in the interpretation of sedimentary proxies.

Keywords : Eastern Mediterranean, Sapropel, Atmospheric Input, Paleoceanography, Geochemical Cycles.

Eastern Mediterranean Sediments are known to be ideal recorders of Global paleoclimatic continental and marine signals. This is due to the highly favourable semi-enclosed nature of the basin and the various surrounding landmasses. As a consequence, climatic variations are accurately recorded not only by giving variations in typical 'marine' signals, but also in typical 'continental' signals. The 'Monsoonal index' is strongly associated with the paleoclimatic conditions in the area around the Eastern Mediterranean, i.e. Sahara/ Africa, Middle East, Southern Europe. This association is clearly present and visualized in its sediments, mainly in a ~21 kyr precession-controled cycle: during 'humid' climatic periods organic-rich sediment (Sapropel) is deposited containing strong river and marine productivity signals, whereas during 'arid' climatic periods organic-lean sediment is deposited containing high dust input signals. The Eastern Mediterranean, therefore, is an ideal area to study land-sea interactions of Global paleoclimatic variations. In particular, as this area is influenced and preserves paleoclimatic signals from the mid to high latitude northern borderlands to the low latitude Monsoonal influeced southern borderlands.

The occurrence of sapropels is related to relatively humid climatic periods, whereas the intervening, arid periods are characterized by deposition of rather high dust fluxes indicated by Ti/Al (Fig.1) [1].







The last of such 'humid periods' occurred from 10.4 to 5.7 kyr ago, simultaneous with the sustained wet period in the circum Mediterranean area. At the end of this humid period, the rapid increase in aridity coincides

with a peak of high Mn-oxide content. This peak occurs in response to a relatively abrupt re-ventilation event occurring in all studied cores, and is confirmed by several other proxies such as micropaleontological and organic geochemical. From the comparison of organic C and Ba/Al it is clear, that in the sediments of all cores, the upper part of the youngest sapropel, S1, has been removed [2-3]. Following the ventilation event, at 5-6 kyr (14C age), oxygen has continued to progressively move downward into the sediment oxidizing e.g. organic C. The visual evidence for varying depth intervals of the upper reaches of the S1 sapropel have been removed by this process. In line with these observations, microfossil occurrence indicates environmental changes occurring at or near the lower S1 boundary and at the upper boundary of the initial S1 sapropel [2-4]. Although siliceous microfossils have entirely disappeared, their organic geochemical 'signature' is still there (e.g. diatoms, represented by loliolide. Other marine biomarkers are dinosterol, which is predominantly derived from dinoflagelates and  $U^{K'}_{37}$  which is the ratio of 2 ketones and thought to be predominantly related to planktonic nannofossil E. Huxlevi, whereas B-sitosterol is considered to be a terrestrial biomarker. Clearly, it is in particular the marine biomarkers that are enriched in the remaining organic-rich sapropel S1 interval, whereas these are completely removed upon oxidation. The occurrence of such a removal mechanism seriously affects the traditional interpretation based on palaeoproxies, and, therefore, is of vital importance for the interpretation of proxies and our understanding of palaeo conditions. Thus a more reliable reconstruction can be made of initial sediment composition, hence of initial palaeooceanographic, palaeo-climatic, and palaeo-environmental conditions of sapropel formation in the eastern Mediterranean, relative to diagenetic changes.

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# RELATIVE MIDIFICATION, A NEW METHOD FOR MONITORING SEA WATER QUALITY

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## Abstract

Records of long term (seasonally) monitoring of the ambient water dissolved oxygen (DO) concentrations, secchi depth (Sd) and biological oxygen demand (BOD) values were generated to assess sea water quality of Güllük Bay. Modifications in the coastal stations water quality were assessed as the difference between the magnitude of a specific parameter recorded at coastal station and the concurrently recorded value of the parameter at the reference station, relative to the mean value at the reference station. There is a clear difference in parameters among coastal stations and reference stations. This difference can be related to the distance of a given location from human activities. *Keywords : Coastal Waters, Monitoring.* 

### Introduction

Güllük Bay is potentially important area in terms of marine product within the Aegean Sea. The various materials in the Bay of Güllük are sources of pollution [1].

#### Materials and Methods

Sea water samples were collected from seven coastal and three reference stations in the Güllük Bay (Figure 1). All analysis have done to reference methods. Relative Modification (RM) is defined as: RM=(Cc - Cr) /Mr, [2].



Fig. 1. Sampling stations in the Güllük Bay.

### Results and Discussion

Mean RM values are the same all study period. This values show that differences in BOD are the same between coastal areas and reference areas in the summer and winter. This displacement can be explained that coastal municipalities may provide adequate services in Güllük coast areas. Naturally occurring organic matter is present in low concentrations and consequently its oxidation gives rise to low BOD values (<1-2 mg/l) [3]. Although the threshold value of BOD indicating pollution varies with effluent characteristics and environment, we have assumed BOD higher than 2 mg/l as indicative of pollution, considering the vast ecologically sensitive areas of Güllük Bay. The values of BOD on August and June in coastal stations of Güllük Bay are higher than 2 mg/l.

Low levels of secchi depth over long periods can greatly diminish the health and productivity of the marine ecosystem [4]. In this study, secchi depth levels varied among coastal stations and reference stations. But RM values of secchi depth are the same all the period. This situation exhibits a homogeneous distribution at the coastal stations as well as those on the

### open sea.

Dissolved oxygen concentrations in surface waters are influenced by several factors. DO results are considered by many as difficult to interpret [5]. In this study, dissolved oxygen concentration at the coastal stations displayed pattern of seasonal variability dissimilar to the pattern displayed in the reference waters.

### Conclusions

Temporal changes observed for most variables, including those more evidently effected by human activities, followed typical seasonal patterns, characterizing also the Reference site. Behaviours of water parameters in coastal areas can be explained clearly by this method (Relative Modification).

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# HEAVY METAL CONCENTRATIONS IN *HEDISTE DIVERSICOLOR* (POLYCHAETA) AND SEDIMENTS FROM HOMA LAGOON (IZMIR BAY-TURKEY)

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# Abstract

Homa Lagoon is the most important fisheries lagoon in Izmir Bay which is under the influence of heavy metal pollution due to the settlement areas, industrial establishments and agricultural activities located around it. In this study, the bioaccumulation levels of some heavy metals such as Cd, Cr, Cu, Pb were measured in the polychaete *Hediste diversicolor* (Müller, 1776), which constitute one of the most significant groups of benthic organisms in terms of number of individuals and number of species, and the sediment they inhabit. Samples were analysed seasonally from Winter 2003 to Winter 2004. The heavy metal mean levels determined for *H. diversicolor* was found to be 0,05  $\mu$ g/g wet weight for Cd, 1,30  $\mu$ g/g w.w. for Cr, 3,98  $\mu$ g/g w.w. for Cu, 10,15  $\mu$ g/g w.w. for Pb. Mean concentrations of heavy metals in sediments 0,27  $\mu$ g/g dry weight for Cd, 58,40  $\mu$ g/g d.w. for Cr, 27,70  $\mu$ g/g d.w. for Cu, 11,49  $\mu$ g/g d.w. for Pb in Homa fisheries lagoon.

Keywords : Trace Elements, Polychaeta, Sediments, Aegean Sea.

### Introduction

Heavy metals are a major anthropogenic contaminant of estuarine and coastal waters. The main sources of pollution in Izmir Bay are domestic and industrial wastes; rainfall and associated pollutants from run-off; shipping; and agricultured sources. Determination of heavy metal levels in marine organisms and sediments are usually preferred than measuring of the metal concentrations in sea water samples. Sediments contain from three or fives times the concentration of metals in waters. Polychaetes are one of the most significant groups of benthic macroinvertebrate fauna and since these species come in direct contact with the sediments, the potential effect of these toxicants on this group of organisms is of ecological importance. The aim of this study was to investigate the present status of the heavy metal concentrations (Cd, Cr, Cu, Pb) in polychaete Hediste diversicolor and the sediment samples collected from Homa fisheries lagoon (Izmir Bay) and compare these sediment results with other study in the same area. Homa Lagoon is located middle part of the Izmir Bay (Aegean Sea, Turkey). It's the only active lagoon that is in the border of the Gediz Delta and has 1824 ha of surface area. It is added to The Ramsar Convention and preserved by the Ministry of Environment in 1998.

Material and Methods

This study was carried out two stations of the Homa fisheries lagoon in the middle bay as indicated in Fig 1.



Fig. 1. Map of research area with location of sampling stations.

Samples were analysed seasonally from Winter 2003 to Winter 2004. Polychaete species and sediment samples were collected from these stations at the same time. *Hediste diversicolor* were collected by hand and transported daily to the laboratory. These samples were kept in a deep freeze (-21 °C) until analysis and prepared according to international standart methods [1]. The composite samples of polychaetes were weighed and digested with conc. HNO<sub>3</sub>: HClO<sub>4</sub> (5:1) (extra pure Merck) under reflux and filtered. Sediments were collected seasonally with a shovel. Each sediment sample oven dried at 60 °C for 24 h and digested with conc. HCl: HNO<sub>3</sub> (3:1) (extra pure Merck) under reflux and then filtered through Watman 40 filter paper. All samples were diluted with bidistilled water and analysed [2]. Metal samples were analysed by using ICP-OES a Perkin Elmer 2000 DV.

Results and Discussion

The concentrations of some heavy metals (Cd, Cr, Cu, Pb) in *Hediste* diversicolor sampled from Homa Lagoon have ranged between; 0,01-0,16  $\mu$ g Cd/g wet weight, 0,02-11,10  $\mu$ g. Cr/g w.w., 1,54-10,10  $\mu$ g Cu/g w.w., 0,23-15,80  $\mu$ g Pb/g w.w. A large number of studies have been carried out on heavy metal concentrations of various organisms in Izmir Bay but there is no published data about heavy metal concentrations of *H. diversicolor*. The concentrations of heavy metals in sediments varied between 0,03-0,43  $\mu$ g Cd/g dry weight, 6,53-19,10  $\mu$ g. Pb/g d.w., 17,20-41,00  $\mu$ g Cu/g d.w., 33,40-84,90  $\mu$ g Cr/g d.w. in study area. According to the results, obtained sediments from the study area show heavy metal concentrations similar to those reported for Homa Lagoon (Tab. 1).

Tab. 1. Heavy metal levels in sediment from Homa Lagoon of Turkey ( $\mu$ g/g dry weight).

| Locations   | Cd        | Cr        | Cu        | Pb       | References |
|-------------|-----------|-----------|-----------|----------|------------|
| Homa Lagoon | 1,5-4,5   | 32,0-80,0 | 14,0-26,5 |          | 3          |
| Homa Lagoon | 1,6-2,7   | 38,2-45,5 | 24,2-28,5 | 1.14     | 4          |
| Homa Lagoon | 1,6-2,7   | 28,2-38,2 | 14,2-18,5 | -        | 5          |
| Homa Lagoon | 0,03-0,43 | 33,4-84,9 | 17,2-41,0 | 6,5-19,1 | This study |

The Gediz River, which flows to outer bay, is the biggest river in the bay. An important change in Homa Lagoon characterization can be observed according to industrial and agricultural activities along the Gediz River estuary. The order of enhanced metal concentrations found in *H. diversicolor* was: Cd<Cr<Cu<Pb whereas in the sediment the order was different: Cd<Pb<Cu<Cr. According as the results, heavy metal concentrations of sediments are higher than polychaete concentrations. In conclusion, Homa fisheries lagoon is under the effects of Gediz River which is polluted domestical, industrial and agricultural resources.

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# TRACE METALS IN MUSSEL AND SEDIMENT SAMPLES FROM SOUTHEASTERN COAST OF THE BLACK SEA

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# Abstract

The concentrations of trace metals were determined in mussel and sediment samples collected from Yomra at the southeastern coast of the Black Sea. In mussel samples besides of some major elements, As, Zn, Cd, and Se values were higher than sediment samples. The levels of the Mn, Fe, As, Co, Al, Hg and Sc were slight higher at 50 m depth than 200 m depth sediment. On the other hand, the concentrations of the Cu, Pb, Zn, Ni, Sr, Cr, Mg and Ba are high at the 200 m depth sediment.

Keywords : Black Sea, Metals, Sediments.

Pollution levels in the Black Sea have increased due to oil pollution and airborne contaminants [1]. Moreover metal pollution are related to agricultural run offs, insufficient treated sewage effluents and wastes derived from little industry companies in southern east cost of the Black Sea. At the same time, the release of large quantities of soil particles into the Black Sea is the result of high erosion [2]. The objective in this work was to understand the biogeochemical composition of the southern east shelf region under summer conditions with regard to metals in mussel and sediment samples.

| Tab. | <ol> <li>Meta</li> </ol> | al levels | in musse | l and | sediment | samples | s (µg.g <sup>-</sup> - | <sup>1</sup> dry | weight) | ) |
|------|--------------------------|-----------|----------|-------|----------|---------|------------------------|------------------|---------|---|
|------|--------------------------|-----------|----------|-------|----------|---------|------------------------|------------------|---------|---|

| Metal | M       | lus | sel     | Sedim       | ent | (50m)   | Sedim   | ent | (200m)  |
|-------|---------|-----|---------|-------------|-----|---------|---------|-----|---------|
| Cu    | 10.35   | ±   | 1.43    | 60.2        | ±   | 5.58    | 62.7    | ±   | 5.81    |
| Рb    | 0.89    | ±   | 0.14    | 40.4        | ±   | 2.87    | 43.6    | ±   | 3.09    |
| Zn    | 180.2   | ±   | 13.996  | 118.0       | ±   | 6.86    | 184.0   | ±   | 10.70   |
| Mn    | 10.0    | ±   | 0.89    | 718.0       | ±   | 48.10   | 641.0   | ±   | 42.94   |
| Fe    | 120     | ±   | 7       | 41600       | ±   | 2611    | 41200   | ±   | 2586    |
| As    | 9.20    | ±   | 2.72    | 9.5         | ±   | 0.93    | 8.8     | ±   | 0.86    |
| Cđ    | 1.08    | ±   | 0.25    | 0.2         | ±   | 0.02    | 0.3     | ±   | 0.02    |
| Mo    | 0.22    | ±   | 0.05    | 0.6         | ±   | 0.05    | 0.9     | ±   | 0.07    |
| Ag    | 0.005   | ±   | 0.001   | 0.2         | ±   | 0.02    | 0.2     | ±   | 0.02    |
| Ni    | 0.60    | ±   | 0.12    | 27.7        | ±   | 1.98    | 34.5    | ±   | 2.46    |
| Co    | 0.24    | ±   | 0.04    | 17.4        | ±   | 1.33    | 17.1    | ±   | 1.30    |
| U     | 0.030   | ±   | 0.001   | 0.9         | ±   | 0.07    | 1.2     | ±   | 0.1     |
| Th    | 0.020   | ±   | 0.001   | 5.2         | ±   | 0.45    | 5.6     | ±   | 0.48    |
| Sr    | 16      | ±   | 1.42    | 128.0       | ±   | 10.81   | 192.0   | ±   | 16.21   |
| Sb    | <       | 0.0 | 2       | 0.3         | ±   | 0.02    | 0.4     | ±   | 0.03    |
| V     |         | <2  |         | 82.0        | ±   | 6.39    | 90.0    | ±   | 7.01    |
| Ca    | 190.0   | ±   | 19.59   | 17500       | ±   | 1129    | 26400.0 | ±   | 1703.20 |
| Ρ     | 10490.0 | ±   | 1628    | 1060.0      | ±   | 79.50   | 1150.0  | ±   | 86.25   |
| Cr    | 1.50    | ±   | 0.35    | 25.0        | ±   | 1.84    | 29.0    | ±   | 2.13    |
| Mg    | 112.0   | ±   | 12.11   | 14500.0     | ±   | 966.67  | 14600.0 | ±   | 973.33  |
| Ba    | 0.40    | ±   | 0.06    | 98.0        | ±   | 6.80    | 124.0   | ±   | 8.61    |
| Ti    | 36.0    | ±   | 4.50    | 670.0       | ±   | 54.03   | 720.0   | ±   | 58.07   |
| в     | 6.0     | ±   | 0.73    | 12.0        | ±   | 1.12    | 13.0    | ±   | 1.21    |
| A1    | 4       | :10 | 0       | 29800.0     | ±   | 2237.30 | 29500.0 | ±   | 2214.80 |
| Na    | 2740    | ±   | 1370    | 3450.0      | ±   | 330.82  | 6900.0  | ±   | 661.64  |
| K     | 5300.0  | ±   | 620.61  | 2500.0      | ±   | 170.45  | 3200.0  | ±   | 218.18  |
| Hg    | 0.039   | ±   | 0.004   | 0.26        | ±   | 0.017   | 0.07    | ±   | 0.005   |
| Sc    | 0.20    | ±   | 0.07    | 8.5         | ±   | 0.68    | 8.3     | ±   | 0.66    |
| T1    | <       | 0.0 | 2       | 0.1         | ±   | 0.008   | 0.1     | ±   | 0.007   |
| S     | 11400.0 | ±   | 3257.14 | 900.0       | ±   | 42.86   | 4000.0  | ±   | 190.48  |
| Se    | 2.20    | ±   | 0.76    | en en el el | <0. | 5       | 0.5     | ±   | 0.03    |

Two sampling stations were chosen from Yomra where is located in southeastern coast of the Black Sea for sediment samples. Samplings were realized in June, 2006. Mussels (*Mytilus galloprovincialis*) were collected from the same area. Prior to metal analysis, the soft parts were dissected, and dried at 85 °C for 48 h. 1 g sample leached with 2 ml HNO<sub>3</sub> for 1 h, then 6 ml 2-2-2 HCl-HNO<sub>3</sub>-H<sub>2</sub>O at 95 °C for 1 h, diluted to 20 ml, and analyzed ICP-MS. Surface sediment samples were taken from depths of 50 and 200 m using Ekman-type graph sampler. Samples were sliced into 0-4 cm layers with three replicates and desalted using distilled water. On arrival to the laboratory <63 $\mu$ m size fractions were separated and dried at 85 °C for 48 h 0.5 g sediment sample leached with 3 ml 2-2-2 HCl-HNO<sub>3</sub>-H<sub>2</sub>O at 95 °C for 1 h, diluted to 10 ml, and analyzed by ICP-MS. The results obtained for mussel and sediment samples are shown in Table

1. In mussel samples besides of some major elements, Zn, Cd, and Se values were higher than sediment samples taken from depth of 50 m, also As, Cd, and Se values were higher than samples taken from 200 m. In sediment samples taken from depth of 50 m Co, Mn, Fe, As, Au, La, Al, Hg, Sc and Ga values were higher than samples taken from 200m. Therefore other elements were high in 200 m except Ag and Tl which have equal values. Our Cu and Pb values in mussel samples were generally higher than western coast of the Black Sea except Ünye and Amasra [1], [3]. At the same time Cu, Zn, and Mn values were higher than Rize and Pazar samples [4]. In the present study Cu, Fe, Mn, Pb and Zn values in sediment samples were generally higher than western coast of the Black Sea. On the other hand our Cu, Fe, Mn, and Zn values were generally lower than Rize sediments. When this study is compared with a previous work, which was carried out at the same station in winter condition, Cd values decreased in sediment samples. In contrast Cr, Cu, Fe, Mn, Ni, Pb, and Zn values increased [5]. In general, our results showed that the Pb, Cu and Mn values were found relatively high in mussel and sediment samples than southern west coast of the Black Sea.

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# PAH CONTENT AND TOXICITY OF SEDIMENT, SEAWATER AND MUSSEL TISSUE IN GULF OF RIJEKA

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# Abstract

The total concentrations of PAHs at 6 sampling sites of the Gulf of Rijeka vary from bellow detection limit to 305 ng/l in seawater, from 213 to 695  $\mu$ g/kg dry weight in sediment and from 49.2 to 134 ng/g wet weight in mussel tissue. Toxicity of seawater and sediment organic extract is correlated with PAHs content indicating that PAHs are predominant toxic compounds. There is a positive correlation between potential toxicity of mussel biological fluids and reduction of anoxic survival time.

Keywords : Adriatic Sea, Pah, Bivalves, Ecotoxicology.

The Gulf of Rijeka is a landlocked bay of the Northern Adriatic Sea with an area of 450 km<sup>2</sup>, average depth 60 m and volume of 27 km<sup>3</sup> with a number of industrial enterprises (petrochemical, electricity generating facilities fuelled by charcoal, shipyard and harbor) situated along its coastline in suburban areas of Rijeka. Therefore, an increase in anthropogenic influence on marine environment in Gulf of Rijeka especially with PAHs is expected. The concept of integrative chemical and biological monitoring for ecotoxicological evaluation of risk in environmental management was applied. The relationship between presence of specific contaminants (PAHs) in different matrices, their potential toxicity and ability to affect marine mussel was investigated. Collection of seawater, sediment and mussel specimens was performed at six sampling sites comprising site under the direct influence of refinery waste waters (1), oil refinery dock areas (2, 3), recreational areas (4, 6) and marina (5). The quantification of the PAH content in the samples was performed with HPLC and the potential toxicity of organic extracts of seawater and sediment as well as mussel biological extract was measured by Microtox bioassay. Physiological condition of mussels was measured as anoxic survival time [1].

The total concentration of the PAHs detected in the seawater, sediment and mussel varies indicating differences in recent input of PAHs in marine environment are in the range similar to those reported for the Thermaikos Gulf, Greece [2] (Table 1.).

Tab. 1. Total PAH content and toxicity of sediment, seawater and mussel tissue in Gulf of Rijeka.

|           | SEDIMENT                 |                           | SEA                  | WATER                    | MUSSEL                  |                          |
|-----------|--------------------------|---------------------------|----------------------|--------------------------|-------------------------|--------------------------|
| SITE<br>1 | ΡΑΗ<br>μg kg-1 DW<br>213 | TOX<br>1/EC50*100<br>0.65 | PAH<br>ng 1-1<br>237 | TOX<br>1/EC50*100<br>6.3 | PAH<br>ng g-1 WW<br>103 | TOX<br>1/EC50*100<br>1.4 |
| 2         | 241                      | 0.80                      | 294                  | 5.4                      | 134                     | 1.7                      |
| 3         | 624                      | 0.89                      | 291                  | 8.5                      | 57                      | 1.4                      |
| 4         | 511                      | 0.92                      | d.1.                 | 2.0                      | 99                      | 1.8                      |
| 5         | 695                      | 1.30                      | 305                  | 7.6                      | 101                     | 2.9                      |
| 6         | 577                      | 0.90                      | 195                  | 5.3                      | 49                      | 3.9                      |
|           | R = 0.819                |                           | R = 0.894            |                          | No correlation          |                          |

The total PAH levels in sediment samples were similar to those reported for the Gulf of Trieste [3]. Two sediment samples (1, 2) could be classified as slightly contaminated and 4 sediment samples (3, 4, 5, 6) as highly contaminated. The levels of PAHs in mussels Mytilus galloprovincialis are within the same range reported for the same species from Thermaikos Gulf, Greece [2], in M. edulis from Northern Irish Sea Loughs [4] and in Baltic Sea bivalves Macoma balthica and Astarte borealis [5]. A good functional linear regression between toxicity data sets over seawater and sediments PAHs was noted (R = 0.894 for seawater, R = 0.819 for sediment) while no correlation between mussel toxicity and PAHs was observed. This result suggests that the PAHs represent the majority of toxic compounds present in organic extracts of seawater and sediment from the Gulf of Rijeka, while the level of toxic content in mussels depends not only on PAHs concentration in the environment but on their bioavailability, bioaccumulation and metabolisation in mussels, as well as on the presence of other toxic environmental contaminants accumulated by mussels. In search of correlation between PAH accumulation and physiological response determined as reduced capacity of mussels to adapt to additional stress, anoxic survival has been measured and the result are presented in Table 2.

The lowest anoxic survival time was detected for mussels with the lowest tissue PAH content suggesting that other environmental factors have influenced this response. Additional stressors might have affected viability of mussels as is the case with any field study. Positive correlation (R = 0.935) between potential toxicity of mussels and reduction of anoxic survival time confirms the presence of other unknown toxic contaminants, besides PAHs, that were accumulated in mussels and impacted the physiological parameter measured.

Tab. 2. Toxicity and anoxic survival of mussel *Mytilus galoprovincialis* collected in the Gulf of Rijeka.

| SITE                      | 1   | 2   | 3   | 4   | 5   | 6   |           |
|---------------------------|-----|-----|-----|-----|-----|-----|-----------|
| TOX<br>1/EC50*100         | 1.4 | 1.7 | 1.4 | 1.8 | 2.9 | 3.9 | R = 0.935 |
| Anoxic survival<br>/ days | 8.4 | 7.4 | 7.8 | 7.2 | 6.4 | 6.0 |           |

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# ARSENIC METABOLISM IN THE MEDITERRANEAN POLYCHAETE SABELLA SPALLANZANII

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# Abstract

The bioaccumulation and biotransformation of arsenic was investigated in the Mediterranean polychaete *Sabella spallanzanii*. This species is considered an interesting model which concentrates in branchial crowns very elevated levels of dimethylarsinic acid (DMA), a moderately toxic arsenic compound. Organisms were exposed to different arsenic compounds and the total concentrations and chemical speciation were measured. The overall results suggest the ability of *S. spallanzanii* to produce DMA through transformation reactions including both methylation and degradation of other arsenic compounds.

Keywords : Annelida, Bio-accumulation, Chemical Speciation, Metals.

Nearly all marine organisms contain measurable levels of arsenic which is present as organic non toxic compounds. Arsenic concentrations vary widely in different taxa and species-specific characteristics more than environmental factors appear to modulate basal arsenic bioaccumulation in bivalve molluscs and fishes, without a consistent trend by taxonomic group or trophic levels [1]. On the other hand crustaceans seem to exhibit greater As concentrations in temperate or cold regions compared with tropical latitudes [1]. Among polychaetes, some species accumulate elevated levels of this element and also exhibit the presence of moderately toxic arsenic compounds; the natural variability in arsenic total content and speciation of chemical forms among various polychaetes species are not explained in terms of anthropogenic impact, geographic distribution, phylogenetic similarities, trophic habits or ecological features [2]. The Mediterranean fan worm Sabella spallanzanii is characterized by marked differences of arsenic concentrations in different tissues, with values ranging between 40 and 60 ppm in body portions and higher than 1000 ppm in the branchial crowns [3]. Arsenic is associated to cytosolic fraction in a soluble form and analyses of chemical speciation revealed the great predominance (more than 85%) of dimethylarsinic acid (DMA), a moderately toxic compound [3]. The presence of DMA in these tissues might suggest both the degradation of more complex arsenic-compounds i.e. arsenobetaine (AsB), arsenocholine (AsC) or arsenosugars (AsS) accumulated from phytoplanctonic algae, or the methylation of inorganic arsenic usually present in abiotic matrices, such as seawater and sediments [2,3]. To obtain further insights on the capability of S. spallanzanii to accumulate different forms of arsenic compounds and to operate transformation reactions, organisms were exposed under laboratory conditions to various chemical species of arsenic including arsenate (As<sup>V</sup>) (20  $\mu$ g/L), DMA (60  $\mu$ g/L), trimethylarsine (TMA) (60  $\mu$ g/L) and AsB (60  $\mu$ g/L). After 20 days total arsenic content and chemical speciation were measured in both branchial crowns and body portions and differences among tissues and kind of experiments were compared using ANOVA and SNK post-hoc tests.



Fig. 1. Total As content (ppm) in branchial crowns and body tissues of organisms exposed to different chemical forms. Letters indicate statistical differences between means of values (p<0.0001).

The highest increases of arsenic content were observed in branchial crowns of organisms treated with arsenate, which can enter the cell through the phosphate carrier system; lower variations were measured with DMA and TMA, while not significant changes of total As occurred after treatments with AsB (Figure 1). In body tissues, exposure to  $As^V$ , DMA, TMA confirmed a progressively lower accumulation of total arsenic, while a marked increase was caused by AsB (Figure 1). The basal level of arsenic chemical species in branchial crowns of *S. spallanzanii* were about 1100 ppm for DMA, 6 ppm for TMA, 67 ppm for tetramethylarsonium

(TETRA), 58 ppm for AsB and 63 ppm for AsC. Concentrations occurring in the body portions were about 25 ppm for DMA and 5 ppm for AsB.



Fig. 2. Arsenic bioaccumulation and biotransformation pathways occurring in the polychaete *Sabella spallanzanii*.

Analyses of chemical speciation of organisms exposed to AsV revealed that inorganic arsenic never occurred in the tissues and the variations of total arsenic were explained almost exclusively by the significant increase of DMA with concentrations always close to 80-90%. Levels of other As compounds remained unchanged during this experiment. Similar trends were obtained after exposures to DMA and TMA when only concentrations of DMA significantly increased in tissues of S. spallanzanii while levels of TETRA, AsB, AsC did not change compared to control values. Different results were obtained after exposures to AsB which caused no accumulation of arsenic in branchial crowns and a marked increase in body tissues mostly related to AsB (39 ppm) and especially TMA (222 ppm), not previously detected in any of other experimental conditions. The overall results allowed to hypothesize the mechanisms of arsenic bioaccumulation and biotransformation in S. spallanzanii (Figure 2). During all the experiments, DMA was the most accumulated molecule, suggesting that this polychaete species possesses the enzymatic pathways for methylation and de-methylation reactions of inorganic and tri-methylated arsenicals. Only AsB was not accumulated in branchial crowns and not converted to DMA, supporting a microbial pathway for degradation of this molecule, particularly important in body tissues of S. spallanzanii for the presence of bacteria associated to digestive tracts [4]. The efficient biotransformation of arsenic would explain the elevated basal levels of DMA typical of S. spallanzanii which may represent an adaptive mechanism against predation in more vulnerable tissues.

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# MONITORING ENVIRONMENTAL STRESS IN INDIGENOUS BLUE MUSSELS (*MYTILUS SP*) SAMPLED FROM THE LAGOON OF VENICE

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# Abstract

The environmental stress of *Mytilus sp.* specimens collected from the mussel populations of four specific sites inside the Lagoon of Venice and from one offshore site nearby, has been investigated by means of an ecotoxicological biomarker. The approach has been applied to the Lagoon of Venice in that it constitutes the drainage basin of a highly industrialized region. The study concerned the genotoxic effects, evaluated as DNA strand breaks by single cell gel electrophoresis, in digestive gland cells and in hemocytes of mussels collected from December 2005 to September 2006. In both tissues mussels collected inside the Lagoon showed higher levels of DNA damage compared to specimens from the offshore site with a damage trend significantly increasing from the Lagoon border towards the inner parts *Keywords : Bivalves, Ecotoxicology, Monitoring, Pollution.* 

The Lagoon of Venice is a complex ecosystem extending over an area of about 550 square kilometers with an average depth of 1 m and a consistent number of navigable channels. It constitutes the drainage basin of a highly industrialized region with a population of about 1.300.000 persons. About twenty years of pollution monitoring through the whole basin and in specific areas of the lagoon, showed the presence of heavy metals, PAHs and PCBs [1-3]. However the chemical based monitoring of this environment has been mainly focused in the identification of xenobiotics while their impact on aquatic life in the natural environment has yet to be determined. The study of biological response to stress in sentinel species presently constitutes a major issue in environmental risk assessment (ERA) and quality evaluation.. Among these approaches the evaluation of DNA strand breaks (double and single) and alkali labile sites by means of Comet assay [4] is increasingly studied not only in laboratory experiments but also in field evaluations, due to the high sensitivity and the early response to genotoxic agents [5].

In the present study the environmental stress of *Mytilus* sp. specimens collected in four distinct sites inside the Lagoon of Venice, two of these located in the proximity of the sea side, the other two in inner parts of the lagoon, has been investigated and compared with the response of mussels collected in a offshore site nearby the lagoon. The study concerned the genotoxic effects, evaluated as DNA damage (as double and single strand breaks and alkali labile sites) by single cell gel electrophoresis (comet assay), in: a) digestive gland cells and b) hemocytes, of mussels monthly collected, from December 2005 to September 2006.

In both tissues mussels collected inside the Lagoon showed higher levels of DNA damage compared to specimens collected from the offshore site, with a damage trend significantly increasing from the Lagoon border towards the inner parts. The transplant of mussels collected in the offshore site in Lagoon inner sites showed, after one month, a significantly increased damage, reaching levels similar to those observed in the native inner site specimens. DNA damage levels in digestive gland cells resulted always significantly higher than in hemocytes.

Our data, that will be matched with chemical pollution assessment data, confirm and extend results obtained in a previous field study performed with blue mussels and comet assay in the Lagoon of Venice [6], and suggest a high sensitivity and a remarkable reliability of the comet assay as early biomarker in field ERA studies

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# MICRONUCLEUS TEST IN MUSSEL AS A TOOL IN BIOMONITORING NETWORKS: RESULTS ALONG THE IBERIAN MEDITERRANEAN COAST

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# Abstract

Micronuclei (MN) frequency was measured in gill tissue of native mussels, *Mytilus galloprovincialis*, along the Iberian Mediterranean Coast. Significant differences (p<0.05) on MN frequencies were found between some sampling sites and the reference area. Higher MN frequencies were found in sampling sites located along Murcian Coast and southwest Andalusian Coast which may be indicative of a higher exposition to genotoxic compounds of mussels inhabiting these areas. Results supported the application of the MN test in branchial mussel cells as a sensitive biomarker for applying in biomonitoring networks. *Keywords : Bio-indicators, Monitoring, Western Mediterranean.* 

Introduction

Micronucleus cell frequency demonstrates objectively the level of genotoxic damage and, among many mutagenesis assays, the MN test has been successfully applied as it is simple, reliable and sensitive. Mussel has proved to be an adequate organism for the study of the genotoxic effect of pollutants due to its capacity to accumulate high levels of contaminants including those with genotoxic properties. In this study, MN frequency was determined on branchial cells of mussels from coastal sites affected by different levels of anthropogenic pollution with the aim of determining the adequacy of this test to detect genotoxic effects of pollutants in a field study performed along the Iberian Mediterranean Coast.

#### Material and Methods

Native mussels were collected from 18 sampling sites during May-June 2003 (Figure 1). Gills were removed, digested and filtered to obtain a cellular suspension. After centrifugation, cellular pellet was fixed in methanol:acetic acid, dropped onto clean glass slides and then stained with 3% Giemsa. Sampling size (n) ranged from 6 to 8 and at least 1000 cells per mussel were scored in the subpopulation of cells prevailing in gill tissue, the main gill cells [1]. MN identification was based on the criteria described in [2].

#### Statistical analysis

Results were expressed as mean  $\pm$  S.E. Significant differences on MN frequencies among sites were tested by applying the independent samples T-test (significance was set at p<0.05). Analysis were performed using SPSS 11.0 packet.



Fig. 1. Map of the Iberian Mediterranean Coast showing the sampling stations.

# Results and Discussion

As brachial epithelium represents the primary target for water-borne, gills tend to have higher MN frequencies than haemocytes. According to Brunetti et al [3], for unpolluted areas of the Mediterranean, within the thermal range of 15 to 20 °C (spring), it may be assumed a spontaneous MN gill frequency on *M. galloprovincialis* of  $2^{\circ}/_{oo}$ . The lowest MN frequency recorded in Cadaqués ( $1.92^{\circ}/_{oo} \pm 0.50$ ) could be assumed as a spontaneous frequency not related with genotoxic pollution, and therefore, this site could be a realistic reference area for this purpose.

Taking this into account, significantly higher MN frequencies than in this control site, were recorded in two main areas that included Cartagena, Cabo Palos and Portman on Murcia Coast, and Algeciras (1 and 2) and Manilva on the southwest Andalusian Coast (p<0.01). Also Tarragona and Vallcarca (Catalonian area), and Torrox and Almuñecar (Andalusian area) showed high MN frequencies (p<0.05).

Higher MN frequencies recorded in these areas may be indicating strong exposition of mussels to genotoxic agents. Majority of the areas that showed highest MN levels are well known hot-spot of the Iberian Mediterranean Coast.

This study demonstrated the feasibility of MN test on mussel gill cells to be applied in biomonitoring networks as a tool to detect effect of genotoxic pollution. In further studies, special attention should be paid in areas where mussel seems to be affected by genotoxic damage to identify pollutants which may be causing these observed biological effects.



Fig. 2. MN frequencies (per 1000 cells) in the gills of mussels (mean  $\pm$  S.E.). MN frequency significantly higher than the reference site (darker bar) at p<0.05 (\*) and p<0.01 (\*\*).

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# MICRONUCLEUS TEST IN ERYTHROCYTES OF *MULLUS BARBATUS* FROM THE IBERIAN MEDITERRANEAN COAST: A BIOASSAY FOR THE *IN SITU* DETECTION OF GENOTOXIC POLLUTION

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# Abstract

Feral red mullet, (*Mullus barbatus*), were sampled from four different areas located in the Iberian Mediterranean Coast. Peripheral blood samples were analyzed for erythrocyte micronuclei (MN). The results shown significant differences on MN frequencies among areas (p<0.05) but these were only demonstrable for female specimens. Higher MN frequencies were found in Ebro Delta and Cartagena, indicating a higher exposure to genotoxic contaminants in fish from these areas. The results of this study indicate that the MN test in *Mullus barbatus* could be a suitable biomarker for *in situ* monitoring of genotoxic pollution in the marine environment. *Keywords : Fishes, Bio-indicators, Monitoring, Western Mediterranean.* 

#### Introduction

In the study of the biological effects of the marine pollution is recommended to apply a battery of test that includes biomarkers of genotoxicity such as the MN test [1]. Micronuclei are small intracytoplasmic pieces of chromatin that result from chromosome breakage during mitosis. The MN test has been adapted to fish species (piscine micronucleus test) where MN can be analysed in peripheral erythrocytes and also in cells from tissues such as gill, kidney, liver and fin. The use of erythrocytes allows a rapid enumeration and blood smears are easily obtained and prepared. In this study we assessed the usefulness of the piscine MN test on erythrocytes of *Mullus barbatus* for the monitoring of genotoxic pollution.

#### Material and Methods

A survey was carried out in April 2006, to collect specimens of *Mullus barbatus* and superficial sediments from four areas of the Iberian Mediterranean Coast exposed to different degrees of anthropogenic activities (Figure 1.B) in the framework of the MEDPOL Biomonitoring Program [1]. Individual red mullets were sexed and their length measured. Peripheral blood samples were drawn and smeared onto microscope slides and air-dried. After fixation in pure methanol for 10 minutes, slides were left to air-dry and then were stained with 5 % Giemsa solution for 30 min. Due to the high interindividual variability on MN frequency, twelve fishes were analysed in each area and a minimum of 2000 erythrocytes per animal were scored under oil immersion at 1000 x magnification. MN were counted using the criteria of Carrasco et al. [2] and MN frequencies were expressed per 1000 cells.

#### Statistical analysis

Results were expressed as mean  $\pm$  S.E. Data were log10 transformed to achieve normal distribution and homogeneity of variances. Differences between sexes within each area were evaluated by non-parametric Mann-Whitney U-test. One-way ANOVA was used to test differences of MN values among areas, followed the Tukey-b test multiple comparison test (n unequal). Level of significance was set at 0.05. Analysis were performed using SPSS 11.0 packet.

# Results and Discussion

Field studies provide most realistic information about the potential genotoxicity of complex contaminant mixtures in aquatic environments than in vitro and laboratory assays. None of the four areas selected in this study could be considered as a clean or control site because all of them are influenced by anthropogenic activities. Cartagena and Valencia are highly industrialized cities while Santa Pola Bay and Ebro Delta are under the influence of the Segura and Ebro rivers inputs of contaminants, due to the urban, industrial and agricultural activities developed in their river basins. Although we did not find differences among sexes on MN frequencies within each area (Mann-Whitney U-test, p>0.05), one-way ANOVA test applied separately to males and females, shown significant differences in MN levels among areas only in females (p<0.05). MN frequencies in females were significantly higher in Ebro Delta than Santa Pola Bay (p<0.05). Also higher MN frequencies were recorded in Ebro Delta than Valencia, and in Cartagena than Valencia and Santa Pola Bay, though such differences could not be statistically demonstrable (Figure 1.A). In this study, we could not assume any area as a control. However, Bolognesi [3] found a spontaneous MN frequency of 0.33 in erythrocytes of M.barbatus from a reference area in the Mediterranean Sea. MN frequencies recorded in Ebro Delta and Cartagena indicate a strong exposition

to genotoxic compounds in these areas. MN frequencies in Valencia and Santa Pola Bay were lower, though higher than 0.33, so it could be pointing to fishes inhabiting these areas were also exposed to genotoxic contaminants.



Fig. 1. A) MN frequencies (mean  $\pm$  E.S.) in males and females. (\*) MN frequency significantly higher than Segura (p<0.05); B) Location of the sampling sites.

MN test was able to detect differences among areas affected by different degrees of genotoxic pollution. Only females' results shown such differences, and therefore, further studies should be performed in future to assess the influence of biotic factors on this biomarker. Regardless, the use of erythrocytes from native *M. barbatus* proved to be a sensitive and promising tool for the marine environment genotoxicity monitoring.

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# SEA SURFACE MICROLAYER: FRACTIONATION AND ANALYSIS

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# Abstract

The sea surface microlayer (SSM) as a key interface for exchange of gases, material and energy between the ocean and the atmosphere, consists of a wide variety of organic chemical substances. The SSM was studied as *ex-situ* reconstructed films after previous extraction by different organic solvents using phase sensitive ac. voltammetry, which offers a direct analytical possibility to investigate physicochemical characteristics and interactions in natural films. The electrochemical results will be compared with Iatroscan (TLC/FID) analysis of microlayer lipid material.

Keywords : Interfaces, Surfactants, Electrochemistry, Organic Matter, Chemical Analysis.

The sea surface microlayer (SSM) is a thin layer between the ocean and the atmosphere with special physical, chemical and biological properties that either affects or is affected by global climate change. Actually, it hosts the main exchange processes of organic and inorganic matter, gases, water vapour, heat and energy between those two departments. Moreover, some other boundary processes develop in this thin layer including the transformation of dissolved organic material into a dispersed state, the transformation of compounds from low- to high-molecular and photochemical transformation. The SSM is also known to concentrate many chemical substances that originate from both the air and seawater, with particular preference to those that are surface active and show particularly strong interfacial affinity. The environmental significance of surface microlayer is widely accepted, although there are still many gaps in our understanding of the morphology and chemical composition affecting the mechanisms of exchange processes.

During the three-year period, the SSM has been sampled in different marine environments in different seasons and weather conditions. Due to the fact that the SSM is complex mixture of organics as polysaccharides, proteins, lipids and their products of condensation and degradation, fractionation of microlayer material was performed by extraction using organic solvents of different polarities (n-hexane and dichloromethane). The extracts were evaporated to dryness in a rotary evaporator and dissolved again in preparatory solvent.

The capacitance of different *ex-situ* reconstructed films was estimated by a.c. voltammetry (*out-of-phase* signal) after transferring organic extracts of natural microlayers spread onto electrolyte from the air-water interface to the mercury surface by vertical dipping the electrode through the film (1). The capacity minimum values as well as the shape of capacitance curves and the position of desorption peaks of different films will be compared with those of model surfactants and their mixtures relevant for natural samples. The method will also offer a direct analytical possibility to investigate the structure, morphology and interactions in natural films, analysing the effect of potential organic pollutants such as polycyclic aromatic hydrocarbons present as solutes in the aqueous phase.

Additional characterization of the structure of natural films was carried out by ac. voltammetry (*in-phase* signal) using an electrochemical probe. The cathodic process of cadmium, as potential pollutant in natural waters, was chosen as an indicator of the permeability of adsorbed microlayers at the mercury electrode. The influence of transferred *ex-situ* microlayers on the reduction of cadmium was followed through the change of the peak current (I) relating to peak current (I<sub>0</sub>) of pure cadmium. Fractionation of original SSM by extraction using solvents of different polarity enabled the selection of specific material which adsorbed to the mercury surface have different effects on the electrode process of cadmium.

The highest inhibition was noticed for almost all dichloromethane films.

Further, by using the Iatroscan, which combines thin layer chromatography (TLC) and flame ionisation detector (FID) technique, it would be possible to separate and quantify classes of lipids present in the SSM (2). Each lipid class will be identified and quantified against authentic standards. Although lipids are not the most abundant group of compounds in SSM, the study of these compounds is extremely important, since due to their reactivity they are essential in the processes of formation and stabilization of the microlayers. The Iatroscan results would be compared with electrochemical responses of different *ex-situ* films and would add a new dimension to physicochemical characterization of natural surface films.

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# DINITROGEN FIXATION IN WESTERN MEDITERRANEAN SEA: A SIGNIFICANT NITROGEN INPUT FOR BIOGEOCHEMICAL BUDGET.

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# Abstract

Nitrogen fixation ( $^{15}$ N method), investigated in the Northwestern Mediterranean Sea, was detectable all over the year with rates ranged from 2 to 17 nmoles. $I^{-1}$ . Highest values were obtained during spring associated with the phytoplankton bloom. High rates were also measured during the oligotrophic summer period. This biological nitrogen input could balance the annual biogeochemical budget in the Mediterranean Sea and could explain the high nitrate/phosphate ratio observed in deep waters. *Keywords : Gulf Of Lions, Cyanobacteria, Primary Production.* 

While any direct nitrogen fixation data are still unavailable,  $\delta^{15}$ N data in settling particles suggest that dissolved atmospheric N<sub>2</sub> may act as a significant new nitrogen source in the Western Mediterranean basin[1]. To test this hypothesis, N<sub>2</sub>-fixation experiments were carried out during 12 cruises in the Ligurian Sea at one station named DYFAMED (43°25'N, 7°52'E- MELISSA program, 2003-2004) and in the Gulf of Lions during the BIOPRHOFI cruise (May 2006). Dinitrogen fixation and primary production rates were simultaneously determined at surface or at 6 level depths using the dual labelling <sup>13</sup>C/<sup>15</sup>N procedure.

Figure 1 reveals vertical profiles of nitrogen fixation observed along the year at the Dyfamed site. In autumn and winter, primary production rates were weak and variable while nitrogen fixation was very low (<2 nmoles.l<sup>-1</sup>. d<sup>-1</sup>) and often close to the detection limit (<0.5 nmoles.l<sup>-1</sup>. d<sup>-1</sup>). During the spring period, nitrogen fixation increased concurrently to primary production reaching 17 nmoles N.l<sup>-1</sup>. d<sup>-1</sup> in March 2003 and 4 nmoles N.l<sup>-1</sup>.d<sup>-1</sup> in April 2004. In summer, primary production rates were low, close to those measured in winter, while nitrogen fixation seemed to be more variable with high rates (>4 nmoles.l<sup>-1</sup>. d<sup>-1</sup>) measured in surface in July and August.



Fig. 1. Dinitrogen fixation vertical profiles in the 0-60 m upper layer obtained in the Western Mediterranean.

Areal dinitrogen fixation rates were around 40 to 100  $\mu$ moles N.m<sup>-2</sup>.d<sup>-1</sup>along the year, but could reach 400  $\mu$ moles N.m<sup>-2</sup>. d<sup>-1</sup>in spring. Dinitrogen fixation generally represented less than 5% of new production. But, under oligotrophic conditions, this process contributed significantly to new production, up to 40%. Data obtained during BIO-PRHOFI confirm the importance of this process in the Mediterranean during spring: high rates (4 to10 nmoles.l<sup>-1</sup>. d<sup>-1</sup>) were measured in the total fraction, as well as in the less than 10  $\mu$ m fraction. The calculated annual fixation rate (34 mmoles N.m<sup>-2</sup>.year<sup>-1</sup>) could have implications in the long-term biogeochemical functioning of the Mediterranean Sea as proposed by and Béthoux et al. (1998) [2]. According to the these authors, our annual budget of atmospheric N<sub>2</sub> fixation could balance the nitrogen budget for the whole Mediterranean Sea or for the western basin [3], and

could explain in part the high nitrate/phosphate ratio observed in deep waters.

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# ARSENIC DISTRIBUTION IN KALLONI BAY, ISLAND OF LESVOS, GREECE

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# Abstract

Arsenic levels were studied in seawater, sediments and bivalves from Kalloni Bay, island of Lesvos, Greece. The concentrations of As in dissolved phase of seawater showed a uniform distribution (1.00 to 1.68 ppb), while in sediments they ranged from 10.9 to 32.9 mg/kg, showing slight enhancement in some coastal stations. The mean concentrations per dry weight in four bivalve species of the Bay were relatively increased compared to literature data (28.7 mg/kgfor *Venus Verrucosa*, 40.8 mg/kgfor *Modiolus Barbatus*, 20.9 mg/kgfor *Chlamys Glabra* and 41.8 mg/kgfor *Arca Noe*), suggesting possible contamination from geological formations in the drainage basin of the Bay.

Keywords : Aegean Sea, Trace Elements, Bivalves, Sediments.

Arsenic is a ubiquitous element in earth crust and natural waters, which is known to be carcinogenic. Elevated natural concentrations of As are usually related to local geology and the presence of hydrothermal fields [1]. In Kalloni Bay, Lesvos island, Greece, the presence of hydrothermal springs at the eastern basin of the Bay and igneous rocks at the western - northern basin, as well as sparse data on elevated As concentrations in water from deep irrigation boreholes at the area [2], suggested possible As contamination. To investigate possible impact on the marine environment, As concentrations were determined in seawater, sediments and bivalves from Kalloni Bay.

Seawater and sediment samples were collected during July 2006 from fourteen sampling stations (Figure 1). Dissolved As in seawater was determined by Hydride Generation Atomic Absorption and As in the sediments (<1 mm), was determined by Graphite Furnace Atomic Absorption (GFAAS) after a high-pressure microwave digestion in teflon bombs, with a mixture of HCl - HNO3 - HF. Bivalve species ( Venus Verrucosa, Modiolus Barbatus, Chlamys Glabra and Arca Noe) were collected during February 2006 from the station K3. Composite samples of the selected species were produced by the homogenization of the edible part from 3 to 9 individuals and digested in teflon tubes, with a mixture of HNO3 and H2O2. Arsenic was determined by GFAAS. The quality assurance of the analytical results was controlled with the use of appropriate reference materials. Arsenic concentrations in dissolved phase of seawater ranged from 1.00 to 1.68 ppb and showed uniform distribution. These values are considered normal worldwide [3]. The concentrations of As in sediments ranged from 10.9 to 32.9 mg/kg. Higher concentrations were found at stations K7 (29.4 mg/kg), K10 (32.9 mg/kg) and K14 (27.0 mg/kg), and were comparable to values found in coastal sediments influenced by an As rich geological background [4]. However, the natural variation of As in marine sediments worldwide is wide [1] and therefore no conclusive comments can be made before further investigation on the possible land-based sources of As in the area. In the selected bivalve species, As concentrations were as follows: for Venus Verrucosa 25.8-31.5 mg/kg (dry weight - d.w.) (mean 28.7 mg/kg), for Modiolus Barbatus 35.2-46.3 mg/kg (mean 40.8mg/kg), for Chlamys Glabra 20.7-21.1 5 mg/kg (mean 20.9 mg/kg)and for Arca Noe 41.8 mg/kg (mean). The As levels in bivalves of the Bay were relatively higher than those found in Mytilus galloprovinchialis from the Aegean Sea (8.8 to 34.1 mg/kg d.w. [5]), the Adriatic Sea along the Croatian coast (mean 12.80±2.85 mg/kg d.w. if we assume moisture 80% [6]), or the Venice lagoon (12 to 18 mg/kg d.w. [7]). The above data suggest a possible As contamination of the bivalve species in the Bay, probably related to local geology (presence of igneous rock formations and thermal springs). This contamination process needs further investigation to draw more definite conclusions on the As pollution sources in the drainage basin of the Bay.

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Fig. 1. Study area and sampling stations.

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# USE OF CAGED MUSSEL *MYTILUS GALLOPROVINCIALIS* IN AN ECOTOXICOLOGICAL APPROACH TO ASSESS ENVIRONMENTAL IMPACT IN OFF-SHORE ACTIVITIES

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# Abstract

Mediterranean mussels, *Mytilus galloprovincialis*, are well recognized bioindicator organisms which can be easily caged in investigated areas to assess the impact of anthropogenic activities. In this work a monitoring protocol was developed for off-shore installations in the Adriatic sea. Integration of chemical analyses with a wide range of biomarkers analysed in mussels caged at 2 platforms, allowed to evaluate the biological disturbance and confirmed the utility of the ecotoxicological approach for monitoring off-shore activities. *Keywords : Bio-indicators, Adriatic Sea.* 

Several environmental issues are associated with the off-shore oil and gas industry, from the impact caused during installation to various form of disturbance related to daily ship traffic, extraction activities, maintenance of structures and, finally, decommissioning of old platforms. During the last year a monitoring protocol with caged mussels, *Mytilus galloprovincialis*, has been developed, to evaluate the potential ecotoxicological effects caused from the off-shore platform "Giovanna" in the Adriatic sea. Obtained results allowed to exclude marked biological disturbance and demonstrated the suitability of this approach. In this respect considering "Giovanna" as model platform, the monitoring protocol with caged mussel has been extended including also another off-shore installation, the "Emilio" platform.

In this work native mussels were collected on a seasonal basis from a reference site on the Adriatic coast (Portonovo, Ancona) and transplanted for 4-6 weeks in both the sampling area and to the investigated platform "Giovanna" (42° 46' 060N, 14° 27' 750E) and Emilio (42° 56' 305 N; 14° 13' 915 E). After the translocation period, mussels were recovered dissected tissues frozen in liquid nitrogen and maintained at -80°C until analyses.

Translocation procedures have been performed in Autumn 2005 (November-December, I sampling period), Winter 2006 (February-March, II sampling period), Spring 2006 (May-June, III sampling period), Autumn 2006 (September-October 2006) in order to characterize seasonal variability of analyzed parameters. Chemical analyses on trace metals (arsenic, cadmium, chromium, copper, iron, mercury, manganese, nickel, lead, zinc) in mussels tissues [1] were integrated in a multimarker approach for the early detection of biological responses at several cellular targets. Induction of metallothioneins-like proteins, acetylcholinesterase activity and peroxisomal proliferation were measured as typical responses to metals and organic aromatic pollutants [2]. An important role in environmental toxicity of both metals and organic contaminants is certainly assumed by the enhancement of intracellular reactive oxygen species (ROS) which modulate the onset of several deleterious effects and cell damages [3]. Analysed antioxidants in caged mussels included the activities of superoxide dismutase, catalase, glutathione S-transferases, glutathione reductase, Se-dependent and Se-independent glutathione peroxidases and the levels of total glutathione. Variations of the redox status were further investigated with the total oxyradical scavenging capacity (TOSC) assay which, measuring the overall capability to neutralise various oxyradicals, provides a quantitative index of the susceptibility of biological tissues to oxidative stress [4]. Lysosomal impairment is largely recognised as a sensitive marker of chemical disturbance in mussels where this compartment is highly developed both in digestive tissues and in haemocytes: lysosomal alterations were measured through the analysis of membrane stability, accumulation of lipofuscin and neutral lipids, and content of malondialdehyde which reflect the intensity of lipid peroxidation [5]. The appearance of genotoxic alterations in caged mussels was investigated as loss of DNA integrity; the Comet assay, measuring the early onset of strand breaks was integrated with the frequency of micronuclei (MN). A general index of physiological status, was finally measured in caged mussels as their capability to survive in air [6].

An overall evaluation of results confirmed the absence of marked biological effects caused by the activities of "Giovanna" platform, as already demonstrated during the previous monitoring project. More variations were observed in mussels translocated to "Emilio", i.e. higher activities of glutathione S-transferases, catalase and peroxisomal proliferation decrease of oxyradical scavenging capacity toward hydroxyl and peroxyl radicals and lysosomal destabilization (inhibition of neutral red retention time), indicating an onset of impairment condition in the organisms. Compared to mussels transplanted at the reference site, those from "Emilio" platform did not exhibit more elevated concentrations for the various metals and only for zinc and cadmium an higher bioavailability was detected close to the platform, suggesting the influence of galvanic anodes for cathodic protection.

The overall results of this work confirmed the utility of using caged mussels as an additional contribution for monitoring off-shore activities and provided an ecotoxicological protocol based on cellular biomarkers for the early detection of biological disturbance.

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# SPATIAL AND TEMPORAL VARIABILITY OF ATMOSPHERIC FLUXES OF METALS AND PHOSPHORUS OVER THE WHOLE MEDITERRANEAN: RESULTS FROM A ONE-YEAR MONITORING EXPERIMENT

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# Abstract

During the ADIOS program, the bulk atmospheric deposition of metals (Al, Fe, Zn, Pb, Cd) and phosphorus was collected monthly during one year at 9 sampling sites around the Mediterranean. The temporal variation was high for elements of crustal origin (Fe, Al) in relation with Saharan fallout events and lower for mainly anthropogenic ones (Zn, Pb, Cd, P). Examining the annual fluxes for each site, complex spatial trends are evidenced.

Keywords : Atmospheric Input, Phosphorus, Metals, Eastern Mediterranean, Western Mediterranean.

During the ADIOS EU funded program, the bulk atmospheric deposition of Al, Fe, Zn, Pb, Cd and P was collected monthly during one year (June 1, 2001 to May 31, 2002) at 9 sites all over the Mediterranean Sea (fig. 1). Sampling was made according to the same protocol [1] and the same schedule, and the analysis of samples (described in [2]) was centralized in order to avoid any bias in assessing spatial and temporal trends.



Fig. 1. Location of the ADIOS atmospheric sampling sites.

The annual mean fluxes for Al, Fe, P, Zn, Pb, Cd were 808, 525, 41, 10, 1.3 and 0.035 kg  $\cdot$ km<sup>-2</sup>  $\cdot$ y<sup>-1</sup> respectively.

When considering the whole data set, the variation coefficients are good indicators of the temporal and spatial variability of the fluxes over the whole Mediterranean Sea. These coefficients were high for the elements of crustal origin, around 250 % for Al and Fe and lower for mainly anthropogenic elements (150 % for P, 130 % for Zn, 100 % for Pb and Cd). Examining the annual fluxes for each site, complex spatial trends are evidenced. For example fluxes of crustal elements, ie originating mainly from north-African arid areas, decrease from south to north in the Eastern basin while the opposite pattern is observed in the Western one.

We used the typical ratios of Fe, Pb, P, Cd and Zn to Al [3,4] in Saharan aerosols to quantify their fraction of non Saharan origin. Only 12 % of the total atmospheric deposition of iron was non Saharan; Al/Fe ratios were very close for eastern and western Mediterranean sites. Phosphorus was mainly anthropogenic (75%), like lead (80%); 20% of lead was found to be of Saharan origin for both basins at the annual scale. 95% of Cd and 88 % of Zn were anthropogenic.

The comparison of our data with the bulk deposition ones available for the Mediterranean coastal stations [2,7,8,9] confirms the general decrease of lead atmospheric fluxes over the past decades. Although quite a few data are available for phosphorus [5,6], no change in fluxes were evidenced over the past decades for this element.

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# EVALUATION OF HEAVY METALS IN IZMIR BAY

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# Abstract

The level of marine pollution in Izmir Bay was investigated using heavy metal values obtained from surface sediments. These values were transferred to GIS database for 1997 and 2005 for the analysis and the study was carried out on sediment samples taken from 10 sampling stations located in inner, middle and outer Izmir Bay. The data used in this study were collected within the frame of a project namely "Izmir Bay Pollution Monitoring Project" supported by Izmir Metropolitan Municipality. Hg, Cd, Pb, Cr, Zn and Cu parameters were analyzed in this period.

Keywords : Coastal Waters, Gis, Trace Elements.

#### Introduction

The most important vital problem of seaside countries is the pollution of the sea and the coastal areas. In this region, this pollution spoils the ecological balance spoils, threats the public health and ceases the fishery activities. Izmir Bay is one of the greatest natural bays of the Mediterranean. The main urban center around the bay is Izmir Metropolitan Municipality, which is an important industrial, commercial center and a cultural focal point. The Gediz River, which flows to the outer bay, is the biggest river in Izmir Bay.





# Fig. 1. Exchange values of heavy metal parameters between 1997 and 2005.

The inner bay is heavily polluted by nutrients, organic material and heavy metals, before urban wastewater treatment plant, which became operative in 2000. The streams and hundreds of domestic and industrial discharge outlets flow to the bay before 2000. The main industries in the region include food processing, beverage manufacturing, tanneries, oil, soap, paint production, chemical industries, paper and pulp factories, textile industries, metal processing, etc[1].Eutrophication of inner bay was a serious problem throughout the year. In this study, the changes of heavy metal pa-

rameters (Hg, Cd, Cr, Zn, Cu and Pb) were evaluated in 10 stations located in Izmir Bay for the year of 1997 and 2005. The data was transferred to GIS database and thematic maps were done to observe the changes more simply. For this study, July 1997 [2] and September 2005 [3] values were used. The analysis was carried out according to background levels of Mediterranean Sea.

# Results and Discussion

As a result of the evaluation, between 1997 and 2005, a little improvement was observed in sediment in the heavy metal concentrations. The reason for this little improvement could be explained as the accumulation of heavy metals in sediment district since 1960.

Throughout Izmir Bay; in the outer-I bay, the effects of drainage waters coming from irrigation in Gediz River Basin were seen. In the outer-III bay, pollution carried By Gediz River had a far reaching influence. Heavy metal enrichments are also reported from shallow water sediments off the Gediz River. The effect of mineral deposits in Karaburun, high heavy metal concentrations were seen in the outer-III bay. In outer-I bay, wastewaters discharge effect of Urla that flows to the bay was seen. In outer-II bay, effects of wastewaters discharged from industries especially leather industry was seen. Also moderate levels of heavy metal contamination observed around the Uzunada and outer-II bay, was probably caused by the continuous dumping sediments excavated from the most polluted inner-most inner Izmir Bay [4]. Despite the improvement from 1997 to 2005 in inner bay, anyway, it can still be counted as the one in worst condition.

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# HEAVY METAL CONCENTRATIONS IN MARINE ALGAE FROM THE TURKISH COAST OF THE BLACK SEA

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# Abstract

Macroalgae samples were collected at different stations of the Turkish Black Sea coast in order to establish for concentration of Cu, Cd, Mn, Ni, Pb, Zn and Cr from 2001 to 2003. The levels of the heavy metals in seawater were also measured in 2003 to estimate the degree of accumulation of the each element by algae species. The patterns of heavy metal accumulation rates in decreasing order were Mn>Cu>Zn>Cr>Cd.

Keywords : Algae, Metals, Black Sea.

There have been made numerous studies on the heavy metal concentrations of the marine organism and sediment samples in the Black Sea marine environment, but limited information exists on the content of the heavy metals in seawater of the Black Sea. The papers were published on heavy metals content of macroalgae collected from Turkish Black Sea coasts between 1979 and 2000 [1-5]. Şile and Sinop are the main stations where our investigation on metal pollution of macroalgae have been carried out since 1979, because they are on the route of the water currents coming from the Danube river. The Black Sea coast is more than 4000 km long of which 1400 kilometers belongs of Turkey. The station of the Igneada is located near the Bulgaria border at the western part of the Black Sea. We selected one station from Yomra the eastern part of the Black Sea.

The aims of the present study were: (a) to determine the levels of Cu, Cd, Mn, Ni, Pb, Zn and Cr in seawater and algae species of the Igneada station in 2003 for examination of the concentration factors and (b) to determine the concentration the selected heavy metals in algae species at different stations of the Black Sea between 2001 and 2003.

Samples of algae collected from Igneada, Şile, Sinop and Yomra were green algae; *Chaetomorpha linum, Ulva rigida, Ulva lactuca, Enteromorpha linza,* brown algae; *Cystoseira barbata,* and red algae; *Pterocladia capillacea, Gelidium latifolium, Corallina granifera, Phyllophora nervosa, Coralina officinalis, Gracilaria verrucosa.* 500 g fresh weight sample was harvested at low tide and chose thalli as similar stage of each species. All procedures of the methods were similar to that previosly described [2, 5].

Tab. 1. The concentration and concentration factor values in Igneada station during August 2003.

| Cu                                                | Cd                                                                | Mn      | Pb    | Zn      | Cr      |  |  |  |
|---------------------------------------------------|-------------------------------------------------------------------|---------|-------|---------|---------|--|--|--|
| The mean                                          | The mean metal concentrations ( $\mu g \Gamma^{1}$ ) in seawater  |         |       |         |         |  |  |  |
| 1.74±0.1                                          | 0.31±0.08                                                         | 1.6±0.4 | <0.01 | 4.9±0.7 | 1.8±0.4 |  |  |  |
| The meta                                          | The metal concentrations (µg g <sup>-1</sup> dry weight) in algae |         |       |         |         |  |  |  |
| 8.8±0.2 <sup>a</sup>                              | 0.03±0.02                                                         | 41.7±2  | 14±2  | 18±0.2  | 2.5±0.4 |  |  |  |
| 6.9±0.1 <sup>b</sup>                              | 0.13±0.06                                                         | 57.2±3  | <0.02 | 8.3±.01 | 2.5±0.3 |  |  |  |
| The conc                                          | The concentration factors                                         |         |       |         |         |  |  |  |
| 5066 <sup>a</sup>                                 | 96.8                                                              | 25567   | -     | 3693    | 1371    |  |  |  |
| 3993 <sup>b</sup>                                 | 419.5                                                             | 35070   | -     | 1705    | 1349    |  |  |  |
| <sup>a</sup> P.capillacea, <sup>b</sup> C.barbata |                                                                   |         |       |         |         |  |  |  |

The heavy metal concentrations determined in seawater are shown in Table 1. The Cu, Cd, Mn, Zn and Cr concentrations are higher than the range found in uncontaminated nearshore waters elsewhere in the world. In the present study, Cu, Mn, Zn and Cr concentrations are lower than were found in the same metals determined at northern Adriatic and northwestern Black Sea. On the other hand, the concentration of Cd was higher in the Turkish Coast of the Black Sea. The concentration factors of the heavy metals are also given in Table 1. The patterns of heavy metal accumulation rates in decreasing order were Mn>Cu>Zn>Cr>Cd. The rate of the concentration factors may be useful to determine of the heavy metal

### levels in seawater samples.

The highest accumulation of different metals in the tested algae species were, Cu and Mn in *C. officinalis*, Pb and Zn in *P. capillacea*, Cd in *G. latifolium*, Ni in *P. nervosa*, Cr in *E. linza*. In general, Cd, Zn and Cr decreased from 2001 to 2003, whereas, Cu, Mn and Ni levels increased in the same period. Regarding the areas, the highest amounts of Cd, Ni, Pb, Zn and Cr were found in Şile, while Cu and Mn in Yomra.

In our group studies, the heavy metal concentrations were determined in *C. barbata* and *U. lactuca* from Bosphorus during 1990-1991 [6] and Marmara Sea in 2000 [7]. In general, our results showed that the heavy metal concentrations in the Black Sea are lower than Bosphorus and Marmara Sea algae.

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# MARINE RISK ASSESMENT: LINEAR ALKYLBENZENESULPONATES (LAS) IN BLACK SEA, BOSPHORUS AND MARMARA SEA

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# Abstract

The concentrations of the LAS in the Turkish marine environment were determined. The results showed that the LAS concentrations in the Black Sea, Bosphorus and Marmara Sea waters within the range of 4.14 to 107.37, 3.32 to 204.86 and 8.07 to 243.99  $\mu$ g l<sup>-1</sup>, respectively. The mean LC<sub>50</sub> values were calculated to be 9.25, 3.75 and 9.75 mg l<sup>-1</sup> the crustacea, mussel and fish species after 48 h, respectively. *Keywords : Detergent, Ecotoxicology, Black Sea, Bosphorus, Sea Of Marmara.* 

LAS is not a homogeneus compound. It is composed of a linear alkyl chain consisting of 8-16 atoms, a benzene ring and sulponate group. Nowadays, the wastewater treatment facilities are limited in Turkey and detergents are often discharged directly to the marine environment . For this reason, one of the biggest culprint in marine pollution is detergent phosphate. In a previous study, the phosphate concentration of the tested stations originates mainly from laundry detergents [1]. At the same time, it is well known that detergents can adversely affect marine organisms. Some studies have been investigated on the ecotoxicology of LAS [2-4].

The aims of the present study were: (a) to determine the concentration of LAS detergents in different stations in Bosphorus, Black Sea and Marmara Sea of the Turkish marine environment in 2004 and 2005 (b) to examine the acute toxicity of some commercial detergent powders in different marine organisms under laboratory conditions.

The seawater samples were collected from surface and bottom of the 18 stations from Turkish marine environment in 2004 and 2005 (Fig. 1). LAS concentrations were determined use of MBAS method. The standard curves of LAS was plotted in a concentration of 0.2-2  $\mu$ g ml<sup>-1</sup>.



# Fig. 1. Sampling sites

A mixture of four commercial detergents has been used as surfactant. These commercial LAS detergents, according to the Turkish regulation have the following percentage composition: LAS 25; sodium tripolyphosphate 23; sodium carbonate 25; sodium bicarbonate 13; sodium sulphate 8; sodiun perborate 5; carboxymethyl cellulose 1; fluorescent whitening agents 0.1 and perfume 0.1. Stock solution was prepared by dissolving 1 g of the surfactant mixture in a 1 liter of bidistilled water. The toxicology experiments were carried out use of a crustacea (*Crangon crangon*), mussel (*Mytilus galloprovincialis*) and fish (*Proterorhinus marmorathus*) species in a temperature controlled room ( $13\pm2$ ). LAS concentration was kept at constant level in the experiment due to biodegradation. For this, the water of the test basin was changed each day. Lethal concentration values (LC<sub>50</sub>) for each definite time were calculated use of dosage-mortality curve method. Each experiment repeated twice.

The concentrations of detergent (LAS) found in the Turkish marine environment during the two sampling periods ranged between 4.14 and 243.99

in surface and 4.05 and 149.68  $\mu$ g l<sup>-1</sup> in bottom samples. The detergent concentrations not changed during the sampling periods. The high degree of detergent pollution determined in Marmara Sea. In general, the data showed that the detergent concentrations in the Black Sea are lower than Bosphorus and Marmara Sea.

Measurements showed that 1 ppm detergent mixture contained 0.139 ppm LAS. The ecotoxicological results is given in Table 1. The results showed that there was no significant differences between the mean  $LC_{50}$  values of crustacea and fish species for short time acute tests. On the other hand it appeared that the sensitivity among the tested organisms were significantly different during long time acute chronic tests.

Tab. 1. Mean acute (LC50) values (mg  $l^{-1}$ ).

| Time    | Crustacea | Mussel | Fish |
|---------|-----------|--------|------|
| (hours) |           |        |      |
| 48      | 9.25      | 3.75   | 8.75 |
| 96      | 3.10      | 2.50   | 7.10 |
| 120     | 2.00      | 2.10   | 5.75 |
| 192     | 0.45      | 1.15   | 4.10 |

The present study has characterized the risk of LAS in the water column of the Turkish marine environment. The minimum  $LC_{50}$  values were found to be 3.75 and 0.45 mg  $l^{-1}$  for short and long term acute tests. The measured maximum concentration of LAS in this marine environment are 15.4 and 1.8 times lower than that these ecotoxicological values. As a consequence, it is apparent that the risk of LAS in the Turkish marine environment is low.

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# ESTERASES AND LIPID PEROXIDATION LEVELS IN TWO COMMERCIAL FISH, PHYCIS BLENNOIDES AND MICROMESISTIUS POUTASSOU AND THE DEEP-SEA DECAPOD CRUSTACEAN ARISTEUS ANTENNATUS FROM THE NW MEDITERRANEAN

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#### Abstract

Few studies have monitored neurotoxicity biomarkers in offshore marine areas. To partly fill this gap in information we sampled the gadiform fish *Phycis blennoides* and *Micromesistius poutassou* and the crustacean decapod *Aristeus antennatus*, all species of great commercial interest in the Mediterranean, offshore the coast of Blanes (41.0N 3.0E; NE Spain) in two different grounds located in a submarine canyon. The trawling took place in July 2006, at depths of 585 m, canyon head close to the coast, and at 841 m, in the canyon axis and further from the coast. Esterase activities and lipid peroxidation levels were measured individually in muscle tissue and activities/levels recorded are discussed in relation to sampling depths, animal sex and size.

Keywords : Crustacea, Deep Waters, Ecotoxicology, Fishes.

Cholinesterases (ChEs), namely acetylcholinesterase-AChE- (EC 3.1.1.7), regulate the nerve impulse transmission in vertebrates and invertebrates, its inhibition causes a build up of acetylcholine that derivates in tetany, paralysis and eventual death. The physiological role of other ChEs such as butyrylcholinesterase-BChE- (EC 1.1.1.8) and propyonylcholinesterase-PrChE- is not so well established, although in some marine fish, BChE has shown to be a better marker than AChE [1]. Inhibition of AChE in marine pollution monitoring of the Mediterranean has been extensively applied using either fish or invertebrates in coastal areas [2]. However, to the best of our knowledge no studies are available on these markers in deep water species, this despite levels of pollutants in some regions being considerably high [3]. Carboxylesterases-CbE- (EC 3.1.1.1) catalyze the hydrolysis of a wide range of xenobiotic esters, amides and thioesters. Although more dominant in the liver, we included these enzymes for their role in the metabolism and subsequent detoxification of many xenobiotics, and endogenous compounds. Lipid peroxidation (LP) is considered a biomarker of effect. It is also included in many monitoring programs as it integrates the negative effects caused on the lipid membranes by reactive oxygen species (ROS). LP occurs when the natural antioxidant defences are overcome and membrane and membrane-bound enzyme destabilisation takes place [4]. A biomarker approach, using esterases responses in pollution monitoring seems adequate as it will integrate the effects on the targeted species, regardless of the chemical(s) involved. Even sublethal levels of neurotoxic compounds may have a negative result on the marine species, compromising their behaviour and altering predator-prey interactions, thus having a negative consequence at the ecological level [5].

The gadiform fish, *P. blennoides* (Phycidae) and *M. poutassou* (Gadidae) and the red shrimp, *A. antennatus*, (Crustacea, Aristeidae) are important species in Mediterranean fisheries. Nevertheless, they have not been considered in monitoring studies due to their habitat being situated far from pollution sources. To the best of our knowledge, there are no many studies reporting on esterase activities and LP levels for any of the species here described. For that, the aim of our study was to provide baseline data that could support their future inclusion in monitoring neurotoxicity in offshore fishing grounds of the NW Mediterranean.

During the sampling, on board of the fishing vessel, all specimens were immediately sexed and measured, the fish as total length (TL  $\pm$  1 cm) and the crustacea as cephalotorax length (CL  $\pm$  1 mm). A portion of the muscle and liver/hepatopancreas was also dissected and frozen in liquid nitrogen for further biochemical determined as recently described (6). ChEs and CbEs activities and LP levels were determined as recently described (6). ChEs and CbEs activities are reported in nmol/min/mg protein (Figure 1) and LP is expressed as nmol malondialdehide (MDA)/g wet tissue. Statistical analysis of the data was done using the one-way ANOVA test to determine differences due to either sex, size or sampling depth. The posthoc Newman-Keuls test was used to show were statistical significance lay. Level of significance was set at p<0.05. Values are presented as mean  $\pm$  SEM (n =7-11).

In fish, AChE was the predominant form (61-66%) followed by PrChE=CbE (14-15%) and BChE. (6-8%). In the crustacea, AChE was also dominant (46-49%) although the contribution of other esterases (e.g. CbE) was quite significant (26-30%). In fish a relationship between esterases and fishing depth was seen but not in the animal sex or size. In crustacea, however, esterase activities were seen as sex and size dependent but not related to sampling depth. LP levels varied between 0.86-3.35

nmol MDA/g w.w. In all cases esterases correlated well between themselves but not with LP levels. In view of our results, in these deep sea water species, the choice of AChE for measuring neurotoxicity seems adequate, however, in the crustacea, CbE in hepatopancreas needs to be further investigated as a potentially more adequate marker of neurotoxicity.



□ P. blennoides 585 m 🚯 P. blennoides 841 m 🖸 M. poutassou 585 m □ A. antennatus 585 m 🗃 A. antennatus 841 m

Fig. 1. Activity levels of esterases (AChE, BChE, PrChE and CbE) in the gadiform fish *Phycis blennoides* and *Micromesistius poutassou* and the decapod crustacean *Aristeus antennatus* at two sampling depths from the Blanes canyon (NW Mediterranean). (n.b. *M. poutassou* was only found at one fishing depth).

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# POLYCYCLIC AROMATIC HYDROCARBONS IN MARINE SEDIMENTS OF THE AEGEAN SEA (EASTERN MEDITERRANEAN): COMPOSITION, SPATIAL VARIABILITY AND SOURCES

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# Abstract

In this study the distribution, composition and sources of polycyclic aromatic hydrocarbon (PAH) mixtures were studied in the sediments of the Aegean Sea (Eastern Mediterranean). PAH concentrations were generally low. The highest values were recorded in the northern part of this marine area, which apparently receives more anthropogenic inputs, from both continental runoff and atmospheric deposition. The study of the compositional patterns of the PAH mixtures indicates that various pyrolysis and combustion processes are the major sources of PAHs, although the presence of some petroleum related residues in all sites was also evident.

Keywords : Aegean Sea, Pah, Sediments, Eastern Mediterranean.

Polycyclic aromatic hydrocarbons, mostly deriving from anthropogenic activities, have been recognized as hazardous environmental chemicals and are included in priority pollutant lists. They are easily associated with fast sinking particles and this is considered as the major mechanism of their transport from the surface to the deep-water column and subsequent accumulation in sediments. Although numerous studies on hydrocarbon geochemistry have been performed in Western Mediterranean sediments [1], much less attention has been given to the Eastern basin [2]. In this work the distribution, composition and sources of PAH mixtures were investigated in sediments of the Aegean Sea, by using a molecular marker approach and several diagnostic criteria and indices. The Aegean Sea is a dynamically active area with unique physiographic and hydrodynamical characteristics and is generally characterized by well-oxygenated waters and low primary productivity. The North part of this area is directly influenced by the brackish and low temperature Black Sea water entering the Aegean Sea through the Dardanelles Straits, whereas it is also the recipient of various riverine discharges. The South Aegean Sea does not receive freshwater inputs, whereas the water exchange with the North part is limited only above 400 m because of the peculiar bathymetry of the region. Surface sediments were collected from 31 stations during 1998-2004 and PAH were determined using GC/MS technique. Total PAH concentrations varied between 10.3 and 231 ng/g in the north Aegean and between 9.6 and 150.3 ng/g in the south Aegean Sea sediments. These values are generally considered as low and are comparable with those found in relatively unpolluted open sea locations in other marine areas [1,3]. The highest values were recorded in stations located close to the North Aegean coasts and this is probably due to the anthropogenic inputs coming into the sea through the three major rivers outflowing in this area. On the contrary, in South Aegean Sea lower PAH concentrations were measured and this is attributed a) to the lower supply of land-derived material either fluvial or atmospheric and b) to the highly oligotrophic character of this area, which does not favour the efficient transport and accumulation of significant quantities of organic matter in the sediment. The study of the compositional patterns of PAH mixtures can provide useful information regarding their sources and transport pathways. Three types of PAHs are commonly found in marine sediments: pyrolytic PAHs derived during the combustion of all the organic materials, petrogenic PAHs which are contained in petroleum and its products and biogenic PAHs from natural terrestrial or marine sources. In the sediments examined in this study a mixed origin for PAHs both pyrolytic and petrogenic was demonstrated. In most cases the pyrolytic PAH (compounds with four or more aromatic rings) were dominant, especially in the deep stations, and accounted for 51-89 % of the total PAHs. Phenanthrenes, indicative of petrogenic inputs were less abundant, accounting for 11-42 % of the total PAHs. Similar patterns have been reported in many sediment studies worldwide [2,3] and are attributed to the higher resistance of pyrolytic PAHs towards biodegradation and photo-oxidation, leading to a preferential accumulation of pyrolytic compounds in marine sediments. The use of several molecular indices based on ratios of selected PAH concentrations also confirms the mixed origin. Relatively high concentrations of biogenic PAHs (retene and perylene) were found close to the northern coastal zone, indicating the transportation of terrigenous material through the rivers.

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# RÉPONSE D'UNE COMMUNAUTÉ DE NEMATODES LIBRES MARINS À UNE CONTAMINATION PAR LE NICKEL: ÉTUDE MICROCOSMIQUE

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# Résumé

Une étude microcosmique a été réalisée pour examiner l'influence d'un métal lourd (le Nickel) sur une communauté de nématodes libres provenant de la baie de Bizerte (Tunisie). Les résultats des analyses statistiques univariées ont montré des différences significatives entre le microcosme témoin et les contaminés pour la plupart des indices considérés. Les analyses statistiques multivariées ont mis en évidence une spécificité de la réponse des nématodes libres. Ainsi, *Neochromadora trichophora* une espèce affectée à toutes les doses de nickel testées mais jamais totalement éliminée est parue une forme sensible au nickel. *Oncholaimellus mediterraneus, Oncholaimus campylocercoides* et *Daptonema normandicum* semblent être des espèces "opportunistes".

Mots clès : Coastal Waters, Sediments, Metals, Bio-indicators.

#### Introduction

La plupart des substances chimiques rejetées dans l'environnement finit par se déposer et s'accumuler au fond des rivières, des lagunes, des mers et même des océans. Les éléments les plus fréquemment cités sont les métaux lourds, les polychlorobiphényles (PCBs) et les hydrocarbures aromatiques polycycliques (HAP) [1].

Parmi les nombreuses études relatives aux effets des contaminants sur les communautés méiobenthiques [2-4], peu ont été consacrées à l'évaluation de la toxicité du nickel. Le présent travail se propose de fournir les premières données quantitatives et qualitatives sur l'impact d'un enrichissement expérimental en ce métal sur une communauté de nématodes libres marin.

#### Matériel et Méthodes

Du sédiment avec sa méiofaune naturelle a été collecté à partir de la Baie de Bizerte (Tunisie). Des quantités de 100 g de sédiment sec ont été préalablement contaminées avec des doses appropriées de chlorure de nickel en solution pour aboutir à trois doses : faibles (400 ppm), moyennes (580 ppm) et fortes (770 ppm). Les nématodes, taxon méiofaunistique prédominant, ont été colorés au rose bengale, séparés par la méthode de lévigation-tamisage [5] et comptés sous la loupe binoculaire pour le calcul des densités. La plupart des analyses statistiques des données suivent les méthodes standard d'analyse des communautés décrites par [6]. Des indices d'analyses univariées ont été considérés par le logiciel PRIMER [7].

#### Résultats et discussion

Les valeurs prises par les indices d'analyses univariées considérés pour décrire la communauté nématologique de chaque microcosme, montrent que les effets de la contamination du sédiment par le nickel sur les nématodes libres marins varient en fonction de la dose utilisée.

Les résultats de l'analyse statistique par le test de KRUSKALL-WALLIS d'ordre 1 (Test de la médiane) indiquent que la contamination par le nickel entraîne des modifications significatives des paramètres descripteurs des communautés nématologiques (p<0,05). Les résultats des analyses par le test HSD de Tukey, utilisé dans des comparaisons multiples entre le contrôle et les microcosmes traités, montrent des différences significatives pour la plupart des indices des microcosmes traités par rapport au témoin. Ainsi, le nombre d'espèces (S), la richesse spécifique (RS) et l'équitabilité (E) sont réduits significativement parallèlement à l'enrichissement en nickel alors que la diversité (H') n'est affectée que par la forte dose en ce métal lourd.

L'ordination des taxa nématologiques selon la méthode MDS indique un très net effet de la contamination par le nickel sur les peuplements nématologiques. Il en ressort que les microcosmes sont graduellement disposés en séries en fonction de leurs teneurs sédimentaires en nickel.

Les résultats de la procédure SIMPER (similarity percentages) montrent que la dissimilarité moyenne entre les différents microcosmes augmente parallèlement à l'enrichissement sédimentaire en nickel. Ainsi, le microcosme témoin a été dominé par Oncholaimellus mediterraneus, Oncholaimus campylocercoides, Daptonema normandicum, Pomponema sp. et Trichotheristus sp.

Le microcosme contaminé par la faible dose de nickel a été dominé par Trichotheristhus sp., Oncholaimus campylocercoides, Oncholaimellus mediterraneus et Daptonema normandicum. En présence de la dose moyenne en nickel, *Neochromadora trichophora et Metachromadora* sp. ont été dominantes. Dans le microcosme contaminé par la forte dose de nickel, *Pomponema* sp. et *Oncholaimellus* sp. ont prédominé.

# Conclusion

Les résultats de la présente étude montrent que les nématodes libres marins constituent des outils de biosurveillance dans les écosystèmes littoraux. En effet, de simples expériences en microcosmes permettent de confirmer ou d'identifier des espèces indicatrices de conditions de stress existant dans un milieu bien déterminé pour dominer en nombre aux dépens d'autres espèces [4]. Leur présence continue dans les sédiments pollués supporte la notion de leur utilisation comme bioindicateurs des perturbations environnementales.

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# TRACKING DISSOLVED TRACE METALS IN SEAWATER USING LIVING AMPHISTEGINA LOBIFERA (BENTHIC FORAMINIFERA) TESTS FROM HAIFA BAY

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# Abstract

The purpose of this study was to examine the use of metal concentrations in living benthic foraminiferal tests (*Amphistegina lobifera*) as proxy for dissolved metal concentrations in seawater. Living specimens were sampled at two stations and surface seawater was collected at the same time in Haifa Bay, in 8 bi-monthly cruises during 2003-04. The variations of the minor (Mg, Sr, Li, B) elements ratios in *A. lobifera* seems to be related to variations in its growth rates while the trace element ratios such as Ni, Cd and Pb seems to be effected mainly by the ambient seawater fluctuation. A better understanding of the foraminiferal life cycle and the incorporation of HM in their tests will enable the use of foraminifera in assessing short and long-term trends of HM concentrations in coastal seawater. *Keywords : Foraminifera, Eastern Mediterranean, Pollution, Trace Elements.* 

The coastal waters of Haifa Bay, Israel are exposed to heavy metals (HM) introduced from point (Qishon and Na'aman Rivers) and diffusive sources. The dissolve HM concentrations in the bay and the shallow water of the Israeli Mediterranean coast are poorly known due to their extremely low concentrations and analytical complexity. Thus, it is difficult to establish a routine long-term monitoring program and assess water quality in terms of time-integrated ecological environmental criteria. The aim of this study was to use metal concentrations in calcareous tests of living benthic foraminifera, as a proxy for dissolved metal concentrations in seawater.

The working hypothesis in this study is that benthic foraminifera precipitate their tests directly from sea water, reflecting a time integrated dissolved trace element concentration in ambient sea water. The tests precipitated by *Amphistegina lobifera* establish an equilibrium state with the ambient seawater represented by a metal explicit distribution coefficient. The analysis of foraminiferal tests follows a cleaning procedure that removes detritus and mainly the inner cytoplasm.



Fig. 1. The variations of Pb in living *Amphistegina lobifera* (benthic foraminifera) tests and ambient seawater from Haifa Bay, Israel.

A. *lobifera*, symbiont-bearing larger foraminifera, lives in Haifa Bay in large numbers on rocky substrate. It reproduces once a year with juveniles (0.4 mg, on avg.) dominating during summer and adults (1.5 mg, on avg.) during late fall to winter. This differs from other shallow tropical environments where 2-4 reproduction cycles/annum occur. Living specimens were sampled at two stations at 10 m water depth and surface seawater were collected at the same time from 6 representative stations in Haifa Bay, in 8 bi-monthly cruises during 2003-04. Most of the dissolved heavy metals are enriched in Haifa Bay seawater by a factor of 3-10 compared with a control clean station located 100 km offshore the Israeli Mediterranean coast. Mg concentrations in sea water vary seasonally while some heavy metal concentrations (Ni, Cd) are unrelated to seasonality and probably reflect short term influx of metals from land-base sources.

The variations of the minor (Mg, Sr, Li, B) elements ratios (element/Ca) in *A. lobifera* calcareous tests correlate to variations in growth rates, high in summer (2-3%/day), and low in winter (<0.5%/day). The variations of Ni, Cd and Pb (Figure 1) in *A. lobifera* tests seems to be affected by their ambient seawater fluctuations despite the differences in time-scale represented by each of these matrices (sporadic - seawater) vs. prolonged growth period of the foraminiferal test.

We have estimated the trace metal content in *A. lobifera* tests using the highest published values of partition coefficient [Lea 1999] and the measured dissolved metal content in seawater at a control station 100km offshore (mid of the oligotrophic Levantine basin). The comparison between the calculated and measured metal content in foraminifera tests from Haifa Bay revealed an enrichment in the measured values by a factor of up to 20 for Cu, Zn and Cd and less so (<3) for V, U and Sr. This indicates that the seawater in Haifa Bay is continuously enriched in dissolved metals as compared to the open sea, and the minimal measured values of dissolved metals are usually exceptional.

A better understanding of the foraminiferal life cycle and the incorporation of trace elements in their tests will enable their use for assessing short and long-term trends of dissolved metal concentrations in coastal seawater.

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# ZINC IN DIATOM FRUSTULES AS A PALEOCHEMICAL PROXY: AN INTEGRATED FIELD AND LABORATORY APPROACH

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# Abstract

The concentration of individual elements contained in marine and freshwater phytoplankton is generally reflecting the elemental composition of the aquatic environment. This concentration further controls the input of recycled elements throughout remineralization. Combining special laboratory experiments with high-resolution field analyses we aim to identify and quantify the processes behind Zn incorporation in the frustules of living diatoms. These results will be further applied to reconstruct prevailing chemical conditions of the water column at various time windows within the geological record.

Keywords : Diatoms, Sediments, Zinc, Paleoceanography.

The last decades have been marked by a major revolution in our understanding of the Earth system. This has been partially associated with the use of more sophisticated technologies and both the development and calibration of new proxies or indicators of former environmental parameters such as temperature, pH, etc. These variables have an influence on the chemistry and biology of the natural environment and, thus the sedimentary record. Realistic reconstructions of the past environment and climate are, therefore, only possible using well-calibrated proxies. They provide us with quantitative indicators that respond systematically to changes in environmental variables. It still exists, however, a significant gap among the presently available paleoceanographic and limnogeological tools to reconstruct past changing water conditions. This is particularly clear concerning reliable weathering and paleochemical markers. Furthermore, most of the existing marine and lacustrine proxies for water column elemental concentrations have been developed on carbonate material (foraminifera, corals, ostracods, etc.). These organisms can be very scarce in critical areas of the globe that regulate the CO2 budget of the atmosphere such as the southern ocean and the north Pacific. Therefore, there is an urgent need to develop new and independent indicators of former environmental conditions based on diatoms.

The concentration of individual elements contained in marine and freshwater phytoplankton is generally reflecting the elemental composition of the aquatic environment. These concentrations further control the input of recycled elements throughout remineralization. Laboratory and field studies have pointed out the importance of trace elements both controlling primary productivity as well as regulating the community structure of phytoplankton. Hence, the identification of these phenomena encouraged further research on the trace metal content of phytoplankton. Despite the growing interest in this field, however, there is still a clear lack of reliable tools to determine the ratio of trace elements during time intervals involving well-known environmental changes in both marine and freshwater systems.

In this framework we have designed a research strategy to identify and quantify the processes controlling Zn incorporation in the frustules of selected diatoms. The latter will allow us to reconstruct past Zn concentrations in waters. To achieve this task, we combine high-resolution field analyses with selected laboratory experiments.

Currently, culture experiments are performed with the freshwater diatom *Stephanodiscus hantzschii*. Long-term Zn uptake experiments in trace metal ion-buffered medium have been designed in order to evaluate the influence of the concentration of free Zn in the water on the composition of the opal (Zn/Si)<sub>opal</sub>. Preliminary results seem to show a sigmoidal relationship between the Zn incorporated in the opal and the free Zn<sup>2+</sup> concentration of the culture medium. The observed trend is very similar to the results of Ellwood and Hunter [1] in their study with the marine diatom *Thalassiosira pseudonana*. This similarity points towards a common mechanism of zinc deposition in the opal for these two diatom species.

These results will be coupled with elemental analyses of fossil diatom frustules isolated from recent Lake Geneva sediments in western Switzerland. The comparison of this dataset with the known environmental history of the lake will provide a unique opportunity to calibrate this proxy. Finally, diatom-rich marine sediments from sedimentary cores from the Southern Ocean will be analyzed and interpreted using the culture and lacustrine calibration datasets. The latter will provide the ultimate validation of the methodology and establishment of a proxy for former chemical conditions.

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# BIOKINETICS OF RADIONUCLIDES AND METALS IN ADULT AND EMBRYONIC SPOTTED DOGFISH SCYLIORHINUS CANICULA (CHONDRICHTHYS)

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# Abstract

Multi-radiotracer experiments have determined the dissimilar bioaccumulatory characteristics of a cartilaginous fish model, the spotted dogfish Scyliorhinus canicula, relative to a bony fish model, the turbot Psetta maxima. Encased embryos of the spotted dogfish have also been investigated for their capacity to absorb contaminants directly from water. Direct uptake of contaminants from seawater by encased embryos has demonstrated the unexpectedly high accumulatory capacities of the egg case, relative to the embryo, yolk and jelly components. This result has important implications for radiological dose to the encased embryo from the sorbed gamma-emitting nuclides. Keywords: Bio-accumulation, Biokinetics, Trace Elements, Radionuclides, Elasmobranchii.

# Introduction

This paper presents results of current experimental studies on the biokinetics in a representative Chondrichthyan, the spotted dogfish Scyliorhinus canicula (Chondrichthys: Scyliorhinidae) of some anthropogenic radionuclides (241Am, 57+.60Co and 134Cs) that are typically associated with nuclear effluents to the marine environment, as well as a suite of heavy metals typically found in effluents to coastal marine systems from landbased sources. Relatively few experimental studies have been undertaken on chondrichthyans with regard to their bioaccumulation and biokinetics of radionuclides and heavy metals, although they form an important component of fisheries some of which are vulnerable due in part to their relatively slow growth rates, late sexual maturity and low fecundity [1]. However this taxon is quite distinct from the Teleost taxon in various aspects of their anatomy and physiology, as well as life history characteristics [2]. The susceptibility of the dogfish's embryonic stage to these contaminants in seawater was also investigated experimentally.

#### Materials and methods

The experimental protocols for the direct uptake of radioisotopes from seawater by both juvenile dogfish and their encased embryos are reported in references [3 and 4].

#### Results and Discussion

The uptake rates from water, measured over 14 days, varied greatly among isotopes. Concentration factors (CFs) in S. canicula varied by a factor of 350, with CFs for <sup>51</sup>Cr and <sup>241</sup>Am ranging from ca. 0.4 to 140, respectively. With the exception of  $^{134}$ Cs, all radiotracers were accumulated at a faster rate in S. canicula than in P. maxima particularly for <sup>241</sup>Am and  $^{65}\mathrm{Zn}$  where the CFs attained during the uptake phase were, two and one order of magnitude greater in S. canicula, respectively. In contrast, <sup>134</sup>Cs reached a CF of about 2.5 in *P. maxima*, which is 5-fold greater than in *S.* canicula. Patterns of loss from the experimental depuration phase over 29 days showed greater similarities between species, compared to the uptake phase that highlighted the greater differences between elements.

The distributions of these seven radioisotopes among six body components indicated that the skin of the dogfish displayed a very great bioaccumulation potential, particularly its elevated levels of <sup>241</sup>Am, <sup>57</sup>Co and <sup>65</sup>Zn. However <sup>65</sup>Zn was also distinctive from <sup>241</sup>Am and <sup>57</sup>Co in its bioaccumulation, with other body components attaining concentrations of <sup>65</sup>Zn that were comparable to skin. The elevated uptake rates and higher CFs for most radioisotopes indicate that S. canicula is more susceptible than P. maxima to exposure and contamination by these metals and radionuclides in seawater.

Encased embryos of S. canicula absorbed six radioisotopes (241Am, <sup>109</sup>Cd, <sup>57</sup>Co, <sup>134</sup>Cs, <sup>54</sup>Mn and <sup>65</sup>Zn) directly from seawater during shortterm experimental exposure, demonstrating the permeability of the egg case to these contaminants. Embryo to water concentration factors (CFs) ranged from 0.14 for  ${}^{134}$ Cs to 7.4 for  ${}^{65}$ Zn. The  ${}^{65}$ Zn and  ${}^{57}$ Co CF's increased exponentially with embryo length, whereas the CF for <sup>109</sup>Cd declined with length. Among different components of the encased embryo the egg case was the major repository (69-99%) of all six radioisotopes that were evenly distributed throughout its wall. Egg case CF's were as high as 10<sup>3</sup> for <sup>57</sup>Co and<sup>65</sup>Zn, making it a major source of gamma radiation exposure to the embryo and potentially of radioisotopes for continued absorption by the embryo, following the uptake phase of the experiment. The patterns of uptake by the egg-case approximated linearity for most isotopes and loss rates were isotope-specific; egg-case biokinetics were

not greatly affected by the viability of the contained embryo. Within the embryo initial data on radio isotopic distribution show that the skin is their major site of uptake, as previously demonstrated for juveniles.

The mean (+SD) CF's for six radioisotopes in embryos and juveniles (mean wet weight 6.08 g), were also determined after 15 days of uptake under experimental conditions [4]. The CF's are very similar between embryos and juveniles for <sup>54</sup>Mn, <sup>57</sup>Co and <sup>109</sup>Cd but higher in juveniles by a factor of 3 for  ${}^{134}Cs$ , a factor of about 10 for  ${}^{65}Zn$ , and a factor of about 30 for<sup>241</sup>Am. Cadmium-109,<sup>57</sup>Coand <sup>54</sup>Mn, that show comparable CF's for embryos and juveniles, have uptake patterns in juveniles that approximate to equilibrium after the 15 days of uptake. In contrast, the radioisotopes (134Cs, 65Zn and 241Am) that show enhancement in juveniles, relative to embryos, also showed patterns of uptake in juveniles indicating that equilibrium CF's had not been reached in 15 days.

The increased CF's of <sup>65</sup>Zn in juveniles, compared to their mean CF's in embryos, are also consistent with its increasing CF in embryos as they increase in size. This phenomenon of increasing CF with increasing size indicates an expanding exchangeable pool for this radioisotope, in this species. With regard to potential chemotoxic effects the enhanced CFs for juveniles would make them more exposed to contaminant impacts, compared to embryos. However, with regard to radiation exposure from gamma-emitting isotopes the absorptive capacity of the egg-case would result in the potential for radiotoxic effects being much greater for the encased embryo. If the contaminants depurated from the egg case are also subsequently available for absorption by the embryo then their radiotoxic and chemotoxic effects may be more comparable.

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# THE USE OF BENTIX IN ASSESSING ECOLOGICAL QUALITY STATUS OF SHALLOW WATER HARD SUBSTRATE BENTHIC ECOSYSTEMS IN THE BOSPHORUS STRAIT (TURKEY)

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# Abstract

For the assessment of ecological quality status of shallow water hard substrate benthic ecosystems affected by coastal sewage discharges the biotic index "BENTIX" was used. The index values revealed that sewage discharges caused serious disturbance on macrozoobenthic communities in the area investigated. Although so far it has been used for soft bottom communities, BENTIX appeared to work successfully also in hard substrates, at least for the present study.

Keywords : Zoobenthos, Rocky Shores, Sewage Pollution, Bosphorus.

#### Introduction

The north-western Black Sea coastal waters, transported towards the Bosphorus Strait by alongshore currents [1], are drastically polluted by large inputs of nutrients and organic matter via riverine and wastewater discharges ([2], [3]). In addition, the polluted Black Sea surface waters, before spreading into the Marmara upper layer, is further contaminated by the waste discharged into the Bosphorus Strait from the city of Istanbul by the numerous industries and approximately the 15 million population [4]. The purpose of the present study is to assess the degree of disturbance and ecological quality status (ECoQ) of shallow water hard substrate benthic ecosystems in the Bosphorus Strait using BENTIX (a biological quality index). This is the first case of applying the index in hard substrate benthic data.

## Materials and Methods

The study was carried out seasonally at 15 stations from May 2004 to February 2005 in the rocky shores of the Bosphorus Strait. While 9 stations (B6, B7, B8, B9, B10, B11, B12, B13, B14), which were directly influenced by sewage, were selected as target (discharge) stations, 6 stations (B1, B2, B3, B4, B5, B15), which were rather far from discharge points, were selected as control stations. Samples, as triplicates of area of 400 cm<sup>2</sup>, were collected from the upper infralittoral zone at the depth range of 0.5-1 m by using a spatula and fixed in 4% neutral formaldehyde solution in seawater. In the laboratory, all macrozoobenthic samples were sieved through a 0.5 mm mesh with tap water and sorted according to major systematic groups. Thereafter, all organisms were identified to the lowest possible taxonomic level and counted under stereo- and compound microscopes. For the assessment of ECoQ of the study area the biotic index "BENTIX" was calculated according to the scores of three ecological groups described by Simboura and Zenetos (2002) [5]. The determination of scores of some species which cannot be found in the score list of BENTIX were determined according to their dominance or their exclusive presence in some of the sampling sites and whether they are k-strategy or r-strategy species. Stations classified according to their ECoQ by using the classification scheme given by Simboura and Zenetos (2002) [5].

#### Results and Discussions

The analysis of 180 samples yielded a total of 167,537 individuals belonging to 85 taxa. The BENTIX scores of control stations, which were varied between 2.40 and 5.37, were distinctly higher than that of discharges, which were varied between 2 and 3.13 (Fig.1). Stations, which were directly affected by sewage discharges (discharge stations), were classified as heavily polluted and possessed poor ECoQ. Although station B6 was also directly affected by sewage discharge, it was classified as moderately polluted and possessed moderate ECoQ. All other stations, which were far from the discharge points (control stations), were classified as normal/pristine, slightly polluted - transitional and moderately polluted and possessed high, good and moderate ECoQ. In this sense, the BENTIX index revealed that sewage discharges cause serious disturbance on shallow water hard substrate macrozoobenthic communities in the Bosphorus Strait.



Fig. 1. BENTIX index trend in the study area.

As a very descriptive and effective tool, the BENTIX index precisely classifies the benthic communities into ecological quality classes. According to the authors who created the index, its robustness lies in the fact that it is independent of habitat type and sample size. It has therefore a potential for global application. Its effectiveness in discriminating between ecological classes is because of its ability to reflect the faunal composition in relation with the resistance of species to disturbance factors [5]. Although so far it has been used for soft bottom communities, BENTIX appeared to work successfully also in hard substrate communities, at least for the present study.

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# ENVIRONMENTAL POLLUTANTS AND HISTOLOGICAL LESIONS IN *GOBIUS NIGER* (BLACK GOBY) FROM THE IZMIR BAY OF TURKEY

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# Abstract

It is known that heavy metals can accumulate in tissues during aquatic organism growth and often biomagnify up the food chain interfering with the health and reproduction of both wildlife and humans. In the present study, the effects of due to pollution of environmental pollutants on liver of the black goby *Gobius niger* from the Izmir Bay of Turkey were analyzed by histology. The presence of histological lesions in Livers of the fish as result of pollutant exposure was evaluated. There was no important cellular alteration from liver histology except minor pathologies in both clean and dirty area. The absence of lesions in liver may show either detoxification ability of fish or the clearance of Izmir Bay from environmental pollution by recent protection with waste water treatment plant. Keywords: *Gobius niger*, Liver, Pollution, Marine, Histopathology

Keywords : Aegean Sea, Bio-accumulation.

#### Introduction

At present, heavy metal contamination in aquatic ecosystem is one of the most critical environmental issues. Heavy metals are generally carried by rivers and/or by waste waters. The problem of waste release to the sea is generally associated to heavy metal contamination. These problems become more serious in coastal sediments, where heavy metals accumulate, and nearby towns. In the Mediterranean sea the distribution of dissolved zinc, copper, lead, and cadmium is mainly controlled by their production and release, by hydrodynamic phenomenon and by biological production. Mediterranean sea is highly impacted by heavy metal pollutions. It is known that bioaccumulation of heavy metals can occur in tissues during organism growth and often biomagnify up the aquatic food chain.

We used a marine teleost, the black goby *Gobius niger*, a small species widespread over the Mediterranean. Several Gobius niger as a indicator of pollution from the İzmir Bay, a coastal system located on Egean sea were collected between 2004-2005. Many years ago, the presence of pollution with many heavy metals including organochlorine pesticides in sediments because of the absence of waste water treatment was reported (Arinc et al., 2001). The aim of this study was to take part in an integrated environmental evaluation of the Bay through the determination of the histological analysis of Liver to determine possible relationships between pollution and biological effects in Gobius. The information generated with this study can be useful in conservation programs for the Bay, which has been declared a refuge for the economic fishes.

#### Material and Method

*Gobius nigers* were collected at two stations, Bostanlı(dirty) and Urla (clean), along the Izmir Bay of Turkey between 2004-2005. Livers were removed and sections of liver each fish were fixed in 10% formalin solution buffered with sodium phosphate for histological analysis. For histology, tissues were dehydrated and embedded in paraffin. Tissue sections were stained with haematoxylin and eosin.

#### Results

Fish liver histology has particular characteristic in normal structure. Hepatocytes constitute about 80 percent of the cell population of the liver. The liver has a great number of functions, most of which is performed by the hepatocytes. Light microscope observations show that it is not possible to distinguish hexagonal subdivisions of hepatic parenchyma or lobules. Hepatocytes in fish livers are arranged as tubules or cords. Between the neighboring sinusoids, the hepatocytes are arranged as plates. The hepatic parenchyma of fish is very homogeneous and the hepatocytes are polygonalshaped cells, appearing hexagonal, often weakly basophilic. The cell membrane of individual hepatocytes is clearly visible through light microscopy analysis. Normal liver is pleomorphic. High fat content in hepatocytes with nuclei displaced to the cell periphery. One characteristic for fish liver is different staining properties of hepatocytes in different zones of liver parenchyma.

Most Gobius analyzed had none important macroscobic or microscobik histological lesion in both clean and dirty area. Symptoms like lymphocyte infiltration and pycnosis showing toxic insult to liver was found scarcely in a few samples from both clean and dirty area. Liver damage involving cellular degeneration and granuloma, as well as an increase in the number of hepatocytes and hyperaemia were not found. Cellular alteration foci as preneoplastic lesions or precursors in hepatic neoplasms histogenesis were not seen. Therewas only a parasite infection in one liver from clean area.

#### Discussion and Conclusion

The present study investigated the pollution effect on the liver of the black goby *G. niger*. Liver being the main site for heavy metal accumulation was used for pollution criteria. The prevalences of hepatic lesions involving cellular alteration registered in this study are not similar to those reported by previous studies (McCain et al. 1988). Among hepatic lesions, the presence of granulomas and tumors was always low in previous studies (Malins et al. (1988) It has been shown that liver hemosiderosis in fish has been associated with the presence of organic pollutants in the environment (Thiyagarajah et al., 1998). The degree of association between contaminants and lesion prevalences, and explained variance, reported in previous studies were different depending on circumtances occured study area (Malins et al. (1988). Therefore, association between fish histopathologies and the presence of organic pollutants should be carefully studied given the histological lesions observed.

In conclusion, the present study represents an important observation on toxic effect of pollution on fish liver from Izmir bay showing that this is not the case. Pollutants were not associated with the presence of histopathologies in livers. This observation may explaine by either very effective detoxification ability of the fish or cleaning of the bay by the water waste treatment plant. These results could be more meaningful by confirming with water, sediment and in vivo pollutant analyses of fish liver.

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# INVESTIGATION OF ORGANOCHLORINE PESTICIDE RESIDUES IN LIVER AND MUSCLE TISSUES OF ATLANTIC BLUEFIN TUNA (*THUNNUS THYNNUS* L., 1758) FROM GULF OF ANTALYA, MEDITERRANEAN, TURKEY

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# Abstract

The aim of this study, an investigation of organochlorine pesticide residues in liver and muscle tissues of Atlantic bluefin tuna (*Thunnus thynnus* L., 1758). The organochlorine pesticide residues were analysed in fish liver and muscle tissues by GC-ECD and confirmed by GC-MS. Organochlorine pesticide residues levels compared to reported values from similar studies conducted elsewhere in the other Mediterranean countries.

Keywords : Pollution, Pesticides, Ecotoxicology, Eastern Mediterranean.

# Introduction:

Organochlorine pesticides are ubiquitous and persistent pollutants due to bioaccumulation in the food chain, either as such or as their metabolites, thus causing concern on the animals at the top of the food chain [1]. This pesticides and related chemicals originating from human activity or agricultural farming are discharged directly or indirectly into the receiving waters. The presence of these chemicals in the marine environment has become a global issue [2]. Organochlorine pesticides have toxic effects on the biota; the former because of their high environmental persistence and the latter because of their chemical and thermal stability [3]. Mediterranean is heavily polluted because of agricultural, industrial and domestic sewage wastes. Every year millions of oil has been transported by tankerships and due to unfortunate accidents and leakages do occur. Another very serious cause of pollution is chemical and petroleum wastes made on purpose to the sea. The increased use of various types of pesticides has led to concerns regarding the potential for contamination of environmental media (i.e., water, sediment and biota) and associated effects on human health and wildlife [4]. The aim of this study is to investigate the levels of organochlorine pesticides residues in the Atlantic Bluefin tuna (Thunnus thynnus L., 1758) from the Gulf of Antalya, Turkey.

#### Materials and Methods:

A total of 20 mature Atlantic Bluefin tuna (*Thunnus thynnus*) were collected from Gulf of Antalya, Turkey, in 2006. The organochlorine pesticide residues were analysed in fish liver and muscle tissues by GC-ECD and confirmed by GC-MS [5].

# Results and Discussion:

Sea water circulation is relatively higher than other closed seas. This situation, place an important role in the dilution of pollutants. Because of physical properties of Mediterranean, its oxygen dissociation is more constant and sufficiently. In our study, the organochlorine pesticide residues in the fishes that has been analysed were almost the same with each other. Ueno et al. were determined specific accumulation of persistent organochlorine residues in bluefin tuna ( Thunnus thynnus) collected from Japanese coastal waters. The concentrations of DDTs in bluefin tuna increased significantly with body length (30-190 cm). Their results suggest significance of dietary uptake of DDTs compared to the intake via the gill [6]. In this study, organochlorine residue levels have founded between normal ranges accordint to FAO/WHO. The levels of organochlorine residues in the Atlantic Bluefin tuna ( Thunnus thynnus) from Gulf of Antalya were measured by Gas Chromatography-Mass Spectrophotometry (GC-MS) for monitoring organochlorine pesticide pollutions in Mediterranean Sea. However, further monitoring of these contaminants in the aquatic system is recommented to insure the protection of food sources in Turkey.

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# SEASONAL DISTRIBUTION OF COPPER IN *MYTILUS GALLOPROVINCIALIS* IN BAYS OF NORTHERN AEGEAN SEA

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# Abstract

In the current study, samples of *Mytilus galloprovincialis*(*Mollusca*) were taken periodically in each season from 11 stations on bays of Northern Aegean Sea (Çandarli, Dikili and Edremit Bays) between August 2002 and November 2003. ANOVA - Analysis of variance was done for analyzing copper in mussels. Results of ANOVA showed that there was no significant difference in Cu levels in mussels among the stations and seasons (p < 0.05). Cu level in the mussels was found as 0.43 - 0.84  $\mu$ g/g wet weight. *Keywords : Aegean Sea, Mollusca, Bio-indicators, Pollution.* 

# Introduction

Izmir Bay has been the only region where marine pollution is being studied well for the reason that it is focus of rapid population increase, developed industry and tourism activities. Aliaga Seaport which is located on one of the counties of Izmir hasn't draw attention although there are intensive industrial activities, petrol refinery, and similar facilities in it. Similarly, other ports and bays on Aegean Sea has not been studied enough so far. The current study aimed to investigate copper pollution in the region.

#### Study area

11 sampling stations were established in order to detect Cu levels deposited in *M. galloprovincialis* distributing in Northern Aegean Sea. Sampling stations were chosen considering the distribution of mussels and pollution sources. The stations are located between the coordinates of N  $38^{\circ}44.404/E$   $026^{\circ}$  46.760(Sazlica Beach in Yeni Foça) and N  $39^{\circ}34.990/E$   $026^{\circ}$  55.395 (Akçay Port ).

#### Material and Methods

Individuals of M. galloprovincialis (Mediterranean mussel) which is an indicator species served as material in investigating copper pollution in Northern Aegean Sea between August 2002 and November 2003. Crusts of the mussel samples harvested from the field by hand were cleaned in the laboratory with a stainless steel lancet so that any organism or other remnants would not remain on them. Then, they were washed in tap water and pure water and they were dried out filter paper and weighted. They were stored in sealed bags in deep-freeze at -21 °C prior to the analyses. Modified EPA - 3051 method was used in preparing the mussel samples to measurements in AAS [1]. Before starting analyses, the mussels were taken from the deep-freeze and warmed to ambient temperature. Then, they were dissected in order to investigate the amount of copper distributed in total soft tissues of the mussels. 0.5 gram of homogenized mussel samples was placed in cups of microwave device and decomposed by adding 10 ml of nitric acid of 65% purity. Decomposed mussel samples were stored in polyethylene bottles at +4 °C prior to the measurement procedure. They were measured using Varian SpectrAA 300/400 Plus Atomic Absorption Flame Spectrometer.

#### Results

Cu concentration in mussel soft tissues was measured for 11 stations in several bays on Northern Aegean Sea (Çandarli, Dikili and Edremit Bays). The lowest concentration of Cu in the mussel samples was detected in Sazlica Beach in November 2002 with a value of 0.43  $\mu$ gCu/g wet weight and the highest one in Dikili Harbor in February 2003 with a value of 8.4  $\mu$ gCu/g wet weight. Results of ANOVA showed that there was no significant difference in Cu levels in mussels among the stations and seasons (p <0.05). It has been observed that Cu concentration in mussel soft tissues varies depending on developmental stage of the organism and the region in which pollution is dense.

#### Discussion

It has been reported that Aegean Sea is subjected to heavy metal pollution and other kinds of pollution arising from numberless settlement and industrial constructions around it [2, 3]. The main sources of pollution contributing to pollution load in Aegean Sea are industrial constructions in Izmir and Aliaga. Other sources are regarded as minor pollution sources [4]. M. galloprovincialis can grow easily in clean and semi-clean waters as well as in the regions with dense pollution. It is very important for us in that it can provide information on pollution in communities in hard substrata. As mussel is an organism feeding by filtering their food, it is a very good indicator species in studying marine pollution. It is a very important benthic organism in determining hem structure and composition of the pollution [5]. The lowest concentration of Cu in the mussel samples was detected in Sazlica Beach in November 2002 with a value of 0.43  $\mu$ gCu/g wet weight and the highest one in Dikili Harbor in February 2003 with a value of 8.4  $\mu$ gCu/g wet weight. Acceptable amount of Cu in marine products in several countries ranges between 10 and 30  $\mu$ gCu/g. In the current study, amount of Cu in of M. galloprovincialis was found to be between 0.53 and 8.4  $\mu$ gCu/g wet weight. Amount of Cu in samples collected from all stations was found to be lower than acceptable limits. Additionally, one can argue that these amounts are lower than those found in other studies although the region is under risk due to industrial activities and intensive and uncontrolled urbanization.

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# COPPER AND ZINC CONTAMINATIONS IN THE COASTAL SEDIMENTS AND POSIDONIA OCEANICA

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# Abstract

We investigated fish farm impacts on *Posidonia oceanica* by comparing meadows in polluted and unpolluted sites. The density of *Posidonia oceanica*, total organic matter in sediment, copper and zinc concentrations in sediments and plant tissues were examined. The results confirm that the *Posidonia oceanica* meadows and sediment characteristics were strongly affected by the activity. *Keywords : Aegean Sea, Aquaculture, Metals, Posidonia, Sediments.* 

#### Introduction

The environmental impacts of fish farming activities in coastal waters were documented widely. However, studies of marine aquaculture on seagrass meadows are scarce in Mediterranean [1-3]. The impacts of organic waste derived from the various types of human activities, the development of aquaculture would appear a main cause for a strong regression of *Posi-donia oceanica* which is key-stone macrophytes of coastal ecosystems in the Mediterranean Sea. Environmental changes were investigated by using various parameters such as density of meadows, total organic matter (TOM) of sediments, nutrient concentrations of water column and heavy metal concentrations (copper and zinc) in sediments, leaves and rhizomes.

#### Material and Method

The study area in the Engeceli Bay (Aegean Sea) is characterized by the presence of sandy-muddy sediments. The samples of sediments (0-5 cm) and *P. oceanica* from different depth range (0-5m; 5-10m; 10-15m) were collected by scuba diving in September 2004. At two selected sites include three replicates for each depth range. The impacted site (stations I1, I2 and I3) by fish farming activity is 300 m far from the cages and the other selected site (stations C1, C2 and C3) as a control is near the shore.

Shoot density at each site and each depth range was measured by counting the shoots present in five replicate quadrates of  $400 \text{ cm}^2$ . The amount of organic matter (TOM) was determined spectrophotometrically in sediment samples following the sulfochromic oxidation method [4]. Temperature, salinity and pH values were measured in situ. Nutrient analysis was carried out using autoanalyzer and the colorimetric methods adopted were similar to those described by Strickland and Parsons [5]. Heavy metal concentrations in sediment and leaves, rhizomes of *P. oceanica* were determined by flame atomic absorption spectrometry.



Fig. 1. Mean concentration of Cu and Zn in rhizomes and leaves of *P. Oceanica* and sediments.

#### Result and Discussion

Density of *P. oceanica* meadow (number of shoots per m<sup>2</sup>) is higher at control stations than impacted site. The highest value was recorded at C1 (545±89). However, at two sites, shoot density decreased with increasing depth. This may be explained with changes in light intensity [6]. The organic matter contents in the sediment at impacted site range from 7.6 to 10.7%. The highest values measured at station II was close to the values recorded under the cages. Only the ammonium values show differences between sites. Samples collected from control sites represented with low ammonium values (0.6-0.9  $\mu$ M). However total phosphate and nitrate concentration did not show remarkable changes at two selected sites. Correlation coefficients were calculated among TOM, Zn and Cu in sediments, rhizomes and leaves. The level of TOM was significantly correlated with Cu and Zn in sediment (p<0.05, r=0.91 and r=0.55; in respectively). There were significant relationship between Cu and Zn in sediment (p<0.05, r=0.81). TOM in sediment was correlated with Cu in

rhizomes but not correlated in leaves. However, the Cu and Zn concentration in rhizomes was correlated with Cu and Zn levels in leaves (p<0.05, r=0.70). Rhizomes and sediments contain the highest amounts of Cu (8.5-14.7 $\mu$ g g<sup>-1</sup>; 152-170  $\mu$ g g<sup>-1</sup>) at station I1. This metal was recorded at lower levels both sediments and rhizomes in French coast impacted by aquaculture [2]. In fact, these results are similar to the data obtained from highly contaminated regions in Gulf of Naples [7]. Zinc shows considerable concentration peak in leaves (79-102  $\mu$ g g<sup>-1</sup>). Zn levels in rhizomes and sediments ranged between 24.4 and 82.7  $\mu$ g g<sup>-1</sup>dry wt (Fig. 1).

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# ASSESSMENT OF CU, MN, NI, ZN AND FE LEVELS IN SEDIMENT AND BIOTA OF THE IZMIR BAY (EASTERN AEGEAN)

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# Abstract

Baseline metal (Cu, Mn, Ni, Zn, Fe) concentrations in sediment and biota were investigated in Izmir Bay of the Eastern Aegean Sea. Cu and Zn concentrations and organic matter contents in sediment increased from the outer bay to the middle-inner bays. Maximum Cu concentrations were obtained in Penaeus kerathurus. Maximum Zn and Fe concentrations were found in Mytilus gallopronincialis. Relatively high Cu levels were found in Sardina pilcardus and Mullus barbatus than other fish species. Cu levels were lower in Diplodus annularis and Merluccius merluccius than in other species.

Keywords : Metals, Sediments, Fishes, Organic Matter, Aegean Sea.

# Introduction

In the present study, the level of metals in the Izmir Bay was determined in organisms and bottom sediment.

Materials and Methods

Samples were collected during the cruises of R/V K. Piri Reis in 1996 in the Izmir Bay. Sediment samples (UNEP, 1986) and biota tissues (UNEP, 1984) were digested in suitable acid mixture. All acid digestions were made in Milestone 1200 close microwave digestion system. Organic matter were determined spectrophotometrically. Metal concentrations were quantified using a Varian SpectrAA 300 Plus spectrometer.

#### Results

Sediment: Organic matter contents in the bay ranged between 0.40-4.09 % for the outer bay and attained their highest values, between 3.27-10.1 % in the middle-inner bays. In general, organic matter content increased from the outer bay to the middle-inner bays. Metal concentrations in the sediment (dry weight) ranged between 4.26-45.2 for Cu, 233-923 for Mn, 14.9-127 for Ni, 25.6-154 for Zn, 12404-76899  $\mu g g^{-1}$  for Fe in the outer parts of the bay. In the middle-inner parts of the bay, sediment metal concentrations ranged between 27.4-70.8 for Cu, 356-583 for Mn, 72.8-106 for Ni, 93.5-295 for Zn, 42109-68901  $\mu {\rm g}~{\rm g}^{-1}$  for Fe. Cu and Zn concentrations of Izmir bay sediments increased from the outer bay to the middle-inner bays. Relatively high concentrations were measured at Gediz Estuary and Dump Site in the outer bay. Maximum Cu (70.8  $\mu g \ g^{-1})$  and Zn (295  $\mu$ g g<sup>-1</sup>) concentrations were observed at harbour station in the inner parts of the bay. Maximum Mn (923  $\mu$ g g<sup>-1</sup> at station 7), Fe (76899  $\mu$ g g<sup>-1</sup> at station 7) and Ni (127  $\mu$ g g<sup>-1</sup> at station 15) concentrations were measured in the outer parts of the bay. Based on the correlation matrix obtained for metal data, organic matter was the dominant factor controlling Cu (r=0.84) and Zn (r=0.87) distributions in the sediment. Sediment Cu showed positive correlation with Zn (r=0.93). A significant positive correlation was also observed between Fe and Mn (r=0.83) and Ni (r=0.94). According to Salomons and Förstner (1984), those correlations are probably indicating that these elements have the same source, possibly lithologic, characteristic of sediment was non impacted and therefore, of natural origin. Those correlations are also indicators of the importance of the co-precipitation process controlled by Fe and Mn oxy-hydroxides.

Biota: Maximum Cu concentrations (6.98  $\mu$ g g<sup>-1</sup> wet weight) were obtained in *Penaeus kerathurus* and maximum Zn (30  $\mu$ g g<sup>-1</sup>) and Fe (130  $\mu$ g g<sup>-1</sup>) concentrations were found in *Mytilus gallopronincialis*. Relatively high levels of Cu were found in *Sardina pilcardus* (values ranging between 1.39-1.91  $\mu$ g g<sup>-1</sup>), *Mullus barbatus* (0.16-1.88  $\mu$ g g<sup>-1</sup>) and *Mytilus gallopronincialis* (values ranging between 0.71-1.72  $\mu$ g g<sup>-1</sup>) than other species. Cu levels were lower in *Diplodus annularis* and *Merluccius merluccius* than other species. Relatively high Zn (values ranging between 2.62-14.9  $\mu$ g g<sup>-1</sup>) and Fe (values ranging between 7.84-24.7  $\mu$ g g<sup>-1</sup>) concentrations were found in *Diplodus annularis* than other fish species. Interestingly, the standard error and deviation for mean Zn and Fe concentrations were significantly different in each tissue from different fish species as a result of their biological needs.

#### Conclusion

Cu and Zn concentrations in sediment were high in the inner bay. The results demonstrated that the middle-inner bays are facing severe copper and zinc pollution. Gediz River was the most important input of metals to the outer bay. Maximum Cu concentrations were obtained in *Penaeus* 

*kerathurus*. Maximum Zn and Fe concentrations were found in *Mytilus* gallopronincialis. Relatively high Cu levels were found in *Sardina pilcar*dus and Mullus barbatus than other fish species. Cu levels were lower in *Diplodus annularis* and *Merluccius merluccius* than in other species.

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# BIOCHEMICAL PROPERTIES AND ANTIBIOTIC SENSITIVITIES OF VIBRIO ALGINOLYTICUS ISOLATED FROM EUROPEAN SEA BASS LARVAE (*DICENTRARCHUS LABRAX*, L.) IN TURKEY

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# Abstract

A *Vibrio alginolyticus* infection in European sea bass (*Dicentrarchus labrax*, L.) and also antibiotic properties of isolated strains were described in this study. All isolates were resistance to ampicillin and trimethoprime and sensitive to flumequine and oxolinic acid tested. These results are discussed in the light of treatment of vibriosis already reported in moribund sea bass and other marine fish species. *Keywords : Antibiotics, Aegean Sea, Aquaculture, Bacteria.* 

Aquaculture is the growth of fish, molluscs, crustaceans and aquatic plants [9]. From 1970 to today, aquaculture has been the most rapidly growing sector of agriculture, when compared with aquatic products from fishing and meat products from land animals [8-9]. In the Mediterranean Region, aquaculture has been growing from yearly. Total aquaculture production reached 1 266 959 tonnes in 1999. When the present aquaculture in Turkey is evaluated, Turkey has potentially rich inland and marine aquatic resources with coastal lines (8333 km), economic marine areas (151080 km square), natural lakes (1 million ha) and dam sources (500 000 ha) [13]. In Turkey, the first rainbow trout farm was set in the end of 1960s. However, the first gilt-head sea bream and European sea bass production units did not start, until 1985 [13, 16]. Total aquatic production with 3075 tonnes in 1986 was estimated as 63,000 tonnes in 1999; however, it was 79,031 tonnes in 2002 [13-16]. Commercially cultured marine species in Turkey are gilt-head sea bream (Sparus aurata) and European sea bass (Dicentrarchus labrax) [5, 20]. According to the bacterial diseases of these species, earlier bacteriological studies of moribund sea bass documented of pasteurellosis [10-11, 15, 19] vibriosis [12, 14] and Aeromonas hydrophila [18]. The aim of this study is to evaluate antibiotic resistance/susceptibility of Vibrio alginolyticus isolated from moribund sea bass larvae. In April of 2005, sea bass ( Dicentrarchus labrax) (0.5-1.0 g) mortalities were noted at a daily rate of %3 in a sea bass and gilth-head sea bream farm located at Aegean Region of Turkey. Water temperature was 21.5 °C-23 °C; the salinity of water was %0 17. Ten moribund fish, weighing 0.5-1.0 g, were selected from one of square concrete ponds and autopsied under aseptic conditions. Samples taken from visceral organs, i.e., the spleen, liver, and kidney, were inoculated for bacterial isolation on Trypticase Soy Agar (TSA; Merck, Germany). Plates were incubated at 24  $C^\circ$  for 72 h. Biochemical and physiological tests were carried out on the isolates according to standart tube and petri procedures. The disk diffusion method was used to test the susceptibility of the isolates to antibiotics on Mueller-Hinton agar (Merck) by adding 1 % NaCl [1, 4, 7, 17]. Flumequine, kanamycin, ampicillin, oxolinic acid, tetracycline, trimethoprime, c. sulphonamide, erythromycin disks were used. Affected fish showed ulcers on the dorsal part of the body, haemorrhagies on the operculum, whitish colour on the abdomen. Some of the moribund fish intestine were out of the anus. Internal lesions included enlargement of the spleen, paleness of the liver and kidney, haemorrhages in the intestine. The gastro-intestinal tract was empty. After incubation, the bacterial strains isolated from moribund fish (n=10) produced cream-coloured, convex colonies. Isolates were Gram-negative, cytochrome oxidase positive, fermentative and sensitive to vibriostatic agents. Isolates produced yellow colonies on TCBS (Thiosulphate-Citrate-Bile-Sucrose agar, Merck). The isolated strains had similar phenotypic properties to other Vibrio alginolyticus strains [2-3, 6]. According to the results of antibiotic tests, all of the isolates were resistance to ampicillin and trimethoprime. They were susceptibility to flumequine and oxolinic acid.

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# VERTICAL HYDROCHEMICAL STRUCTURE OF THE BULGARIAN BLACK SEA PART

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# Abstract

The aim of the article is to improve understanding of open-sea area peculiarities of nutrient distribution in comparison with coastal waters. The data was obtained cruises during 2001-2005 period in a sampling grid along Bulgarian Black Sea coast. Physical parameters were obtained by Sea Bird CTD device. Dissolved oxygen was analysed by Winklermethod and nutrients by standard spectrophotometric methods on board. Key characteristics of vertical hydrochemical structure correspond to those already established for the Black Sea. There are differences in densities where extreme values of parameters are found in comparison to other Black Sea regions. This is due either to specific processes for the area and/or to recent changes in the state of the basin. *Keywords : Black Sea, Density, Oxygen.* 

Black Sea is one of the semi-enclosed seas with limited water exchange with World Ocean and significant amount of freshwater into the NW region. The western part of the Black Sea ischaracterised by considerable influence of river inputs and eutrophication due to nutrients stock [1]. The aim of the article is to improve understanding of open-sea area peculiarities of nutrient distribution in comparison with coastal waters in last years. The study is based on data obtained cruises during 2001-2005 period in a sampling grid along Bulgarian Black Sea coast. Water samples were collected by rosette sampling bottles system at standard depths dawn to 300 m and pre-determined thermocline layer. Physical parameters were obtained by Sea Bird CTD device. Dissolved oxygen was analysed by Winkler method and nutrients (phosphates, nitrites, nitrates and silicates) by standard spectrophotometric methods on board [2]. In summer the shallow area is characterized by homogeneity of the water column in respect of temperature, salinity and nutrients. Dissolved oxygen (DO) gradually decrease with depth [3]. The coastal marine eutrophication is significant which is demonstrated by higher nutrients content in comparison to the open sea (surface distribution).SHL: For deep stations surface homogeneous layer includes the water column from 0 to 30 m. Nutrients content is low (near zeroes) especially phosphate concentration. The measured phosphorous concentrations often are lower than detectable limit of measurement. Density varies from 10.0 to 11.8. Concentrations of dissolved oxygen are high and the layer is oversaturated. Comparison with surface homogeneous layer of the shallow stations shows higher salinity. Thermocline layer varies from 20 to 35 m. Nitrates and phosphates contents decrease and silicates have no changes from surface homogeneous layer. CIL: Cold intermediate layer varies down to 100 m. It is characterized by higher nutrient concentration due to their mineralization. Nitrites distribution is characterized by maximums over and/or nitrates maximum. Nitrate maximum is located at  $\sigma_{\theta} \approx$  15.2. Other nutrients gradually increase down to oxic/anoxic layer. Phosphates show higher values at density about  $\sigma_{\theta}$  $\approx$  16.0. Increasing trend of silicates is extended in anoxic zone as well. Dissolved oxygen content of 20  $\mu$ Mas an upper boundary of suboxic zone is determined at  $\sigma_{\theta} \approx 16.1$ . Dissolved oxygen is undetectable under  $\sigma_{\theta}$  $\approx$  16.5. Density scaled oxygen saturation (OS)follows generally strictly vertical distribution of DO. The higher dispersion in thermocline layer is compensated completely in oxygen saturation profile. In contrast with the other Black Sea regions the nitrates maximum in front of the Bulgarian coast corresponds to higher values of dissolved oxygen even for a long term periods. Thus, in spite of missing investigations in relation to density we can assume a typical similar vertical distribution for the region. Phosphates content increases gradually from  $\sigma_{\theta} \approx 14.5$  to  $\sigma_{\theta} \approx 15.2$ . The vertical profile of silicates corresponds to the expected content values as well as to its distribution. A minimum above the upper boundary of suboxic zone is observed. Key characteristics of vertical hydrochemical structure correspond to those already established for the Black Sea. There are differences in densities where extreme values of parameters are found in comparison to other Black Sea regions. This is due either to specific processes for the area and/or to recent changes in the state of the basin.

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# MONITORING PROGRAMS AND ENVIRONMENTAL RESEARCH: CAN THEY COMPLEMENT EACH OTHER?

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# Abstract

Monitoring programs, although focused in scope and space, can initiate dedicated environmental research of extensive general scope. Careful analyses of the monitoring results are the first step in identifying general environmental questions worth pursuing, complementing and broadening the monitoring studies.

Keywords : Monitoring, Coastal Systems, Sediments, Coastal Management.

Regular monitoring programs aim at supervising the influence of anthropogenic discharges on the marine environment and as a warning system to protect the environment. Compared to basic research, monitoring is more specific and adapted to the particular environmental risk posed by a specific activity, limited in space and scope. In Israel, discharge of industrial and municipal treated effluents into the sea is regulated by a strict permit system granted by an inter-ministerial committee. Monitoring of the composition of pollutants in the effluents and monitoring of the marine environment at the discharge area are among the requirements for receiving a discharge permit. Therefore, while environmental research suffers from decreasing financial support, monitoring programs are required by law and continue to be funded.

However, even in specific monitoring programs one can find interesting and unexpected findings that can be translated into scientific questions worthy of dedicated research. For example, three "hot spots" of total mercury concentration in the sediments were recognized along the Israeli Mediterranean coast within the framework of different monitoring programs: 1.the northern part of Haifa bay, opposite a chlor- alkali plant, 2. the southern part of Haifa Bay, opposite the Qishon estuary and 3. the marine disposal site of excess sewage sludge at the southern part of the coast [1-2]. The scientific question raised was why does mercury accumulate in fish and benthic fauna from Haifa Bay and not in fish and benthic fauna from the sewage sludge disposal area, even tough the total mercury concentration in the sediments at all sites are similar (Table 1). A dedicated research on mercury speciation found that ca. 90% of the mercury at the sewage sludge disposal site was bonded to humic matter via sulfur or bonded directly to sulfide in the mineral phase and therefore unavailable to methylation and not bioavailable.

Tab. 1. Mercury at three locations along the Israeli Mediterranean coast.

| Site                                                      | Source                                                       | Hg sediment<br>µg g <sup>-1</sup> dry wt | Hg species                                                        | Environmental<br>effect                                         |
|-----------------------------------------------------------|--------------------------------------------------------------|------------------------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------|
| Northern Haifa<br>Bay<br>3-12 m water<br>depth            | Electrochemical<br>industry                                  | ca. 0.25                                 | Probably Hg <sup>0</sup><br>and Hg <sub>inorg</sub> <sup>42</sup> | Elevated<br>concentrations in<br>sediments, fish and<br>benthos |
| Qishon estuary<br>10-12 m water<br>depth                  | Unknown                                                      | ca. 0.25                                 | Unknown                                                           | Elevated<br>concentrations in<br>sediments and fish             |
| Sewage sludge<br>disposal site<br>ca. 38 m water<br>depth | Sewage sludge<br>from municipal<br>sewage<br>treatment plant | 0.005-1.4<br>average of<br>0.26          | Associated<br>with organic<br>matter and<br>sulfides              | Elevated<br>concentration in<br>sediments                       |

An additional example is chromium anomaly found during regular monitoring at the southern Mediterranean coast of Israel. Chromium concentrations are higher than expected in the sediments along a narrow stripe at ca. 15 m depth and are associated with high concentrations of Fe, Mn, and to a lesser extent Zn. The scientific question that cannot be answered at this stage is what is the source of chromium? Is it natural or anthropogenic? The question has ramifications into the use of sediment quality criteria in the area.

These two examples, out of many others show that monitoring programs, although focused in scope and space, can initiate dedicated environmental research of extensive general scope. Careful analyses of the monitoring results are the first step in identifying general environmental questions worth pursuing, complementing and broadening the monitoring studies.

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# CLOSED CHLORALKALINE PLANT AS HG-POLLUTION SOURCE IN KASTELA BAY, ADRIATIC SEA (CROATIA)

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# Abstract

Concentrations of gaseous mercury (2.1 - 9.6  $\mu$ g m<sup>-3</sup>) were measured within the former chlor-alkali plant in Kaštela Bay. This is a hazardous source of pollution and could present a serious problem for the town of Split and Jadro River. The aim of the work was to find the direction in which Hg-pollution was distributed. Soil samples were collected and total Hg concentrations were measured in soils and in sediments of Jadro River. Hg was transported in NW direction from pollution source and did not affect the source of Jadro River. *Keywords : Mercury, Pollution, Adriatic Sea.* 

The present work is the continuation of our earlier studies of mercury pollution in Kaštela Bay [1, 2], in which papers are experimental methods described in details. Concentrations of gaseous mercury 2.1 - 9.6  $\mu$ g m<sup>-3</sup> were measured within the closed chloralkaline factory in which there are neither windows nor doors. Thus the chloralkaline plant still presents a hazardous source of mercury. The concentrations measured in air about 1000 m in diameter from the pollution source were 0.015 - 0.400  $\mu g~m^{-3}.$ Along atmospheric "lifetime" of an elemental gaseous mercury, as well as its easy transport to remote areas could present a serious problem. In vicinity is the town of Split and also Jadro River, which is a drinking water supply for Split. Polluted Kaštela Bay and Jadro River are presented in Figure 1. The aim of the work was to measure concentrations of total mercury in soil around the pollution source in the PVC factory and find out which direction was pollution distributed. From 40 soil samples taken in all directions around the pollution source it was concluded that mercury was transported from Kaštel Sućurac towards the upper part of Kaštel Gomilica in NW direction, what corresponds to the direction of Jugo wind. Concentrations of Hg in soil toward north and east from the factory are  $<0.2 \ \mu g \ g^{-1}$  at the distance of 600 m. It is significant that Hg-pollution did not influence the source of Jadro River. It is a drinking water supply for the town of Split and the river flows into the eastern part of polluted Kaštela Bay. The concentrations of total mercury and of methyl-mercury were measured in three locations, both in sediments and in water. With respect to mercury, Jadro presents clean environment, what is a significant conclusion.



Fig. 1. Map of the study area.

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# ELECTROCHEMICAL BEHAVIOR OF COPPER COMPLEXES IN MODEL ELECTROLYTE SOLUTIONS AND NATURAL WATERS

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# Abstract

Several electrochemical techniques and methods were used to explore electrochemical behavior of copper while determining its complexation parameters in model electrolyte solutions, as well as in fresh, brackish and sea water. It was shown that adsorption of natural organic matter (NOM) strongly influences electrochemical reaction of copper during anodic stripping scan causing obstacles in obtaining proper copper complexing parameters. Experimental procedure setup that overcomes these difficulties is proposed. *Keywords : Trace Elements, Chemical Speciation, Organic Matter, Aeolian Arc, Metals.* 

The toxicity and bioavailability of metal ions to aquatic organisms is mainly related to concentrations of their free (hydrated) form - Free Ion Activity Model (FIAM)[1]. The chemical speciation of metals in natural water samples is determined by the net of chemical reactions of metal ions with inorganic and organic ligands existing in particular natural water [2]. Several physico-chemical methods are available for the determination of the chemical speciation of trace metals, among them anodic stripping voltammetry (ASV) satisfies requirements concerning sensitivity and selectivity, while keeping the benefit of low contamination risk and low alteration of original sample composition during analysis. However, ASV suffers from interferences during redox reactions, which could influence the determination of complexing parameters of investigated trace metal.

In this work, electrochemical reactions of copper in model electrolyte solutions (sodium-choride and sodium-perchlorate), as well as in fresh, brackish and sea water (river Gapeau, Hyères, France) were studied, in order to find the best parameters of experimental setup in obtaining reliable data, regarding copper complexation parameters. The methodology is based on pseudopolarographic measurements[3,4] and determination of copper complexing capacity (CuCC)[5] applying ASV method and a hanging mercury drop as a working electrode. Both methods yield data concerning complexing properties of copper.



Fig. 1. DPAS voltammograms of copper in raw seawater sample obtained using different experimental parameters: (1) -  $t_{dep} = 300$  s @  $E_{dep} = -0.45$  V; (2) -  $t_{dep} = 297$  s @  $E_{dep} = -0.45$  V and  $t_{dep} = 3$  s @  $E_{dep} = -1.6$  V; (3) -  $t_{dep} = 300$  s @  $E_{dep} = -1.6$  V.

It is found that ASV of copper is strongly affected by the adsorption of surface active substances (SAS) of natural origin (natural organic matter - NOM) on the mercury surface[6]. As a consequence, a distorted shape of copper anodic peaks appears, which further leads to poorly developed pseudopolarograms. Moreover, incorrect data of copper complexing capacity parameters, ligand concentration and apparent stability constant, could be obtained.

Applying a.c. voltammetry, we found that only anodic stripping step is influenced by the adsorbed layer, and that the effect is more pronounced for longer accumulation times and accumulation potentials at electrocapilary maximum (around -0.6 V). At very negative potentials (<1.4 V) most of the surface active substances are desorbed from the mercury surface giving well defined anodic stripping peak of copper. Desorption of SAS from the mercury electrode is relatively fast and only about 1% of total accumulation time at very negative potential (e.g. -1.6 V) is enough to remove practically all adsorbed SAS (Figure 1). The procedure to overcome this artifact is proposed and exploited to show its influence and consequences on copper pseudopolarographic measurements and determination of copper complexing capacity.

The influence of synthetic SAS Triton-X-100 on the electrochemical reaction of copper, the benefit of using Stripping ChronoPotentiometry (SCP) and the importance of maintaining the original pH of the natural sample will be shown and discussed.

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# PSEUDOPOLAROGRAPHY AS A TOOL FOR COMPLEXATION STUDIES OF TRACE METALS WITH DISSOLVED NATURAL ORGANIC MATTER

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# Abstract

The potentialities of pseudopolarographic approach regarding trace metal speciation were explored. Recorded pseudopolarogram of a particular metal serves as a fingerprint of the analyzed sample. It gives initial information related to qualitative and quantitative purpose: a first approximation of trace metal distribution with respect to labile and inert metal complexes and the strength of inert metal complexes present in natural sample. Several model electrolyte solutions and natural estuary/seawater samples containing different quantity of Dissolved Natural Organic Matter (DNOM) were used in this study. In addition, Differential Pulse Anodic Stripping Voltammetry (DPASV) measurements were carried out with logarithmic additions to reach information about DNOM complexing capacities and stability constants.

Keywords : Chemical Speciation, Organic Matter, Electrochemistry, Trace Elements, Metals.

Complexation of trace metals in natural waters by natural organic mater and inorganic ligands i.e. their chemical speciation, determines their mobility and bioavailability. NOM is ubiquitous in the environment and consists of a complex mixture [1]. It is known to play important roles in the fate of many contaminants due to its complexing properties. A better determination of NOM structural and functional properties can greatly improve our understanding of the underlying mechanisms responsible for heavy metals complexation.

Among the techniques allowing trace metal speciation in natural waters, voltammetry is appropriate because it offers high sensitivity, enough selectivity and ability for direct measurement with minimally disturbing of the original sample. Obtained voltammetric data are related to the physico-chemical characteristics of the electroactive metal species, and information on speciation parameters of the investigated metal could be obtained.

In this study, the ability of pseudopolarographic approach to trace metal speciation is investigated [2, 3]. Pseudopolarogram represents a series of anodic stripping voltammetric (ASV) peak current values plotted as a function of deposition potential (Fig. 1).



Fig. 1. Experimental 3D-pseudopolarogram of copper inseawater sample without any additions.

As in classical polarography, the parameters extracted from the pseudopolarograms are half-wave potential and limiting current. The reduction half-wave potentials of inert metal complexes are separated from the reduction potential of free and labile metal complexes and are shifted towards more negative values. The amount of these shifts is the basis for the determination of the type of inert metal complexes in natural waters, because they depend on their stability constant [4]. In addition to this direct speciation mode, pseudopolarography is used to optimise a choice of

accumulation/deposition potential where only free/labile metal is reduced which is a prerequisite for the procedure of metal complexing capacity (MCC) determination.

Several model electrolyte solutions and natural estuary/seawater samples from different locations in the Mediterranean and Adriatic Sea were used in this study. DPASV on mercury drop electrode was used in all experiments. It is experimentally verified in model electrolyte solutions containing metal complexes with known stability constants, that the shift oft he half-wave potential of the inert metal complex is related to its stability constant. This relation is further used as a general rule for the estimation of the stability constants of trace metal complexes formed by DNOM in analysed natural waters. Additional effort has been made to couple standard addition method and pseudopolarography in order to obtain more information on trace metal complexation. Such measurements are very time consuming, so automated measurement system has been assembled.

The influence of accumulation potential on determination of metal complexing capacity was investigated, as well. Metal additions were performed in a logarithmic mode, allowing a wider analytical window, and therefore a better accuracy of the complexing parameters determination [5]. The voltammetric data were further modelled with PROSECE (Programmed'Optimisation et de SpEciation Chimique dans l'Environnement), a very manageable software based on a discrete model [5]. Calculated metal complexing parameters (ligand concentrations and stability constants) strongly depend on accumulation potential as well as on experimental setup, which needs to be better understood and quantified.

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# SIGNALS OF FLOOD DRIVEN PROCESSES RECORDED IN CHANNEL-LIKE STRUCTURES NEAR THE GRAND RHONE RIVER MOUTH

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# Abstract

The study of sedimentary processes in the Gulf of Lions has been the topic of various works and is dealt today in the frame of several programs, like ORME (Mediterranean Regional Observatory of Environment), PNEC (Coastal Environment National Program) or EU-ROSTRATAFORM (UE-5th PCRD). However, the fate of river-borne sediments supplied during river floods is still poorly understood. Several major river-flow events occurred on the Rhone River in 1994, 2002, 2003. In the area close to the mouth, channel-like structures were investigated in order to assess their role in the sediment transport during flow events based upon analysis of granulometric parameters as well as <sup>210</sup>Pb and <sup>137</sup>Cs vertical profiles.

Keywords : Gulf Of Lions, Sediment Transport, Radionuclides.

### Desciption of the studied area

With a catchment area of nearly 98800 km2 and a length of 812 km, the Rhone is the most important river of the western Mediterranean basin. Its average liquid flow rate is 1700m<sup>3</sup>/s. Nevertheless, it can reach 13000m<sup>3</sup>/s during exceptional flood period, for instance in December 2003. The Grand Rhone is thought to transport average annual amounts of 7.4Mt of sediments with high interannual variations [1]. Most of its annual sediment load is discharged during flood events. The area close to the Rhone River mouth is characterized by very high apparent sedimentation rates, i.e. 30-50cm per year, due to aggregation and floculation processes in the mixing zone between fresh and saline waters. Recently, channel-like structures have been reported on seabeam survey in this area. These structures may play a significant role in sediment transports during flood events. In order to better assess this role we analyzed cores from these structures regarding both their granulometry and their content in particle-reactive radionuclides (<sup>210</sup>Pb, <sup>137</sup>Cs). <sup>210</sup>Pb is produced naturally while <sup>137</sup>Cs is a man-made radionuclide originating in this area from fallout arising from past atmospheric bomb testings and the Chernobyl accident and also from authorized released into the Rhone river by nuclear installations. Indeed, four power plants and the site of Marcoule with a reprocessing plant which is being dismantled since 1997 are installed along the Rhone banks.

#### Material and methods

Since 2001, IRSN has realised various cruises of sediments sampling in the Gulf of Lions. Among them, the REMORA 3 (November 2002) and BOBORHONE 2 (February 2004) cruises aimed at studying the sediment compartment in the close vicinity of the Rhone River mouth. The last quoted was carried out just after the exceptional flood that occurred in December 2003 with the highest flow rate ever recorded on this river.



Fig. 1. (a)  $^{137}$ Cs profile, (b)  $^{210}$ Pb in excess profile, (c) granulometric profile sampled in a channel-like structure during REMORA 3

Multicorers were used to sample the channel-like structures at 30m depth. In the laboratory, samples undergo two kinds of analysis: granulometry and gamma spectrometry respectively realized with a laser granulometer Beckmann & Coulter 13320 and performed using Ge-detectors in a very low background installation in Orsay in order to detect  $^{210}$ Pb and  $^{137}$ Cs.

#### Results and discussion

In both cores (fig1& 2), <sup>210</sup>Pb and <sup>137</sup>Cs profiles are very similar, indeed the correlation coefficient is high between these two parameters (>0,75). Higher radionuclides contents are concomitant with higher silts contents (<63 $\mu$ m). On the contrary, increase in coarse grain contents (>63 $\mu$ m) appears when <sup>137</sup>Cs and <sup>210</sup>Pb decrease giving clear signals of flood events.



Fig. 2. (d)  $^{137}\rm{Cs}$  profile, (e)  $^{210}\rm{Pb}$  in excess profile, (f) granulometric profile sampled in a channel-like structure during BOBORHONE 2

It is obvious that floods led to supply of coarser sediments and in addition it is well known that when particles are delivered in high quantity they do not scavenge dissolved <sup>210</sup>Pb as efficiently as sediment supplied with lower concentrations. In the same way, during flow events <sup>137</sup>Cs dilution factor is very high leading to low contents when high flow rate occurs (Fig f). However regarding radionuclides released into the Rhone river remobilization of sediments labelled by former releases can also happen, and the relationship with flow rates may not be that simple.

Another interesting feature is the almost constant lag appearing in the peak layers between radionuclides and granulometry. Peak in fine grains content seems to occur prior to the peak in <sup>210</sup>Pb and <sup>137</sup>Cs. This is certainly to be linked to sediments dynamics. The instrumentation of the Rhone River mouth with ADCP, altimeters and CTD probes will be carried out from October 2006 to March 2007 in order to qualify and quantify precisely the impact of such events on sedimentary records (erosion, sedimentation).

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# SPATIAL DISTRIBUTION OF POLYCYCLIC AROMATIC HYDROCARBONS IN MUSSELS (*MYTILUS GALLOPROVINCALIS*) FROM THE IBERIAN MEDITERRANEAN COAST

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# Abstract

Polycyclic aromatic hydrocarbons (PAHs) concentrations were measured in tissues of wild mussels (n=50) (*Mytilus galloprovincialis*) along the Iberian Mediterranean coast in May-June 2004. The total sum of the 13PAHs analysed ranged from 46.85 - 3.83 microg  $\tilde{A}U$  kg<sup>-1</sup> wet weight. Highest concentrations were observed near Barcelona, Tarragona, Tabarca island (declared Marine Reserve) and Guadarranque (Algeciras). An indistinct profile of molecular indices were found in the majority of the sampling areas, which is indicative of a diffuse origin of the PAH contamination.

Keywords : Bivalves, Monitoring, Pah, Western Mediterranean.

# Introduction

Polycyclic aromatic hydrocarbons (PAHs) should be paid particular attention because of their known associated toxicity. Mussels are of great value in terms of biomonitoring due to their sedimentary life, time-integrator capacity and nutritional status (filter feeder). The data obtained represent baseline concentrations along the Iberian Mediterranean coast for future comparisons.

# Material and Methods

Sampling was made under standardized conditions, collecting native mussels during May-June 2004 (outside spawning period). At each site (Fig 1.), three replicates (n= 50), size ranging from 30 to 40 mm, were collected. Preparations of samples and procedure to extract PAHs have been described elsewhere in detail [1].

Tab. 1. Concentrations of total polycyclic aromatic hydrocarbons (mean  $\pm$  standard error of the mean), selected ratios and potential origin of the PAH contamination.

| Areas        | Mean  | $\pm$ SE | Phe / Ant | Fla / Pyr | Origin     |
|--------------|-------|----------|-----------|-----------|------------|
|              |       |          |           |           |            |
| Guadarranque | 28.19 | 3.32     | 17.18     | 0.77      | petrogenic |
| Algeciras1   | 3.83  | 0.9      | 14.61     | 3.48      | diffuse    |
| Manil∨a      | 3.83  | 0.27     | 18.24     | 3.29      | diffuse    |
| Marbella     | 4.64  | 0.17     | 14.6      | 2.37      | diffuse    |
| Fuengirola   | 4.82  | 1.03     | 17.09     | 3.27      | diffuse    |
| Málaga1      | 7.38  | 0.46     | 13.1      | 1.9       | diffuse    |
| Torrox       | 7.29  | 0.97     | 19.65     | 2.24      | diffuse    |
| La Herradura | 4.03  | 1.14     | 17.37     | 4.28      | diffuse    |
| Almuñécar    | 5.37  | 0.33     | 18.08     | 2.84      | diffuse    |
| Calahonda    | 5.73  | 0.17     | 17.11     | 4.83      | diffuse    |
| Cartagena1   | 13.01 |          | 15.09     | 2.34      | diffuse    |
| Tabarca I.   | 36.29 | 6.8      | 8.72      | 1.37      | pyrogenic  |
| Valencia     | 16.37 | 1.06     | 9.2       | 2.26      | pyrogenic  |
| Peñíscola    | 8.59  | 0.46     | 12.81     | 2.16      | diffuse    |
| D. Ebro      | 6.36  | 1        | 14.86     | 3.07      | diffuse    |
| Tarragona    | 46.85 | 4.64     | 7.55      | 1.32      | pyrogenic  |
| Vallcarca    | 15.24 | 1.04     | 10.66     | 1.51      | diffuse    |
| Barcelona    | 39.87 | 1.72     | 8.66      | 1.23      | pyrogenic  |
| Blanes       | 8.83  | 0.9      | 13.66     | 3.26      | diffuse    |
| Medas I.     | 5.81  | 0.34     | 13.82     | 3.64      | diffuse    |
| Cadaqués     | 9.33  | 0.88     | 14.87     | 3.93      | diffuse    |
|              |       |          |           |           |            |

The 13 analysed PAHs (phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo(a)anthracene, benzo (b)fluoranthene,

benzo(k)fluoranthene, benzo(a)pyrene, benzo(e)pyrene, indeno(1,2,3c,d)pyrene, dibenzo(a,h)anthracene and benzo(g,h,i)perylene) were separated and quantified by means of High Performance Liquid Chromatography (HPLC) using a fluorescence detector with programmable wavelength. Results and discussion

The total sum of the 13 individual PAHs analysed ranged from 46.85-3.83 microg  $kg^{-1}$  w.w. (Tab. 1). Higher PAHs concentrations were mainly found near of well-known hotspots along the Iberian Mediterranean coast such as Tarragona, Barcelona and Guadarranque (Algeciras). Tabarca island is a Marine Reserve not directly influenced by any industrial or urban activities, and the high PAH levels observed in this area, could therefore be explained by the dispersion of the inputs provided from inland or pinpoint source inputs of petrogenic origin due to the marine traffic around the Marine Reserve. Origin (pyrolitic or petrogenic) of the main source of contamination in the areas was established by using molecular indices (Tab. 1). Values lower than 10 in phenanthrene/ anthracene (Phe/Ant) ratio but higher than 1 in fluoranthene/pyrene (Fla/Pyr) indicate pyrogenic origin. As the same way, values higher than 15 in Phe/Ant ratio but lower than 1 in Fla/Pyr ratio indicate petrogenic origin . Our finding that PAH contamination near Tabarca island had a possible pyrolitic origin indicates that the high PAH concentrations observed in this area are originating from inland sources.



Fig. 1. Map of the study areas with sampling stations. Circles represent range of total PAH concentrations measured (microg/kg w.w.).

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# PRESENCE OF POLYCHLOROBIPHENYL CONGENERS IN THE TISSUES OF GOLDEN GREY MULLETS FROM THE MEDITERRANEAN SEA

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# Abstract

Concentrations of polychlorinated biphenyls were determinated in the muscle tissues of mullets (*Liza aurata*) caught from two coastal marine areas in Tunis bay: Raoued and Radès. Residue levels of total PCBs ranged from 45 to 194 ng/g wet wt in the mullet from Radès and between 43 and 65 ng/g wet wt in specimens from Raoued. Hexachlorobiphenyls were predominant in fishes caught from both Raoued and Radès.

Keywords : Bio-accumulation, Pcb, Pollution.

Tunis Bay, located on the Mediterranean sea of northern Tunisia, is submitted to the impact of many chemical and physical stressors related to the human activities. Wastes resulting from these activities are dumped into the sea via two channels: Meliane wadi flowing to Radès beach and Khelij channel flowing into Raoued. Coastal fishing activity has been very developped in these areas. Among the exploited fishes, the golden grey mullet (*Liza aurata*), euryhaline fish inhabiting especially rivers mouths and lagoons, is known to concentrate pollutants [1]. To our knowledge, no data have been already mentionned about the contamination of marine organisms by organochlorine compounds from Tunis bay. For this fact, our purpose in the present work is to assess the chemical quality of the golden grey mullet from Raoued and Radès by revealing the possible presence of PCBs residues in the fish flesh.

Tab. 1. Minimum, Maximum and Mean concentration (ng/g w wt) of individual PCB congeners in the mullet muscle from Raoued and Radès. (\*: Coplanar congeners)

| Congeners | Raoued         | Radès           |
|-----------|----------------|-----------------|
| PCB 77*   | (4.1-5.4) 4.5  | (0.9-1.1) 1     |
| PCB 99    | (0.1-1.1) 0.5  | (0.2-0.4) 0.3   |
| PCB 100   | (0.6-2.1) 1.2  | (1.8-7.1) 3.8   |
| PCB 101   | (0.5-1) 0.8    | (0.9-6.8) 3.2   |
| PCB 110   | (0.4-1.8) 1.3  | (ND-2.1) 1      |
| PCB 118*  | (2.3-2.5) 2.4  | (2.1-4.9) 3.2   |
| PCB 138   | (3.9-4.3) 4.1  | (2.7-14.6) 6.8  |
| PCB 141   | (ND-0.4) 0.2   | (0.1-1.7) 0.6   |
| PCB 149   | (5.7-6.9) 6.2  | (5-26.2) 12.4   |
| PCB 153   | (ND-20.4) 11.6 | (8.1-36.2) 18.8 |
| PCB 156*  | (0.1-0.7) 0.4  | (ND-0.4) 0.2    |
| PCB 169*  | (0.1-0.5) 0.3  | (0.2-0.3) 0.2   |
| PCB 170   | (1.1-3.1) 2.1  | (0.6-9.9) 3.9   |
| PCB 176   | (ND-4.9) 2.7   | (ND-3.6) 2.4    |
| PCB 187   | (2.6-3.1) 2.8  | (2.1-10.9) 6    |
| PCB 194   | (ND-4.9) 2.7   | (0.1-0.6) 0.4   |
| PCB 198   | (0.2-0.6) 0.4  | (ND-0.5) 0.2    |
| PCB 200   | (ND-11.7) 7.7  | (6.8-64.3) 26.4 |
| PCB 203   | (0.9-2.9) 1.9  | (1.6-7.8) 3.8   |
| PCB 206   | (0.1-2.3) 1    | (1.4-2.5) 1.9   |
| ∑ PCBs    | (43-65) 52     | (45-194) 96     |

Specimens of the golden grey mullet (length:  $6.4 \pm 0.7$  cm; weight:  $3.7\pm1.2$  g) were sampled using a net in Raoued and Radès, during March 2004. Fishes are immediately sacrificed and kept frozen until analyses. The PCBs analysis was conducted in composite samples of fish muscles according to a standard procedure [2].

Twenty PCB congeners are omnipresent in all fish samples of both sites. Residue levels of total PCBs were ranged from 45 to 194 ng/g wet wt with a median of 96 ng/g wet wt in the mullet from Radès. The concentrations of PCB residues in fishes from Raoued site were between 43 and 65 ng/g wet wt with a median of 52 ng/g wet wt (Table 1). Polychlorinated congeners profiles according to the chlorination degree revealed that hexachlorobiphenyl were predominant in fishes caught from both Raoued and Radès areas accounting for 43 and 40 % respectively. This kind of distribution of PCB congeners was also registred in other studies in fishes from the Mediterranean sea [3,4]. We are also interested in the coplanar PCBs also called dioxin-like PCBs which are considered as the most toxic of all 209 congeners. In fishes from Raoued, coplanar PCBs represent a fraction of 14 % of the total PCBs, while in mullet from Radès, these congeners made up a lower fraction of the total PCBs (5 %). In Raoued samples, PCB 77 accounted for the most of PCB coplanar content with a percentage of 60.3 %, followed by PCB 118 (31.6%), PCB156 (4.8%) and PCB 169 (3.3%). In Radès fishes, PCB 118 contributed with the higher percentage (68.9%) followed by PCB 77 (22.2 %), PCB 156 (4.5 %) and PCB 169 (4.3%).

In conclusion, we dispose here the first data about polychlorinated biphenyl contamination of the grey golden mullet from Tunis bay. PCB profiles showed a similarity between the two investigated sites. On the other hand, it's important to set limits for PCBs in fishes in order to estimate better the risk to human health.

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# ASSESSING METAL BIOMAGNIFICATION AND UPTAKE PATHWAYS IN MEDITERRANEAN FISH

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## Abstract

Metal biomagnification in marine food chains is an important yet contentious issue, and one that has significant regulatory and public health consequences. Nevertheless, few estimates of metal assimilation and retention are available for upper trophic level organisms. Using radiotracers in a laboratory study we measured the trophic transfer of 8 metals (Am, Cd, Co, Cr, Cs, Mn, Se, Zn) and assessed the relative importance of exposure route in metal accumulation in 3 representative species of carnivorous fish that are commonly harvested for human consumption in the Mediterranean. Results indicate that: (1) inter-metal differences in fish assimilation far exceed interspecies differences; (2) the relative potential for biomagnification of metals decreases such that: Cs >Se >Zn >Mn >Cd >Co >Am; (3) for all metals except Am and Cs, dietary exposure accounts for >90% of tissue metal concentrations in marine fish. *Keywords : Fishes, Biokinetics, Bio-accumulation, Metals*.

Fish are known to accumulate trace metals, sometimes to levels that are toxic to themselves or human consumers. Numerous studies of metal concentrations in fish have found great variability, both intra- and interspecifically, but mechanistic studies have been largely lacking, and consequently the processes governing such variability remain largely unknown [1]. Mercury is the only metal recognized to biomagnify in top level predators, but recent evidence indicates the potential of other metals to biomagnify in some food chains [2]. The kinetic parameters determining biomagnification are not fully quantified at upper trophic levels despite the fact that biomagnification has important regulatory and public health concerns. In general there are relatively few studies that provide quantitative measurements of the kinetics of metal uptake and depuration or that delineate the relative importance of diet or the aqueous phase as sources in marine fish. In addition, while early studies considered metal uptake from solution and indeed many environmental regulatory agencies still consider only aqueous exposure in risk assessment and wildlife protection, there is increasing recognition of the importance of metal accumulation from dietary exposure in marine food webs [1, 3].

In order to assess the importance of dietary metal uptake in marine fish and the extent to which it may vary between fish, we measured metal uptake from dietary exposure in three fish species (two teleosts and one elasmobranch) with different phylogenies and life histories. Included in the study were the spotted dogfish, *Scyliorhinus canicula*, the turbot, *Psetta maxima*, and the sea bream, *Sparus auratus*, three species that are abundant in the Mediterranean and that comprise important and valuable commercial fisheries.

Biokinetic models can provide a quantitative description of the processes governing metal bioaccumulation in aquatic organisms. Under steady state conditions, metal accumulation in organisms from both dietary and aqueous exposure can be calculated from the following equation:

 $C_{ss} = [(k_u \ge C_w)/(k_{ew} + g)] + [(AE \ge IR \ge C_f)/(k_{ef} + g)]$ 

where  $C_{ss}$  is the metal concentration in fish at steady state,  $k_u$  is the dissolved uptake rate constant,  $C_w$  is the dissolved metal concentration, AE is the assimilation efficiency from food, IR is the ingestion rate,  $C_f$  is the metal concentration in food,  $k_{ew}$ ,  $k_{ef}$  is the efflux rate constant from water and food respectively, and g is the growth rate constant [4]. The trophic transfer factor (TTF) of a metal through the food chain is then: TTF =  $C_n / C_{n-1} = (AE \times IR) / (k_e + g)$ , where  $C_n$  is the concentration of metal in an organism at trophic level n and  $C_{n-1}$  is the concentration of metal in an organism from the trophic level below. A value of TTF >1 indicates the possibility of biomagnification of the metal in question; a TTF <1 indicates biodiminution [5]. Currently, TTFs remain largely unknown in marine food chains [2].

Pulse-chase radiotracer methods are commonly used to quantify the parameters used in biokinetic models. The use of gamma-emitting radioiso-topes enables the simultaneous measurement of multiple elements at environmentally realistic concentrations via non-destructive sampling of live organisms. In our study, we labeled prey fish (juvenile *Sparus auratus*) via the aqueous phase with <sup>241</sup>Am, <sup>109</sup>Cd, <sup>60</sup>Co, <sup>51</sup>Cr, <sup>134</sup>Cs, <sup>54</sup>Mn,

<sup>75</sup>Se and <sup>65</sup>Zn. 12 individuals each of *Sparus auratus* and *Psetta maxima* and 6 individuals of *Scyliorhinus canicula* were then fed with a pulse of radiolabeled food and radioactivity was measured in each fish over a 3-wk period to assess the uptake rate, assimilation efficiency, retention, and tissue distribution of these metals in the three fish species.

Here we compare the relative ranking of TTF of the 6 metals; values were averaged for the 3 fish species as no significant differences were evident

among the fish. We report relative TTF values for each metal (AE/k<sub>e</sub>). Of the metals examined the greatest potential for biomagnification was shown by Cs, Se, and Zn, with Am and Co showing the lowest potential (Table 1). We combined the kinetic parameters obtained from dietary exposure with those determined from aqueous exposure in the laboratory for the same fish species to determine the relative importance of exposure route of metals to fish. Our modeling indicates that, with the exception of Am and Cs, dietary exposure is the dominant exposure route, accounting for  $\geq$ 90% of total metal in fish (Table 1). Regulatory bodies that determine appropriate water quality criteria need to consider dietary exposures in protecting aquatic animals from toxic metal contamination.

Tab. 1. Relative potential for biomagnification, expressed as AE/k<sub>e</sub> (see text), and percent of metal from dietary exposure in carnivorous Mediterranean fish. Percent from diet was calculated using data from this study and from Jeffree et al. [6]. Values represent means + SD of values obtained for all fish species.

| Metal | AE/k,          | Percent from diet |
|-------|----------------|-------------------|
| Am    | 14 <u>+</u> 5  | 4 <u>+</u> 2      |
| Cd    | 27 <u>+</u> 6  | 99 <u>+</u> 0.2   |
| Co    | 23 <u>+</u> 10 | 93 <u>+</u> 9     |
| Cs    | 56 <u>+</u> 30 | 35 <u>+</u> 26    |
| Mn    | 30 <u>+</u> 6  | 96 <u>+</u> 5     |
| Zn    | 34 <u>±</u> 17 | 99 <u>+</u> 0.1   |
|       |                |                   |

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# METAL CONCENTRATIONS IN MEDITERRANEAN FISH TISSUES: EXPLORING BIOMAGNIFICATION PATTERNS

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### Abstract

Metal bioaccumulation is highly variable at the upper trophic levels in marine food webs [1], and the dynamics and processes controlling metal uptake and retention remain poorly understood [2]. To explore the behavior of metals in a Mediterranean food web, we collected samples of hake (*Merluccius merluccius*) tissue from different sites (riverine- dominated, marine) in the Gulf of Lions as well as samples of its common prey for metal analysis via ICP-MS. Metal measurements are combined with stable isotope ratios of carbon and nitrogen in an attempt to assess the relative impact of food web pathway in determining metal bioaccumulation. Analyses to date of metal concentrations in hake of different size classes and in two species of its prey indicate that 10 metals (Ag, Cd, Co, Cr, Cu, Mn, Ni, Pb, Sn, Zn) do not display evidence of biomangification but the two metalloids examined, As and Se, do appear to biomagnify. Of these elements, only Se and As speciate predominantly in anionic form in seawater and show negligible uptake by fish from the aqueous phase in laboratory bioaccumulation experiments.

Keywords : Fishes, Food Webs, Metals, Bio-accumulation.

Metal bioaccumulation is of great interest to environmental managers, toxicologists, and public health experts, since risk analyses have shown that the consumption of seafood is a major route in human exposure to environmental contaminants. The biomagnification of metals in marine food chains remains largely understudied. There is increasing recognition of the importance of dietary exposure as a source of metals for marine animals [1], but studies linking trophic level with contaminant level are rare in marine systems.

In ecological studies, the fractionation of the stable isotopes of nitrogen ( $\delta^{15}$ N) and carbon( $\delta^{13}$ C) provide powerful tools to elucidate trophic transfer processes. <sup>15</sup>N enrichment allows for the assessment of relative trophic position of an organism within a given system, while  $\delta^{13}$ C is a good tracer of carbon source [3]. Thus,  $\delta^{15}$ N and  $\delta^{13}$ C can provide an integrated (and therefore more realistic) measure of trophic position which represents the energy-weighted mean path length leading to a consumer, and they have the potential to capture complex trophic interactions (e.g., omnivory) [4], [5]. Several studies have used stable isotopes to investigate contaminants and primarily in freshwater ecosystems, but for metals only Hg has been investigated in this way extensively.

Our laboratory studies have shown that while there are great differences among metals in terms of metal assimilation and retention in marine fish, the differences between fish species are relatively small for the same metal. For this reason, our field study focused on the trophic dynamics and metal transfer in a common species representative of the Mediterranean, the Mediterranean hake (*Merluccius merluccius*). The hake ranks among the most important commercial fishes of the world and is the most heavily fished species in the Gulf of Lions [6]. The major factors affecting interannual recruitment and population variability of this key species, including details about its life cycle, food web, and exposure to contaminants are currently under study as part of the integrative MEDECIS (chemical contamination in the Mediterranean) program.

Under this comprehensive sampling campaign, trawling cruises were conducted in November 2005 at four sites distinguished by their differing riverine inputs in order to sample across gradients of contaminant concentration and to include different size structures in fish populations. Samples of hake from different size classes were taken from each site, as well as samples of the prey species for each size class of hake. Samples from the same individual fish were taken for analysis of metal concentration as well as for stable isotope ratios of carbon and nitrogen. Precautions were taken to dissect and store samples as cleanly as possible. Samples were transported frozen on dry ice and kept frozen until analysis. Sample manipulations were done using trace metal clean techniques and digestion followed established protocols for trace metal analysis via ICP-MS.

Metal concentrations in tissues ranged from the very low  $\mu g kg^{-1}$  range for Ag and Cd to the mid mg kg<sup>-1</sup> range for Zn in hake liver. Without exception, metal concentrations in liver tissue were higher than in muscle tissue of the same fish, sometimes by about an order of magnitude (e.g., Ag, Cu). Also, for all metals except Se and As, metal concentration in smaller or prey fish was generally higher than for larger fish. Generally, the tissue metal concentration data are consistent with experimental results in laboratory studies examining patterns of metal bioaccumulation in marine animals. Thus, laboratory bioaccumulation studies indicate that Zn is typically regulated to within a fairly narrow range in animal tissue, similar to these first field measurements. Further the experimental uptake rates of the two metalloids being considered, Se and As, are negligible in marine animals following aqueous exposure; these elements only accumulate through dietary pathways, and they are the only elements that display evidence of biomagnification in field samples. In this way, these elements behave similarly to methyl mercury, which also accumulates in fish almost exclusively from diet.

Currently, patterns of metal concentrations in food web tissue samples are being compared to those of stable isotopes (C, N) to determine the relative importance of food web pathways in metal bioaccumulation in upper level carnivores in the Mediterranean.

Tab. 1. Mean metal concentrations ( $\mu g kg^{-1}$ ) in the muscle and liver tissue of large hake (*Merluccius merluccius*), length >25 cm; the muscle tissue of small hake, length 15-19 cm; the muscle tissue of squid (*Alloteuthis* sp.); and the muscle tissue of mackerel (*Trachurus trachurus*), length 15-19 cm.

| Tissue type           | Pb  | Ag | Co | Ni   | Cu   | Zn    | Mn   | Cr   | Sn   | Cd | Se    | As    |
|-----------------------|-----|----|----|------|------|-------|------|------|------|----|-------|-------|
| large hake muscle     | 55  | 1  | 4  | 50   | 412  | 5939  | 256  | 45   | 1525 | 3  | 5059  | 4831  |
| large hake liver      | 239 | 9  | 12 | 285  | 5720 | 24701 | 1181 | 173  | 8157 | 7  | 15443 | 10563 |
| small hake muscle     | 154 | 2  | 9  | 1007 | 227  | 5231  | 383  | 1969 | 2227 | 3  | 900   | 3439  |
| squid                 | 73  | 7  | 6  | 387  | 2193 | 10763 | 265  | 733  | 1500 | 6  | 628   | 11812 |
| small mackerel muscle | 131 | 1  | 9  | 64   | 510  | 6346  | 147  | 48   | 5009 | 3  | 12485 | 5666  |

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# PHOSPHORUS SPECIES CONCENTRATIONS IN THE MIDDLE ADRIATIC COASTAL SEDIMENT

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### Abstract

This paper presents results of investigations of phosphorus species in surface sediment at the central Croatian coast, using modified SEDEX method. Investigated phosphorus species were: P in biogenic apatite (fish-debris P), P in authigenic apatite, P in detritial apatite, P adsorbed on to iron oxyhydroxides and organic P. The predominant inorganic P species in the middle Adriatic is P-Fe form. Seasonal variations of P species and correlations with other parameters (sediment Fe(III)OOH concentration, redox potential, pore water and water column orthophosphate concentration) indicate the importance of P-Fe form in orthophosphate flux. *Keywords : Adriatic Sea, Phosphorus, Sediments.* 

#### Material and Methods

Middle Adriatic stations located in Croatian eutrophicated bay (S1), channel (S2) and open sea (S3) were investigated monthly during 2001/2002. Sediment samples were taken with gravity corer (duplicate cores for P analysis, one for redox potential measurement and orthophosphate concentration in pore water). Phosphorus concentrations in surface sediment layer (0-2 cm) were measured according to modified SEDEX methods [1, 2, 3]. Determined phosphorus species were: phosphorus in biogenic apatite or "fish debris"P-FD, authigenic apatite phosphorus P-AUT, detrital apatite phosphorus P-DET, phosphorus adsorbed on iron-oxyhidroxides P-FE, and organic phosphorus P-ORG. Analysis of ortophosphate concentrations in extractant solutions of particular P species were determined colorimetrically on AutoAnalyzer-3. [4].

#### Results and Discussion

Total sediment P concentrations in central Croatian coastal sediments were in range of 7.9-38.9  $\mu$ mol g<sup>-1</sup> (d.w.) with average values of 22.0 $\pm$ 3.3, 15.4 $\pm$ 3.0 and 13.5 $\pm$ 3.7  $\mu$ mol g<sup>-1</sup>for eutrophicated bay, channel and open sea stations, respectively. Portion of organic and inorganic P species greatly depended on granulometric composition, carbonate content, and trophic level of the water column. Average portion of inorganic P species in total P was 65% at S1, 59% at S2 and 81% at S3 station, with P-Fe as the most predominant inorganic P species at all stations (27-40%) (Figure 1). For S3 station statistical significant correlation between P-Fe and orthophosphate concentration gradients at the sediment water interface (R=0.818, n=12, p<0.01) was found which indicated to a linkage of P-Fe species with ortophosphate flux between water column and sediment. Investigations of vertical distribution of P-Fe concentration have also showed linkage P-Fe with Fe(III)OOH concentration and sediment redox potential as a result of consequent desorption processes in sediment.



Fig. 1. Average phosphorus species concentrations (biogenic apatite FD-P, authigenic apatite P-AUT, detritial apatite P-DET,adsorbed onto iron oxyhydroxides P-Fe and organic P-ORG) in sediment at S1, S2, and S3 station during 2001/2002.

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# BIO-FUNCTIONAL DIVERSITY OF *CYMODOCEA NODOSA* AS BIOINDICATOR FOR ENVIRONMENTAL QUALITY IN THE LAKES OF CIRCEO NATIONAL PARK (ITALY)

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## Abstract

In this research we evaluated the bio-functional diversity of *Cymodocea nodosa* populations by RAPD technique in two of the lakes of Circeo National Park (Caprolace and Fogliano). The ecological structure of the meadows was followed during the year 2004: physicochemical parameters were measured in conjunction with seagrass phenological parameters A high degree of genotypic homogeneity of the seagrass, confirmed by statistical analysis (NT-SYS Cluster), was observed in association to a high vegetative continued growth via rhizome extention. In this investigation we confirm that a high nutrient concentration, in water and sediment, determines a high density and biomass values of meadow. Other environmental factors, such as temperature, salinity and light, are important in controlling seasonal biomass and abundance of *C. nodosa* in these lakes. Finally different modes of reproduction, such as continued growth, via rhizome extension, into new locations and sexual offspring (seedling) recruitment, may contribute to low differentiation in the seagrass *C. nodosa* that can be considered as biological indicators for environmental quality in lagoon ecosystems. *Keywords : Bio-indicators, Biodiversity, Phytobenthos, Lagoons.* 

#### Experimental

Cyanobacteria were grown in axenic laboratory conditions (tab.1) and subsequently DNA extraction was carried out (MagnaRack, Invitrogen SpA, Italy). Biodiversity was detected by PCR (Polymerase Chain Reaction) technique using RAPD markers (Random Amplified Polymorphic DNA). PCR was applied: 2 min 94 °C, 40 cycles of 30 s at 37 °C (annealing), 2 min at 72 °C (synthesis). The amplification products were separated by gel electrophoresis (agarose 1.4%) after ethidium bromide staining. Eight primers were used: BY11 (5'-ATCCACTGCA-3'); BY12 (5'-GGTCGCAGGC-3'); BY15 (5'-CTCACCGTCC-3'); DN4 (5'-GTCGTGCTAT-3'); DN5 (5'-CCGACGGCAA,-3'); DN6 (5'-TGGACCGGTG-3'); UB24 (5'-GGGTGAACCG-3'); UB28 (5'-GCTGGGCCGA-3'). UPGMA Cluster analysis (similarity index) was carried out by NT-SYS software [1].

To analyse fatty acid, the samples were methilated and detected by gas chromatography using C19:0 as internal standard [2, 3].

#### Discussion of results

UPGMA phenogram (fig.1) revealed the pattern of genetic distance, showing two different groups comprising the order of *Nostocales* and *Oscillatoriales*. This analysis confirms the endemism of *Nostoc* genus in the Antarctic and Mediterranean regions, revealing its phylogenetic distribution in relation to geographical position. Data relating to the matrix of similarity [1] revealed an average similarity of 15,37 % between the six populations of cyanobacteria analized; the average value of similarity of 27,04 % appears for *Nostoc* Mediterranean and two *Nostoc* Antarctic. Matrix correlation (r) obtained by Mantel test gave a value of 0.95, revealing a good statistical result. Genomic fingerprinting, revealed by PCR technique, gave several molecular fragments of varying sizes, ranging from 0.1 to 8.0 Kb.

Tab. 1. Morphology of *C. nodosa* plants from the four study sites during the spring season

| Stations | shoot n°<br>(each plant) | leaf n°<br>(each shoot) | leaf length mean<br>(cm) | leaf width<br>(cm) |
|----------|--------------------------|-------------------------|--------------------------|--------------------|
| ST. 1    | $2,2 \pm 0,84$           | $5,27 \pm 0,90$         | $25,8 \pm 13,47$         | 2-5                |
| ST. 2    | $3,2 \pm 2,17$           | $4,6 \pm 1,5$           | $19,9 \pm 11,5$          | 2-5                |
| ST. 5    | $1,8 \pm 1,3$            | $4,1 \pm 0,93$          | $31,2 \pm 10,9$          | 2-5                |
| ST. 8    | $1,8 \pm 0,84$           | $3,67 \pm 0,5$          | $24,58 \pm 10,94$        | 2-5                |

The distribution of molecular fragments for each species analysed indicates that the majority of the molecular fragments are in the range of 251-1000 Kb, especially in the *Nostoc* genus. The genetic variability we encountered was correlated to the fatty acid production of the different strains. The physiological features of the strains showed a high degree of specificity regarding their content of fatty acids. We observed that the largest percentage of fatty acid produced by all the strains was the 16:0 (palmitic) and 18: 2 n6 c (linoleic); whilst the 17:0 ante (IUPAC) was produced in large amounts by the *Leptolyngbya* instead of *Nostoc*. The 18:3 n3 (linolenic) showed an opposite trend with the highest percentage of production by Antarctic *Nostoc* rather than *Leptolyngbya* genera. *Plectonema* showed an intermediate concentration in percentage of production regarding this fatty acid. This analysis revealed that the amount of some fatty acids is sometimes correlated to the genus, as seen in linoleic and alpha-linolenic acids that were abundant in *Nostoc* species. The RAPD-PCR amplification revealed that *Nostoc* genera produced the greatest number and weight of molecular fragments. Molecular analysis together with morphological and physiological study, is confirmed to be a valid tool in determining a first screening of the different cyanobacteria, evidencing an ample range of molecular weight between 0.1 to 8.0 Kb. These results evidence the high capacity of cyanobacteria to adapt physiologically to different environments, producing secondary biologically active molecules which are useful for human health as well as for environmental monitoring in an evolutionary scheme.



Fig. 1. UPGMA phenogram of RAPD genetic distance of *C. nodosa* populations at. Caprolace (St1= r1, r2, r3; St2= r4, r5, r6; St5= r7, r8, r9) and Fogliano (St8= r10, r11, r12)

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# CHLORINATED HYDROCARBONS IN MUSSELS AND SEDIMENTS FROM THE MIDDLE ADRIATIC COASTAL WATERS

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# Abstract

Mussels and sediments from the Middle Adriatic coastal waters were analysed in order to assess the present level of contamination by chlorinated hydrocarbons. The concentrations of PCBs and DDTs were generally higher in mussels than in sediments at all locations. Moreover, higher PCBs concentration, both in mussels and sediments, reflected the prevailing influence of industrial sources of contamination over agricultural ones. In conclusion, the obtained data indicated a low level of contamination of the Middle Adriatic coastal area.

Keywords : Chlorinated Hydrocarbons, Mollusca, Sediments, Adriatic Sea.

### Introduction

Chlorinated hydrocarbons are one of the most widespread, persistent and dangerous pollutants of the marine ecosystem [1]. Coastal zones and estuaries, particularly areas near urban and industrial centres are exposed to the largest concentrations of these contaminants. Due to hydrophobic nature and very low water solubility, chlorinated hydrocarbons tend to accumulate in suspended materials and sediments, and in fatty tissues of marine organisms.

#### Materials and methods

Mussels (Mytilus galloprovincialis) and surface sediments (0-2 cm) were collected from 5 stations, with different hydrographical and environmental conditions, at the Middle Adriatic coastal area (Fig. 1). PCB congeners (28, 52, 101, 118, 138, 153) and DDTs compounds (p,p'-DDE, p,p'-DDD, p,p'-DDT) were determined according to UNEP [2]. Procedural blanks, calibration and internal standards, and referent IAEA marine materials were run routinely during the analytical programme.



Fig. 1. Investigated area with sampling stations.

#### Results and discussion

PCBs and DDTs values were higher in mussels than in sediments at all stations. Average PCBs concentration was 27.3 ng/g dry wt (mussels) and 17.3 ng/g dry wt (sediments), with the highest values observed at the Kastela Bay (Fig. 2). This Bay, a relatively densely populated area with significant industrial and maritime transport activities, is a recipient of untreated/or partially treated urban and industrial wastewaters. The lowest PCBs value was observed at the Neretva mouth (station 5), showing no significant riverine and urban inputs of these contaminants. In all samples, PCB congener's profile dominated by PCB 138 and 153, reflecting their highest persistence among the PCB congeners [3].



Fig. 2. Distribution of PCBs and DDTs concentrations in mussels (M) and sediments (S) along the Middle Adriatic coastal area.

DDTs values were lower than PCBs ones, indicating the predominance of industrial sources over agricultural ones at the entire study area. Average DDT concentration was 5.9 ng/g dry wt (mussels) and 2.6 ng/g dry wt (sediments), with prevalent DDE portion, suggesting the lack of recent inputs of DDT. Kastela Bay (station 4) and the station 5 presented again the most and the least contaminated station, respectively. The comparison of PCBs and DDTs values with those published for similar locations in the Mediterranean Sea indicated a low level of contamination of the studied area [4]. Moreover, the obtained results showed that the accumulation of PCBs and DDTs depends not only on local pollution sources, but also on environmental characteristics as well as on biological factors of the organism and/or geochemical characteristics of the sediment.

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# FLUORESCENCE CHARACTERIZATION OF THE EXTRACELLULAR ORGANIC MATTER (EOM) RELEASED BY THE MARINE DIATOM CHAETOCEROS SP.

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## Abstract

Fluorescence spectroscopy was used to characterize the extracellular organic matter (EOM) released by laboratory cultures of the marine diatom *Chaetoceros*. The accumulation trend of the mixture of chromatophoric compounds into the extracellular medium, as measured on stationary growing cultures, provided a natural system of sample pre-concentration, which revealed just effective for a complete EOM characterization by fluorescence analysis over a wide wavelength range.

Keywords : Organic Matter, Phytoplankton, Mucus Aggregates.

The extracellular organic matter (EOM) produced by phytoplankton represents a significant contribution to the marine DOM on a global scale. Field-based investigations using fluorescence properties of DOM to distinguish water masses from various sources are generally suggesting the UV band (protein-type fluorescence) as a potential tracer of the organic material freshly transferred from phytoplankton to the DOM pool. By contrast, the humic-type fluorescence is typically used as a tracer of riverine inputs of terrestrial humic substances in estuarine and coastal zones [1-3]. Nevertheless, a number of laboratory investigations on different algal species provided experimental evidence that both the protein and humic-type DOM components are released simultaneously by algae, the humic-type fluorescence having species-specific spectral features [4-6].

Since the low concentration, as well as the complexity of the mixture, makes difficult the analysis of EOM in ambient water, the biological procedure based on the monitoring of the extracellular medium from laboratory algal cultures was adopted in this work. The aim was to combine fluorescence analysis with biological assays to provide a complete and distinctive characterization of *Chaetoceros* EOM.

The marine diatom *Chaetoceros sp.*, isolated from North Adriatic coastal waters, was aseptically cultured in laboratory. Controlled conditions supporting a long-lasting stationary growth phase of living cells were provided to favor the natural accumulation of the released EOM compounds [5]. After an incubation time of 7 months, a set of filtered EOM-samples from differently aged cultures was simultaneously sampled and immediately analyzed by synchronous fluorescence spectroscopy in a wavelength range of 250-500 nm using a DI =25 nm [5,6].



Fig. 1. Synchronous spectra of EOM accumulated during 7 months

As shown in Fig.1, both the fluorescing components are present in each of the 6 spectra of the EOM released by *Chaetoceros*. The two, UV and visible excitation-maxima A and B, were recorded at 280 and 340 nm, respectively. As shown in Fig. 2, their fluorescence intensity follows a different evolution trend over time.

The protein-type peak A, which is typically produced by algae only in exponential growth [5,6], maintains an intensity of about 2 FU all over the sampling period. By contrast, the humic-type peak B, which is also present ever since the first sample, increases progressively with ageing of cultures, becoming the main EOM component in the most aged samples. The accumulation trend of the humic-type EOM into the extracellular medium was just working as a sample-preconcentration system, effective

for a spectral fingerprint of the mixture of chromatophoric compounds.



Fig. 2. Trends of the fluorescence-intensity maxima A and B

When spectra of Fig.1 are compared with previously analyzed EOM from different algal species [5,6], the humic-type peak position (B,C,D) as well as the maximum location (B) in the range 300 to 450 nm, contrary to the aspecific UV-peak A, are clearly distinctive of the *Chaetoceros* EOM. The results suggest that the complete spectral fingerprint of EOM released by phytoplankton could greatly help field-based studies on DOM sources in marine environments.

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# THORIUM-234 WATER COLUMN PROFILES AND DOWNWARD CARBON FLUX ACROSS A FRONTAL ZONE IN THE LIGURIAN SEA

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## Abstract

Thorium-234 has been intensively used in the past decade as a proxy for carbon export assessment but, <sup>234</sup>Th-based POC fluxes do not always agree with those directly measured using sediment traps. The present work reports on <sup>234</sup>Th vertical distribution at several stations across a frontal structure in the Ligurian Sea and suggests that hydrodynamic factors could be responsible for the observed discrepancy between radioisotope- and trap-derived particle flux estimates.

Keywords : Particle Flux, Radionuclides, Ligurian Sea, Carbon.

Over the past 4 years, the multidisciplinary MedFlux program has been studying the spatial and temporal variability of carbon fluxes associated with ballast minerals across the "Twilight Zone", a still poorly characterized region extending over a depth range from 100 to 1000 m. Experiments have taken place at the French JGOFS DYFAMED site (NW Mediterranean) where multitracer measurements have been carried out in order to better understand interactions between particle composition, settling velocities, and downward transport of particulate material [see http://www.msrc.sunysb.edu/MedFlux/]. Carbon export from upper waters has been assessed using moored sediment traps [1] and natural radionuclides (234 Th: 238 U; 210 Po: 210 Pb) disequilibria in the water column [2]. Direct measurement of flux and radionuclide-based estimations have agreed in most cases but in late spring-early summer 2003 the two approaches showed some disagreement, which could be associated with an uncommon intrusion of a distinct coastal water mass at the DYFAMED site. In order to evaluate this possible effect, we sampled the water column in May 2006 at four stations between the coast and the central zone of the Ligurian Sea where the DYFAMED station is located (43° 25 N; 7° 52 E).

The main hydrological feature of the Ligurian Sea is a cyclonic eddy which is formed along the northern shore by the Northern Current, a geostrophic current flowing westward generally between 15 - 35 km from the shoreline [3]. This current separates a zone in the centre of the basin from a coastal, peripheral zone. The frontal zone associated with the current is marked by the presence of a density gradient in the sub-surface layer. It is also associated with a secondary circulation system which enhances biological production through a nutrient enrichment of the surface waters [4]. In the present study, the frontal zone was located using the ship's thermosalinograph recordings across a transect from the coastal to the central zone. The recording showed rather complex structures including a relatively warm water mass (and associated low density) at around 14 km from the coast and a fairly weak density gradient starting at about 33 km. We selected the most pronounced section of the gradient at 35 km as being the frontal site. The sites at 46 km and 17 km were retained to represent the central and the peripheral zone, respectively.

The downward flux of mass and carbon have been previously assessed in the frontal zone, as well as in open waters closer to the shore and in the central part of the Ligurian Sea [5]. Reported values indicate that vertical fluxes at 200 m depth are 4 to 6 times higher in the more productive frontal zone as compared to both adjacent zones. Mean values were 832 mg  $m^{-2}d^{-1}$  and 48 mg POC  $m^{-2}d^{-1}$  for mass and carbon flux at the frontal zone, respectively, compared to 119-151 mg  $m^{-2}d^{-1}$  and 10-13 mg POC  $m^{-2}d^{-1}$  measured north and south of the front.

Thorium samples were collected using a CTD-Rosette at the following stations: peripheral, frontal, central and DYFAMED located at 17, 35, 46 and 52 km from the shore, respectively. At each station, samples were collected at 11 or 12 depths in the 0-300 m water column and <sup>234</sup>Th was measured in 2 or 4 litres of seawater according to the single (IAEA-Monaco) or double (UAB-Barcelona) spike procedures described by Rodriguez y Baena *et al.* [6]. Uranium-238 activity concentration was derived from salinity after Chen *et al.* [7].

 $^{234}$ Th/ $^{238}$ U ratios in the upper 60 meters were significantly <1 at all stations. Below that depth,  $^{234}$ Th was in *quasi* equilibrium with  $^{238}$ U at the frontal and central stations, whereas it was in deficit with respect to its parent nuclide throughout the 0-300 m water column at the peripheral

station. Only at the frontal station were  $^{234}$ Th activities in excess with respect to  $^{238}$ U activities at several depths between 60 and 300m.

Preliminary results suggest that (1) the intrusion into the central part of the Ligurian Sea of isolated water bodies originating from north of the Northern (Ligurian) Current may modify the <sup>234</sup>Th signature in the water column and, thus, any carbon export estimation derived from the <sup>234</sup>Th:<sup>238</sup>U disequilibrium, and (2) in the frontal zone, <sup>234</sup>Th-derived calculations do not indicate higher carbon export than in adjacent regions, as previously measured by sediment traps. However, a higher spatial resolution study is needed in order to confirm the latter observation.

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# DISTRIBUTION ET SOURCES DES HYDROCARBURES DANS DES SÉDIMENTS DE SURFACE PRELEVÉS DU GOLFE DE TUNIS (TUNISIE)

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## Résumé

Ce travail a pour but l'évaluation des degrés de contamination et la détermination des différentes origines possibles des hydrocarbures dans des sédiments marins prélevés du golfe de Tunis. L'analyse a été réalisée par spectrofluorimétrie UV pour déterminer les hydrocarbures aromatiques totaux et par chromatographie en phase gazeuse couplée à un détecteur à ionisation de flamme pour déterminer les hydrocarbures aliphatiques et aromatiques polycycliques (HAP). Les résultats ont montré que les concentrations exprimées en poids secs en hydrocarbures aromatiques totaux (<à 9  $\mu g/g$ ), des hydrocarbures aromatiques polycycliques ou HAP (<à 2.6  $\mu g/g$ ) et aliphatiques (<à 3  $\mu g/g$ ) sont réparties surtout près des embouchures de Oued Mejerda et au Nord-Est du petit golfe de Tunis. Le rapport des deux isoprénoîdes pristane et phytane caractérisant la biodégradation des alcanes permet de distinguer deux sources d'hydrocarbures biogénique et/ou anthropique.

## Mots clès : Pah, Pollution, Sediments.

Le Golfe de Tunis est situé au Nord-Est de la Tunisie. Il possède la forme d'une baie largement ouverte vers le nord, sur la mer méditerranée où il occupe une surface totale de 1500 Km approximativement et admet une côte d'environ 160 Km de longueur. Une compagne d'échantillonnage a été réalisée en Août 2004, 16 stations de sédiments réparties sur toute la surface du golfe de Tunis ont été choisies. Les hydrocarbures représentent un groupe important de micropolluants organiques vu leur distribution dans l'environnement [1]. L'extraction et la purification des hydrocarbures ont été réalisées suivant la méthode de l'IAEA [2]. Les HAP et les hydrocarbures aliphatiques sont analysés par chromatographie en phase gazeuse et les hydrocarbures aromatiques totaux sont déterminés par spectrofluorimétrie UV par rapport au standard chrysène [3,4].

#### Résultats

Sur la figure 1 sont représentées les concentrations des hydrocarbures aromatiques totaux dans les différentes stations d'échantillonnage de sédiment. Elles sont comprises entre 0,8 et 9  $\mu g/g$  par poids secs et en équivalent chrysène. Le long d'une même radial les concentrations des hydrocarbures aromatiques totaux varient dans le même sens pour toutes les stations. Elles diminuent en allant de la côte vers le large du golfe de Tunis. Ceci s'explique par la répartition des sédiments dans le Golfe de Tunis qui est contrôlée par deux courants généraux le premier contourne les côtes ouest du golfe alors que le deuxième traverse le centre du golfe avec la direction NNW-SSE. Ce qui conditionne la présence d'une zone centrale caractérisée par un sédiment relativement plus sableux à faibles teneurs en HAP (<à  $2.6 \ \mu g/g$ ).



Fig. 1. Concentration des hydrocarbures aromatiques totaux ( $\mu$ g/g) dans les différentes stations de prélèvement de sédiment

Les hydrocarbures aliphatiques (figure 2) représente à peu près 2 % jusqu'à 88 % des hydrocarbures totaux (la moyenne est de 23 %). Les alcanes les plus dominants sont de n-C10 à n-C17 et de n-C21 à n-C34 avec quelques isoprénoïdes pristane et phytane. Ces deux derniers sont considérés comme des indicateurs de contamination pétrolière et/ou biogénique [5, 6]. Le rapport pristane sur phytane (Pr/Ph) calculé pour tous les échantillons vari de 0 à 8.5. Les stations situées dans le nord du petit golfe et au sud est du grand golfe ou le trafic maritime est important ont des rapports inférieurs à 1 et une grande quantité d'UCM indiquant une origine principalement pétrolière de ces hydrocarbures. La prédominance des alcanes lourds à nombre pair ou impair d'atome de carbone caractérise une origine bactérienne de ces hydrocarbures. La source principale de l'ensemble des hydrocarbures dans le golfe de Tunis est l'oued Mejerda. Ces concentrations sont considérées comme faibles et n'impliquent pas une contamination particulière dans le golfe de Tunis.



Fig. 2. Concentrations de la somme des hydrocarbures aliphatiques et des HAP (ng/g par poids sec) dans les différentes stations de prélèvement de sédiment

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## GROWTH IN LENGTH AND WEIGHT AND MERCURY CONTENT IN SMALL FATTENED BLUEFIN TUNA

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## Abstract

In areas where detailed information on wild young bluefin tuna growth is available, the growth performances of fattened specimens of the same age can be estimated. The present study described growth rates and mercury and cadmium content of 3 - 4 years old tuna, caged in the Tyrrhenian Sea.

## Keywords : Western Mediterranean, Aquaculture, Growth, Mercury.

Growth rates in length and weight undergo marked variation in bluefin tuna, due to the seasonality of environmental parameters and the peculiar migration and reproductive performances of this species. In the last ten years tuna farms have spread in the Mediterranean: bluefin is fattened in floating cages after the capture by purse seining. The fishing activity is addressed mainly to aggregations of spawners. Fattening practices introduce deviation in natural growth processes both increasing feeding and reducing muscular activity of fish; moreover they alter the natural redistribution of lipids which occurs during maturation of gonads; infact stressed fish cannot complete maturation. However, such growth variation has rarely been precisely measured in fattening farms, except by tagging of individuals [1]. This gap can be filled reading the age of the specimens and comparing them with wild tuna of the same age and seasonal period: such information is available for italian waters of the western Mediterranean [2].

Samples of young bluefin tuna, 111-134 cm fork length (FL) and 30.3-57.2 kg round weight (RW), were purchased from a fattening farm located in the Tyrrhenian Sea, 6 in November 2005 and 10 in April 2006. The following parameters were ascertained: age (by reading the basal section of the first dorsal spine [3]), FL (cm), RW (kg), condition index [4], sex, total mercury, organic mercury and cadmium concentrations in the white muscle, i.e. the largest edible part of fish (table 1).

Tab. 1. Biological parameters and mercury content of fattened tuna.

|                                |         | n       | condition          |      | tot Ho                 | ora Ha                 |
|--------------------------------|---------|---------|--------------------|------|------------------------|------------------------|
| harvesting date                | FL (cm) | RW (kg) | index              | age  | (µg/g d.wt.)           | (µg/g d.wt.)           |
| 11/11/2005                     | 111.00  | 30.28   | 2.21               | ~3.5 | 1.37                   | 0.88                   |
| 11/11/2005                     | 120.00  | 32.58   | 1.89               | ~3.5 | 1.93                   | 1.09                   |
| 11/11/2005                     | 121.00  | 36.41   | 2.06               | ~3.5 | 1.75                   | 1.07                   |
| Average value<br>at 3.5 years  | 117 33  | 33.09   | 2.05               |      | 1.68                   | 1.01                   |
| 6/04/2006                      | 118.00  | 36.40   | 2.00               | ~3.8 | 2.28                   | 2.15                   |
| 6/04/2006                      | 122.00  | 39.80   | 2.19               | ~3.8 | 1.00                   | 0.95                   |
| Average value<br>at 3.8 years  | 120.00  | 38.10   | 2.21               | -0.0 | 1.64                   | 1.55                   |
| 11/11/2005                     | 128.50  | 44.63   | 2.10               | ~4.5 | 1.65                   | 1.33                   |
| Average value<br>at 4.5 years  |         |         |                    | 4.0  |                        |                        |
| 6/04/2006                      | 130.50  | 47.20   | 2.12               | ~4.8 | 2.09                   | 1.94                   |
| 6/04/2006                      | 130.20  | 50.20   | 2.27               | ~4.8 | 1.02                   | 1                      |
| 6/04/2006                      | 134.00  | 57.20   | 2.38               | ~4.8 | 1.64                   | 1.68                   |
| Average value                  | 131 57  | 51 53   | 2.26               |      | 1.58                   | 1.54                   |
| at 4.0 years                   | 101.01  | FF      | MALES              |      | 1.00                   | 1.04                   |
| harvesting date                | FL      | RW (kg) | condition<br>index | age  | tot Hg<br>(µg/g d.wt.) | org Hg<br>(µg/g d.wt.) |
| 9/11/2005                      | 126.00  | 36.83   | 1.84               | ~4.5 | 2.97                   | 2.06                   |
| 9/11/2005                      | 119.00  | 36.90   | 2.19               | ~4.5 | 1.77                   | 1.04                   |
| Average values<br>at 4.5 years | 122.50  | 36.86   | 2.02               |      | 2.37                   | 1.55                   |
| 6/04/2006                      | 122.00  | 39.00   | 2.15               | ~4.8 | 1.44                   | 1.44                   |
| 6/04/2006                      | 127.00  | 39.20   | 1.91               | ~4.8 | 1.80                   | 1.8                    |
| 6/04/2006                      | 133.50  | 41.80   | 1.76               | ~4.8 | 1.12                   | 0.98                   |
| 6/04/2006                      | 130.00  | 44.60   | 2.03               | ~4.8 | 1.76                   | 0.88                   |
| 6/04/2006                      | 129.00  | 45.20   | 2.11               | ~4.8 | 1.99                   | 1.68                   |
| Average values<br>at 4.8 years | 128.30  | 41.96   | 1.99               |      | 1.62                   | 1.36                   |

Average values, calculated by keeping the specimens separated by sex and age, are shown in fig. 1, in form of discrete points. Growth performances of wild tuna of age 3 and 4 are shown in the same fig. 1. The growth curves were obtained by the following parameters:  $L\infty$ =160.61; K=0.296; t<sub>0</sub>=-0.571; WP=0.718; C=1, for the growth in cm FL, in the age range 0-5. For the growth in weight (kg) in the above mentioned seasonalized Von Bertalanffy function the length/weight relationship y=0.000026FL<sup>2.908450</sup>; R<sup>2</sup>=0.993 was introduced. Given that captures occur at the same time as reproduction, the starting of captive life as well as birth time were set at 1<sup>st</sup> June.

The growth rates of fattened tuna resulted:

Male aged 3: in the period June-November 3.03 cm/month; 0.092 cm/day; 2.87 kg/month.

in the period June-April 1.78 cm/month; 0.058 cm/day; 1.93 kg/month. Male aged 4: in the period June-November 2.27 cm/month; 0.069 cm/day; 3.42 kg/month. in the period June-April 1.44 cm/month; 0.047 cm/day; 2.40 kg/month. Female aged 4: in the period June- November 1.07 cm/month; 0.033 cm/day; 1.87 kg/month.

in the period June-April 1.12 cm/month; 0.036 cm/day; 1.44 kg/month. The growth in length resulted moderately higher than in wild fish in males, and almost unchanged in females. The growth in weight was considerable, especially in males: so the sexual dimorphism typical of big adult bluefin, with males larger than females, is apparently evident since the beginning of adult life; i.e. at 3 and 4 years. The comparison of growth rates calculated during approximately five or ten months respectively, gives evidence of seasonality of growth in fattened specimens.

Cadmium concentrations were always very low and frequently below the detection limit of the method. Mean total mercury concentration was 1.72  $\mu$ g/g d.wt. ranging from 1.00 to 2.97  $\mu$ g/g d.wt.

A significant (p<0.01) difference for the percentage of organic mercury exists between the specimens caught in November (mean Hg-org 65%) and in April (mean Hg-org 90%), even if in total and organic mercury concentrations no significant difference was observed.



Fig. 1. Seasonalized growth functions of wild tuna, in the age range 3-5 years, and sizes observed in small samples of fattened tuna of the same age (discrete points): a) growth in length - b) growth in weight.

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# RADIONUCLIDES AND RADIOTRACERS IN THE BLACK AND NORTH-EAST MEDITERRANEAN SEAS: THE INTERNATIONAL ATOMIC ENERGY AGENCY'S REGIONAL PROJECTS FOR COLLABORATIVE SCIENCE AND COORDINATED MONITORING

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## Abstract

This paper presents an overview of two regional technical co-operation projects coordinated by the International Atomic Energy Agency (IAEA): the recently concluded Black Sea project and the ongoing northeast Mediterranean project. Both projects focus on radionuclides in the marine environment, but aim more widely to assess marine pollution using nuclear analytical and tracer techniques. The projects complement other on-going regional programmes by addressing those gaps in regional capabilities, coordination, monitoring and scientific investigations which fall within the IAEA's mandate.

Keywords : Black Sea, Radionuclides, Monitoring.

The Black Sea project "Marine environmental assessment in the Black Sea region" involved nine main counterpart institutes and twelve collaborating institutes or laboratories from all six riparian countries (Bulgaria, Georgia, Romania, the Russian Federation, Turkey and Ukraine) and spanned from 1995 to 2001. A coordinated monitoring programme for anthropogenic and natural radionuclides in coastal seawater, beach sand, seaweed, molluscs and fish was implemented at 15 stations around the Black Sea. Basin-wide research was carried out on two international cruises (Fig. 1). The field and laboratory work was carried out according to harmonized methodologies and supported through proficiency tests and intercomaprison exercises. New data were obtained for levels and inventories of <sup>137</sup>Cs, <sup>90</sup>Sr and <sup>239,240</sup>Pu in water and sediment (e.g., [1]). Extensive investigations of <sup>210</sup>Po in molluscs and fish were carried out along the Ukrainian and Turkish coasts. Mass accumulation rates and sediment geochronologies for heavy metals, Hg and PCBs were determined using  $^{210}\mathrm{Pb}$  dating and radioactive markers such as  $^{137}\mathrm{Cs}$  and Pu isotopes. The buffering capacity of the River Koruh watershed was studies using the <sup>137</sup>Cs profiles in sediment deposited at the river mouth.



Fig. 1. Location of stations occupied during the IAEA Black Sea scientific cruises in1998 (full circles, italics) and year 2000 (open circles, bold).

The northeast Mediterranean project was initiated in 2005 with institutes from nine countries: Albania, Bosnia and Herzegovina, Croatia, Cyprus, Greece, Malta, Serbia and Montenegro (Montenegro as of 2006), Slovenia and Turkey. A coordinated monitoring programme was developed for an-thropogenic and natural radionuclides in seawater, sediment, beach sand and marine biota at 35 coastal stations. Sampling, sample preparation, an-alytical methodologies, quality management and data reporting are being harmonized. Pilot testing of the programme was initiated in 2006. Cruises are planned to the Adriatic, Marmara and North-Aegean Seas in 2007-2008 aiming to investigate sediment and water profiles and inventories of natural and anthropogenic radionuclides, geochronologies of pollutants in sediments, fluxes of radionuclides through the straits, transport and dispersal of contaminants from river systems, dating of past earthquake

events, water circulation, mixing and deep water formation processes, remobilisation of radionuclides from sediments.

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# ROLE OF SOLID PHASE AND POREWATER IN EVALUATING MARINE SEDIMENT TOXICITY BY SEA URCHIN BIOASSAYS

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### Abstract

Coastal sediment samples were tested from a series of sites (Mediterranean, North Sea and Baltic Sea), for the induction of toxicity endpoints in sea urchins. The major goals of this study consisted of: a) defining the localisation of toxic sediment sites, and b) comparing the toxicities of sediment components (solid phase, SP *vs.* porewater, PW). The results showed that: a) toxicity outcomes were consistent with the data of pollutant analyses, and b) SP- and PW-associated toxicity was exerted to different extents. *Keywords : Echinodermata, Bio-indicators, Ecotoxicology, Sediments.* 

When evaluating sediment toxicity, most of the literature reports on PW, elutriates, or extracts, whereas only a few authors [1] have recognised the relevance of whole sediment bioassays in providing a realistic evaluation of sediment toxicity. This study was to evaluate the toxicity to sea urchin embryos and sperm by whole sediment (WS) samples with the following goals: 1. providing a topographic characterisation of sediment toxicity, and 2. comparing PW to SP toxicity from sediment samples from various sites.

Sea urchin bioassays were utilised in toxicity testing of environmental contaminants, pharmaceutical drugs, as well as complex mixtures with good agreement between bioassay and analytical data [2].

Two species of sea urchins were utilised (*Sphaerechinus granularis* and *Paracentrotus lividus*); the gametes and embryo cultures were obtained as described previously [2,3]. Sediment was collected from a set of sites in Italy, Germany, and the Netherlands. The samples were tested within two weeks as WS, or SP or PW (0.1 to 1%, dry w/v). Sediment aliquots were laid in 10-ml wells of cultures plates, suspended in filtered seawater (FSW) and stirred. Fertilised eggs were laid on sediment, whereas sperm were suspended (0.1%) in stirred sediment and untreated eggs were fertilised by the supernatant sperm suspension (0.5%).

Tab. 1. Percent developmental defects in *S. granularis* larvae exposed to sediment samples from Kiel Fiord tested as solid phase (SP) or pore water (PW). *Abbreviations:* W = Warnemünde; K = Kiel *Fjord*; R = % *retarded larvae*; P1 = % *malformed larvae*; P2 = % *arrested embryos* (*e.g. gastrulae*); D = % *dead embryos/larvae*.

| #Site | R             | P1            | P2              |
|-------|---------------|---------------|-----------------|
| Blank | 3.5 ± 1.0     | 3.3±0.6       | 3.3±0.8         |
| SP    |               |               |                 |
| K1    | $0.0 \pm 0.0$ | $0.0 \pm 0.0$ | $100.0 \pm 0.0$ |
| K2    | 15.5 ± 2.1    | 6.7 ± 1.6     | 40.7 ± 7.2      |
| КЗ    | 24.5 ± 1.8    | $3.2 \pm 1.4$ | 63.0 ± 5.1      |
| К4    | 48.3 ± 10.7   | 4.7 ± 2.0     | 40.8 ± 12.5     |
| PW    |               |               |                 |
| K1    | 6.8 ± 1.7     | 6.5 ± 1.1     | 4.5±0.9         |
| K2    | 26.7 ± 17.0   | 7.5±3.9       | 65.8 ± 18.5     |
| K3    | 27.5 ± 13.7   | 10.7 ± 5.1    | 61.8±17.6       |
| K4    | 10.8 ± 4.7    | 13.7 ± 10.6   | 3.5±1.8         |

Toxicity of Italian coastal sediment was exerted to a varied extent according to the different sampling sites. The sediment-associated developmental toxicity ranked as follows: Pula (14) >Sarno River estuary (21) >Palermo (15)  $\cong$  Palmas (13)  $\cong$  Capri (20). When sperm were exposed to 0.2% sediment samples, site 21 (Sarno River estuary), showed a significant mitotoxic effect (p<0.01). Mitotic aberrations ranked as follows: 21 >14  $\cong$  22a >15  $\cong$  17  $\cong$  19. The Pula site has been affected by a coal-fueled power plant; the other sites were Palermo harbour, and at the mouth of the Sarno River, affected by a number of pollution sources [4].

Toxicity of Baltic Sea sediment (Germany) was evaluated from four sites in the Kiel Fjord (K) and five sites offshore Warnemünde (W). As shown in Table 1, the highest toxicity to *S. granularis* embryos was exerted by K1, and was confined to the SP component, whereas PW was found to be non-toxic. The K4 site also displayed toxicity for the SP component only. The other two sites (K2 and K3) were effective in inducing developmental arrest for both SP and PW. Mitotic activity and fertilisation success were significantly decreased by the K1 sample.

The other values observed for the K1 site suggested an overall depression of the mitotic activity, as well as an increase in morphologic aberrations. The other sediment samples displayed non-significant changes, with the exception of a decreased MPE for site W1. By exposing *P. lividus* sperm to Baltic Sea sediment, fertilisation success was significantly decreased by the K1 sample and, to a lesser extent, by K2 and K5 samples. The resulting offspring quality was affected, to the highest extent by the K2 sediment sample, as 100% of embryos were either malformed or developmentally arrested.

Offspring quality was affected, to the highest extent by the K2 sediment sample. Toxicity of North Sea sediment showed that PW resulted in stronger toxic effects than SP.

#### Conclusions

The relative toxicities of the two sediment components cannot be assessed a priori, thus both SP and PW should be tested for a reliable assessment of sediment toxicity. For practical purposes, WS toxicity testing may provide realistic information both encompassing SP- and PW-associated toxicities.

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# NATURAL RADIONUCLIDES AND <sup>137</sup>CS IN MARINE SEDIMENTS FROM TWO GULFS OF CENTRAL GREECE

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## Abstract

Natural radionuclides and <sup>137</sup>Cs activity concentrations were measured in marine sediments collected from the most representative areas of Patras and Corinth Gulfs. Their regional distributions depend on geological, geochemical and anthropogenic (mining activities) factors. *Keywords : Radionuclides, Sediments.* 

Introduction - The total amount of radionuclides and  $^{137}$ Cs in the marine sediments depends on many geological, geochemical, biological and anthropogenic factors and processes such as the geology of the surrounding land, mineral composition, content of organic matter, sedimentation rate, resuspension, texture of the sediment, etc. In this paper the  $^{238}$ U,  $^{232}$ Th,  $^{226}$ Ra,  $^{40}$ K and  $^{137}$ Cs specific activities in the marine sediments of Patras and Corinth Gulfs and their possible relation to the above mentioned factors and processes are presented.

Study area - The Gulfs of Patras and Corinth represent a continuous system of WNW-ESE trending basins in the Central Greece. Sampling stations were chosen to cover the most representative areas of the two gulfs as detailed below: (i) Antikyra Bay (ANT): Located at the northern margin of the Gulf of Corinth. This region has been extensively sampled and investigated in previous years [1], as an aluminum processing plant (ALUMINIO HELLAS) discharges bauxitic red mud tailings into this Bay. The discharged red mud tailings have resulted in the formation of a surface layer which covers the seafloor. It should be noted that the bauxites usually contain significant amounts of uranium and thorium as result of their formation. (ii) Galaxidi (GAL) and Kirra (KIR) coastal areas are located at the Itea Bay at the northern margin of the Gulf of Corinth. (iii) Eratini Bay (ERA) and Ag. Pantes (AGP) coastal areas are also situated at the northern margin of the Gulf of Corinth. ERA 5 and 6 sampling points are located in the vicinity of the submarine fan delta of the Eratini seasonal river. (iv) Basin of the Gulf of Corinth (CORBAS): a reference sampling point for background levels which is located at the central basin of the Gulf at a water depth of 850m. (v) Messolonghi Lagoon (MES) is located in the northern coast of the Patras Gulf and constitutes the southernmost part of the Messolonghi-Aetoliko lagoon complex, which is the most extended lagoon system in Greece. This complex is part of the same water course in the drainage basin of the Acheloos and Evinos rivers. The northern part of the drainage basin was heavily contaminated by the Chernobyl fallout. (vi) The Patras harbour (PATH) is located at (in) the southeastern coast of the Gulf of Patras. The Patras harbour due to its vicinity to Patras city (200.000 citizens), is contaminated with respect to harbour and urban activities. (vii) Basin of the Patras Gulf (PATBAS): a reference sampling point for background levels which is located at the basin of the Gulf in a water depth of 95m.

Materials and Methods - Sediments were sampled using a 50x50x50cm box corer, a 3.0 m long gravity corer and a Day grab. The uppermost 2cm of all cores were subjected to a direct  $\gamma$ -ray spectrometry for specific activity measurements of <sup>238</sup>U, <sup>232</sup>Th, <sup>226</sup>Ra, <sup>40</sup>K and <sup>137</sup>Cs using a HPGe detector.

Results and Discussion - The activities of <sup>238</sup>U, <sup>232</sup>Th, <sup>226</sup>Ra, <sup>40</sup>K and <sup>137</sup>Cs are shown in Table 1. The <sup>238</sup>U, <sup>232</sup>Th, <sup>226</sup>Ra and <sup>40</sup>K obtain low activities in the sediments of the basin of the two gulfs (CORBAS, PATBAS) ranging from 19.7 to 22.5, 21.0 to 34.4, 20.4 to 25.8 and 356 to 698 Bq kg<sup>-1</sup>, respectively. These activities are comparable to those of the world average as reported by UNSCEAR [2]; (Table 1). In the Gulf of Corinth, the highest measured <sup>238</sup>U, <sup>232</sup>Th and <sup>226</sup>Ra content was detected in the red mud samples and was found to be in the range of 113 - 400, 113 - 412 and 66 - 185 Bq kg<sup>-1</sup>, respectively (Table 1). On the contrary, the lowest <sup>40</sup>K activity was observed in the natural sediments. The high values of <sup>238</sup>U, <sup>232</sup>Th and <sup>226</sup>Ra are out of the range of those cited in literature. Moreover, the observed values of <sup>238</sup>U-<sup>232</sup>Th-<sup>226</sup>Ra group in the red mud samples represent the maxima of the reported range of values (29-110, 4-106 and 7-159 Bq kg<sup>-1</sup>, respectively) for the Aegean and Ionian seas [3]. The <sup>238</sup>U, <sup>232</sup>Th, <sup>226</sup>Ra and <sup>40</sup>K activities in the sediments of the KIR, GAL, AGP and ERA coastal areas of the Gulf of

Corinth ranging from 9.3 to 30.3, 3.7 to 14.8, 4.5 to 12.3 and 23.9 to 306 Bq kg<sup>-1</sup>, respectively (Table 1). These activities are comparable to those of the world average as reported by UNSCEAR [2] (Table 1). The slightly elevated activities observed in the ERA sampling points may be related to the fine texture of the sediments. The  $^{238}$ U,  $^{232}$ Th,  $^{226}$ Ra and  $^{40}$ K activities in the sediments of the Patras Gulf are comparable to those of the world average and are slightly higher than those of the Gulf of Corinth (Table 1). This may be represents the granulometric and mineralogical influence on the element activities. The sediments collected from the Patras Gulf (muds) are finer than those of the Gulf of Corinth (sand to sandy mud). In addition, the sedimentation at the northern margin of the Gulf of Corinth is dominated by the weathering of the limestones, while the sedimentation of the Patras Gulf is controlled by the erosion of Plio-Quaternary sediments. Regarding the anthropogenic radionuclide <sup>137</sup>Cs and considering that in the surveyed area there are neither nuclear power plants nor other direct sources, its concentration is only due to the fallout of the reactor accident at the Chernobyl NPP. In the surface layers of the sediments (0-2cm) of the Gulf of Corinth, the <sup>137</sup>Cs concentrations varied from between 0.2 to 4.3 Bq  $kg^{-1}$  which are comparable to those found in other Greek coastal areas. The activity concentrations of <sup>137</sup>Cs in the sediments of Patras Gulf are significant higher (1.8 to 52.0 Bq kg<sup>-1</sup>) than those of the Gulf of Corinth, due to increased runoff from the drainage areas of the northern margin of the Patras Gulf, which are heavily contaminated by <sup>137</sup>Cs [4]. Moreover, the high content of the clay minerals and organic matter found in the sediments of the Patras harbour and the Messolonghi Lagoon play very important role in the high level of <sup>137</sup>Cs.

Tab. 1. Specific activities (Bq kg<sup>-1</sup>dw  $\pm$  1s<sub>tot</sub>) of<sup>238</sup>U,<sup>226</sup>Ra, <sup>232</sup>Th,  $^{40}$ K and  $^{137}$ Cs in marine sediments from Patras and Corinth Gulfs (for abbreviations see text). s<sub>tot</sub> : the 1 sigma combined uncertainty, \*n : number of samples,\*\*UDL:under detection limit.

| Sampling<br>Area | n* | Depth     | Range              | 238                                | 228Ra                              | <sup>232</sup> Th                  | «оК                             | 137CS                                |
|------------------|----|-----------|--------------------|------------------------------------|------------------------------------|------------------------------------|---------------------------------|--------------------------------------|
| PATBAS           | 1  | 95 m      | -                  | 22.5 ± 5.0                         | 20.4 ± 1.7                         | 34.4 ± 1.5                         | 698 ± 44                        | 16.0 ± 1.3                           |
| CORBAS           | 1  | 850 m     | -                  | 19.7 ± 5.5                         | 25.8 ± 0.6                         | 21.0 ± 0.6                         | 356 ± 14                        | 3.0 ± 0.4                            |
| KIR              | 1  | 2 m       |                    | 19.1 ± 6.3                         | $11.4 \pm 0.9$                     | 5.5 ± 0.8                          | 85 ± 7                          | $0.9 \pm 0.4$                        |
| GAL              | 1  | 2 m       |                    | 9.3 ± 4.0                          | 4.5 ± 0.7                          | 3.7 ± 0.5                          | 24 ± 5                          | 0.2 ± 0.1                            |
| AGP              | 2  | 2 m       | min<br>max         | 14.8 ± 5.3<br>16.8 ± 6.0           | 6.9 ± 0.7<br>8.2 ± 1.0             | 5.3 ± 1.0<br>6.2 ± 1.0             | 70±6<br>108±8.0                 | 0.7 ± 2.0<br>0.9 ± 0.4               |
| ERA              | 2  | 2 – 3 m   | min<br>max         | 14.8 ± 5.7<br>30.3 ± 8.9           | 12.0 ± 0.8<br>12.3 ± 0.9           | 14.0 ± 0.9<br>14.8 ± 1.0           | 295 ± 7.0<br>306 ± 10           | 1.1 ± 0.4<br>1.6 ± 0.6               |
| MES              | 6  | 0.5 – 3 m | min<br>max<br>mean | 31.0 ± 6.0<br>53.0 ± 4.0<br>(41.2) | UDL**<br>17.8 ± 0.7<br>(9.1)       | 6.4 ± 0.8<br>26.0 ± 1.0<br>(19.4)  | 208 ± 20<br>608 ± 41<br>(434)   | 3.5 ± 0.3<br>52.0 ±<br>0.3<br>(21.1) |
| PATH             | 6  | 7 – 9 m   | min<br>max<br>mean | 16.1 ± 1.2<br>33.3 ± 3.7           | 14.9 ± 0.8<br>21.8 ± 1.0<br>(17.5) | 15.4 ± 1.5<br>26.8 ± 2.7<br>(21.2) | 327 ± 16<br>516 ± 23<br>(423.6) | 1.8 ± 0.3<br>11.1 ±<br>1.2<br>(4.3)  |
| ANT              | 5  | 30 – 60 m | min<br>max<br>mean | 36.6 ± 7.8<br>400 ± 28<br>(127.5)  | 16.2 ± 0.4<br>185 ± 9<br>(60.3)    | 4.4 ± 0.9<br>412 ± 5<br>(112.5)    | 71.5± 15<br>406 ± 22<br>(206.2) | 1.5 ± 0.3<br>4.3 ± 0.5<br>(2.9)      |
| UNSCEAR          |    |           |                    | 10 - 50                            |                                    | 7 - 50                             | 100 - 700                       |                                      |

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# STUDY OF NITROGENOUS SPECIES IN A COASTAL LAGOON IN CENTRAL GREECE UNDER PROGRESSIVE DEPLETION OF DISSOLVED OXYGEN CONCENTRATION. RESULTS OF A SIMULATING **EXPERIMENT**

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## Abstract

The aim of this study is to determine the response of nitrogen species to gradually decreasing dissolved oxygen (d.o.) conditions taking place at a shallow coastal Mediterranean lagoon within the Maliakos gulf, Central Greece. The results showed that even minor changes in the redox conditions at the water-sediment interface have significant impacts on the concentrations of the various dissolved nitrogen species.

Keywords : Oxygen, Redox, Sediments, Coastal Management.

Surface sediment from a coastal lagoon located within the Maliakos gulf, along with the overlying water was sampled using a benthic chamber (May 2006) and transported undisturbed to the laboratory. The chamber is equipped with an electronic system allowing the fine regulation of dissolved oxygen [1].

Total Dissolved Nitrogen (TDN) was determined following a persulfate oxidation [2]. Ammonium, nitrate and nitrite in sea water samples were determined with standard spectrophotometric methods [3]. Dissolved Organic Nitrogen (DON) was calculated as the difference between TDN and Dissolved Inorganic Nitrogen (DIN - sum of nitrate, nitrite and ammonium). This experimental phase lasted 8 days from 3 to 10 May 2006 and the dissolved oxygen concentration in the benthic chamber was gradually decreased from 6.10 mg/l to 2.45 mg/l (Fig. 1a).

During this phase a rapid and significant increase in the concentration of DON (Fig.1b) was observed followed by a major increase of  $NH_4^+$  (Fig. 1c) which prevailed over all other forms of inorganic nitrogen. The concentration of  $\mathrm{NO_2}^-$  (Fig.1d) and  $\mathrm{NO_3}^-$  (Fig.1e) showed an increasing trend. Consequently the TDN concentration was rising.





Increase of DON concentration indicates a transformation of particulate nitrogen forms into soluble ones linked to complex biochemical reactions taking place at the surface sediment, including the autolysis of dead cells and the decomposition of particulate organic nitrogen by bacterial exoenzymes [4]. The significant ammonium concentrations seem to originate from the hydrolysis of dissolved organic nitrogen species (e.g. aminoacid macromolecules) which are common degradation products of the dead organic matter [5]. It is worth noting that, despite the relatively low oxygen content of the water column, part of the ammonium seems to be oxidised to nitrite and further on to nitrate. Apparently the oxygen levels are sufficient to support the bacterial biomass (nitrosomonas, nitrobacter). There are strong correlations between ammonia and nitrite (p < 0.003,  $s_{est} = 0.39$ , R-Sq = 78.3%) as well as between nitrates and nitrites (p<0.029,  $s_{est}$ = 0.56, R-Sq = 57.8%).

For the statistical treatment of data we used the p value (that determines whether the association between the variables is statistically significant), the  $s_{est}$  (standard deviation of the data about the regression line), and the R-Sq predictor (the explained amount of variation in the observed response values).

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# CHEMICAL AND ECOTOXICOLOGICAL QUALITY ASSESSMENT OF THE ROVINJ COSTAL AREA, NORTHERN ADRIATIC, CROATIA

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# Abstract

PAHs content in sediment showed clear differences between pristine, urban industrial and harbor areas. Sites ranged according total HSP70 protein contents in mussel gills and total PAHs content in sediment show the same increased order. On the basis of the present results, we suggest that both sediment chemical (PAHs) and biomarker (HSP70) analyses can serve as a useful index of the contamination level and as an early-warning indicator of environmental alterations.

Keywords : Pah, Mollusca, Bio-indicators, Adriatic Sea, Pollution.

Pollution of the Rovinj costal area was determined by PAHs content analysis in sediment and stress-70 proteins as biomarkers of environmental contamination exposure/effect in natural mussel populations, collected seasonally at differently polluted sites (Fig. 1.). Site out of Limski kanal (S-1), was used as a reference point, while other locations are under the influence of mariculture, industrial and urban runoff waste: mariculture (S-2), fish cannery (S-3), gasoline station (S-4), local harbour (S-5) and tobacco factory (S-6).



Fig. 1. Location of the sampling sites in the Rovinj costal area, northern Adriatic, Croatia.

#### PAH analysis

Contents of PAHs determined in sediment from sites S-1 to S-6 are divided into four groups according to their number of aromatic rings as a sum of all PAHs in each sediment and percent of each group, respectively (Fig. 2.A). Twelve of sixteen analyzed PAH were found at low to moderate concentrations, ranging from 32 to 13681 ng/g of the total PAHs per sediment dry weight. They showed clear differences between pristine, urban industrial and harbor areas. According to the total concentration of 12 PAHs detected in the sediment, sampling sites can be ranged in an increasing order: S-1, S-2, S-3, S-4, S-6 and S-5. Molecular indices revealed that PAHs in the sediment originate mainly from pyrolytic sources, but some petroleum influence was also evident (harbor) [1].

#### Stress-70 protein analysis

The mediterranean mussel *M. galloprovinicialis* Lamarck 1819 was used for ecotoxicological investigation and gills as a target tissue. Stress-70 protein content after exposition of organisms to contaminants for long periods in their environment provide a method for quantifying adverse biological impacts when examined in wild populations from contaminated sites.

Using SDS-PAGE and Western blot analysis two stress-70 proteins (HSP70 and HSP72) were detected [2]. Investigations of natural mussel populations collected at different polluted sites of the Rovinj area in four seasons indicated that there is a significant difference in stress-70

contents in mussels form control sites Limski kanal (S-1) and those from other sampling sites with urban and industrial pollution (Fig. 2.B).



Fig. 2. A) Total PAHs (ng/g dw) and group profile of PAHs (%) from marine sediments. B) Total HSP70 content in gill tissues of *M. galloprovincialis* collected seasonally at 6 locations, control (S-1) and under the influence of mariculture, industrial and urban runoff.

Chemical analyses of PAHs in sediment help to determine the magnitude of anthropogenic contamination by identifying the pollutants but do not provide any information about the contaminant effect on the biota [1]. Stress-70 protein induction as biomarker of exposure/effect of pollution is positively related to total PAHs content at sampling sites. The highest cumulative annual HSP70 content was observed at the site with the highest total sediment PAH content. There is no proof that stress-70 protein induction is in direct connection to PAHs levels found in the sediment of the investigated sites, although a variety of industries indicate the presence of other pollutants and stressors too.

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# CARBON BUDGET AND BACTERIA GROWTH EFFICIENCY IN THE ADRIATIC SEA: A THEORETICAL MODELLING STUDY

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## Abstract

On the basis of numerical simulations carried out with a three dimensional ecosystem model, a carbon budget for the Adriatic Sea was estimated and a theoretical scenarios of carbon exchanges between four Adriatic sub-basins is offered. Bacteria Growth Efficiency (BGE) was also estimated in six different stations sub-sampled from model domain in order to highlight the trophic variability of the basin. *Keywords : Adriatic Sea, Models, Carbon.* 

A three dimensional biogeochemical-hydrodynamic coupled ecosystem model was used to study the carbon fluxes and the Bacterial Growth Efficiency (BGE) variability in the Adriatic Sea.

The model domain encompasses the whole Adriatic basin and extends south of the Otranto channel into the northern Ionian Sea, where the only open boundary is located.

The model has been validated in a previous work for the major biogeochemical bulk properties [1]. Here we further validate simulations against observed primary production profiles.

The ratio between gross primary production and community respiration (GPP/R) and the sedimentation fluxes were estimated for the whole Adriatic Sea and in different Adriatic sub-basins. The BGE was estimated in 6stations sub-sampled from the model domain. The subdivision in sub-basin was made following [2] who divided the Adriatic in 4 main sub basin: the shallow North, the deep North, the central and southern basin; shallow and deep north were separated on the basis of the 40-m isobath The stations were chosen in order to follow the chlorophyll gradient on the basis of the SeaWiFS chl-images.

The Adriatic simulated yearly GPP/Rvalue is less than 1 implying that the Adriatic could be considered as a source of CO<sub>2</sub> for the atmosphere. On the other hand the GPP/R value presents an high variability when calculated in the different sub-basins. Only the shallower northern basin has a GPP/R>1 while deep north basin is at equilibrium and the central and the southern ones present an excess of respiration. Starting from the mass conservation, considering a southward net transport and the sedimentation fluxes in each sub-basin, we found that the surplus of carbon produced in the shallow north would be theoretically sufficient to explain the GPP/R value in the central basin and to match all the sedimentation fluxes but is not sufficient to explain a GPP/R value less than 1 in the southern basin. This implies that allochthonous organic carbon is respired in this sub-basin. We supposed that the ingression of Dissolved Organic Carbon (DOC), mainly associated to the Levantine Waters ingression trough the Otranto Strait, increasing the bacterial respiration, could be responsible of the GPP/R value in the southern sub-basin. This Idea is supported by the fact that the simulated value of the bacterial respiration to community respiration ratio increases from the north to the south where reaches the value of 0.75 mining that bacteria are the principal contributor to the community respiration in that zone.

The model consider the open boundary as a DOC input/output on the basis of the value of the velocity normal to open boundary prescribed from the hydrodynamic model. When this velocity is >0then a fixed DOC concentration (dependent on the depth) is transported in side the model domain; when the velocity on the boundary is <0 the DOC amount simulated on the boundary is transported outside the model domain. On the basis of model simulation the yearly DOC flux at the open boundary is positive implying that the Otranto strait is a source of DOC for the Adriatic Sea.

Sensitivity experiment carried out by taking off the ingression of DOC at the open boundary showed a value of GPP/R equal to 1 for the south basin while left unaltered the GPP/R in the others sub-basins.

The simulated values of BGE range from 0.4 to 0.05 that are value characteristic of eutrophic and oligotrophic environment respectively. High BGE values are simulated in the stations located in the northern area were in high GPP/R value and high sedimentation fluxes were also simulated. The high variability of GPP/R value and BGE implies the presence of different trophic regimes from the herbivorous chain, in the coastal northern zone, to the so called "microbial loop", in the central and southern basin.

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# EFFETS DE LA BASSE SALINITÉ DU MILIEU SUR L'OSMOREGULATION ET LA COMPOSITION EN ACIDES GRAS DES BRANCHIES DU MUGE : *LIZA RAMADA* (RISSO 1826)

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## Résumé

Les activités d'élevage en milieu continental, et en particulier, l'empoissonnement des retenues de barrages, constituent une importante activité aquacole dans notre pays. Parmi les espèces de poissons, les alevins de muges (poissons euryhalins) sont largement exploités dans les opérations d'alevinage. Nos résultats montrent que le passage brusque des alevins de *Liza ramada* à la basse salinité s'est accompagné d'une diminution significative de l'osmolalité du plasma (de 341mosmole/Kg à 234mosmole/Kg) et du taux d'hématocrite (de 25  $\pm$  5.01% à15.37  $\pm$  4.77%). Ce transfert s'est accompagné également d'une réduction des pourcentages des acides gras poly insaturés (n-3) simultanée à une augmentation de ceux des acides gras poly insaturés (n-6). *Mots clès : Aquaculture, Fishes, Physiology, Salinity.* 

#### Introduction

La récolte d'alevins dans le milieu naturel constitue une possible base pour l'établissement d'une activité aquacole. L'impasse faite sur les coûteuses et parfois aléatoire production en écloserie en est le principal intérêt. De ce fait, cette solution parait particulièrement adaptée au contexte économique des pays en voie de développement]. Les espèces les plus recherchées pour l'aquaculture sont en premier lieu *Mugil cephalus* et *Liza ramada* en raison de leur euryhalinité, de leur croissance importante et rapide en eau douce.

Plusieurs auteurs ont démontré que les fonctions majeures pour l'adaptation du poisson à son milieu sont localisées au niveau de l'épithélium branchial. De plus, la branchie étant un organe à structure complexe dont la composition lipidique varie également quantitativement et qualitativement avec les facteurs environnementaux. De ce fait, notre présent travail a porté sur l'étude de l'osmoregulation et de la composition en acides gras de ces branchies en fonction de l'adaptation à la basse salinité.

#### Matériel et méthodes

Dans ce travail, nous avons choisi comme matériel biologique les alevins : *Liza ramada* .La capture de ces alevins a été réalisée dans le golfe de Tunis, au niveau de l'embouchure de l'oued Khélij à Raoued. Cette embouchure est fortement exploitée par le ministère de l'agriculture comme site de collecte pour l'empoissonnement des retenues de barrages.

Les poissons (alevins de *Liza ramada*) d'expérience ont été capturés dans les eaux où la salinité varie entre 8 et 31,5psu, puis transportés au laboratoire où ils ont subit en premier lieu une acclimatation à l'eau de mer (35psu) durant un mois.

Dans un deuxième temps, ces alevins ont été mis directement dans un autre aquarium d'eau douce (0,5psu) pendant 24 heurs pour subir un choc osmotique.

Nous avons suivi par la suite les variations des paramètres sanguines : taux d'hématocrite et osmolalité du plasma.

Pour l'extraction des lipides totaux nous avons adopté la méthode de Folch [1] modifiée par Bligher et Dyer [2].

#### Résultats et discussion

La diminution de la salinité du milieu nous a révélé une réduction des pourcentages des acides gras polyinsaturés de la famille (n-3) simultanée à une augmentation de ceux des acides gras polyinsaturés de la série (n-6). L'augmentation enregistrée au niveau de ces derniers (n-6) pourrait avoir comme origine l'accumulation de l'acide linoléique C18 : 2(n-6) (précurseur des acides gras polyinsaturés (n-6)).

Le transfert à la basse salinité s'est accompagné également d'une diminution significative de l'osmolalité du plasma et du taux d'hématocrite. En effet, les valeurs d'osmolalité diminuent significativement (p<0.05) et respectivement de 341mosmole/Kg à 234mosmole/Kg après le transfert dans l'eau douce. De plus le taux d'hématocrite, trouvé pour les alevins acclimatés à l'eau de mer était de  $25 \pm 5.01\%$  alors que pour ceux mis en l'eau douce (0.5psu), n'était plus que de  $15.37 \pm 4.77\%$ .

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# RECENT DATA OF NITROGEN AND PHOSPHORUS INPUTS INTO MEDITERRANEAN SEA BY THE RHONE RIVER

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## Abstract

Since the damming of the Nile, the Rhone River is the main freshwater supplier to the Mediterranean Sea playing a major role in the productivity of the western basin. Recent data seem to confirm a significant increase of nitrate input, while phosphate concentrations tend to decrease. This opposite pattern leads to a strong evolution of the N/P ratio in the inorganic nutrient available for primary producers. *Keywords : Macroelements, Monitoring, River Input, Western Mediterranean.* 

Since the damming of the Nile, the Rhone River is the main freshwater and sediment supplier to the Mediterranean Sea. Freshwater inputs play a major role in the balance of the water inputs through the Strait of Gibraltar and enhance significantly the primary production of the western basin. It has been seen by remote sensing observations of the river plume that the Rhone input of nutrients could be responsible for 46% of the excess production in the Gulf of Lions, compared with the Western basin. A good knowledge of this flux and of its variability is therefore essential for understanding of the primary production as well as the biogeochemistry of the Mediterranean Sea. An increase in the input may cause a corresponding increase of primary production leading to changes in the functioning of the Mediterranean ecosystem.

Here we report historical data from 1968, completed by recent data obtained during a long term program of high frequency sampling supported by the Agence de l'Eau Rhone-Méditerranée. With the help of an automated sampling system, suspended materials and inorganic, as well as organic, nutrients have analyzed daily, or 6 times per day during floods higher than  $3000m^{-3}.s^{-1}$ .

Nitrate is the main nitrogen source (68%), while dissolved inorganic phosphorus (DIP) represented only 48% of phosphorus concentration, indicating the necessity to take into account organic forms in estimating nutrient budget. High frequency sampling confirms the high seasonal variability of nitrate with higher concentration in winter, while phosphate concentrations remain more or less constant over the year. Mean annual concentration of nitrate was more or less constant from 1968 to 1980 around  $1\text{mg.l}^{-1}$ . Between 1985 and 1990, nitrate concentration has increased by about 50%, but during the last 15 years, concentrations remain around 2 mg.l<sup>-1.</sup> In opposite, DIP concentration tends to continuously decrease since 1985 from 0.2 to 0.08 mg.l<sup>-1</sup>. We can compute the nutrients inputs (tonne.year<sup>-1</sup>) from the values of the flow and those of the nutrient concentrations. It shows that:

1) In spite of some interannual variability, annual nitrate inputs have significantly increased during the last two decades, ranging from 50 to 100 metric Tons, confirming some previous results [1].

2) In the same time, DIP discharges have considerably decreased (more than 50%).

3) Consequently, the atomic N/P ratio of inorganic matter supply has considerably increased, from 20 to 40-60.

But recent measurements of organic forms of nitrogen and phosphorus show that these compounds can represent 20% to 100% of the inorganic forms, with a higher fraction of phosphorus. Then taking into account all nitrogen and phosphorus, atomic N/P ratio appear lower, ranging from 30 to 40.

These results show that it would be of great interest 1) to keep high frequency measurements, 2) to study mores particularly the relationships between river flow and nutrients concentrations and 3) to measure simultaneously organic and inorganic forms of the nutritive elements.



Fig. 1. Annual input of nitrate and phosphate by the Rhone River into the Mediteranean Sea since 1968.

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# COULD <sup>234</sup>TH PARTITIONING IN SEAWATER BE KRILL-DRIVEN?

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## Abstract

 $^{234}$ Th is considered a useful tracer of oceanic biogeochemical processes occurring over timescales of days to weeks. Traditionally,  $^{234}$ Th -based particle export mathematical models have not taken into consideration the biological compartment, as typical zooplankton biomass values are not likely to result in significant biologically-mediated interactions with such models. However, recent experimental results for the Mediterranean krill *Meganyctiphanes norvegica* suggest that, if rapid  $^{234}$ Th uptake by krill is not considered in the modeling, the occurrence of a synchronized molting event within a high-biomass krill school may result in an overestimation of  $^{234}$ Th based particle flux by as much as one order of magnitude.

Keywords : Crustacea, Models, Particle Flux, Radionuclides.

## Introduction

 $^{234}$ Th is a naturally-occurring radionuclide constantly produced in seawater by its soluble parent  $^{238}$ U. Due to its high particle reactivity and relatively short half-life (t<sub>1/2</sub> = 24.1 days),  $^{234}$ Th is commonly used as a proxy to estimate POC export from the upper oceanic water column [1]. This export is usually assessed by quantifying total  $^{234}$ Th deficits with respect to its conservative parent nuclide  $^{238}$ U in seawater (*ibid*.). Recent findings for three species of Antarctic crustaceans have suggested that under certain conditions krill-associated  $^{234}$ Th would generate a severalfold positive export bias in depth-integrated  $^{234}$ Th profiles [2]. Thus, we have tested this hypothesis by conducting analogous experiments using specimens of *Meganyctiphanes norvegica* krill collected in the NW Mediterranean.

#### Material and Methods

Live *Meganyctiphanes norvegica* from the NW Mediterranean were transported to the IAEA-MEL premises (Monaco), where they were acclimated for two weeks to laboratory conditions simulating their original temperature and light conditions ( $14^{\circ}$ C; 37 p.s.u; darkness).

Specimens were individually placed in a 500 ml container containing 400 ml of natural filtered seawater spiked with  $^{234}$ Th. The seawater was changed and the radionuclide spike was renewed daily. During seawater renewal operations, animals were fed shortly on a mixture of uncontaminated phytoplankton and freshly hatched brine shrimp larvae.

At different times, each individual was  $\gamma$ -counted (high-resolution  $\gamma$ -spectrometry system) alive to determine the radionuclide uptake kinetics. At the end of the 7.5-d exposure period, the individuals were placed for 10 d in new containers with clean filtered seawater that was renewed daily. Individuals were then  $\gamma$ -counted daily to determine radionuclide loss kinetics.



Fig. 1. Euphausia superba - Krill [3]

#### Results and Discussion

Krill rapidly took up <sup>234</sup>Th, reaching a steady-state concentration factor of about 200 in less than one week, and strongly retained the accumulated radionuclide until molting occurred. At 14 °C krill molt on average every 8 days [4], and during the experiment 9 molting events were observed which indicated that ca. 50% of whole-body <sup>234</sup>Th activity was associated with the exoskeleton.

Immediately following molting a corresponding amount of <sup>234</sup>Th was rapidly adsorbed on the newly formed cuticle. These results, coupled with published values of krill densities as high as 100 g l<sup>-1</sup> [5] (Fig. 1) which commonly occur in the Southern Ocean suggest that <sup>234</sup>Th bioaccumulation could result in up to >90 % of total water-column <sup>234</sup>Th being associated with krill (Fig. 2). Hence, the occurrence of a synchronized molting event [4] within a high-biomass krill school could cause the <sup>234</sup>Th distribution in the water column to be almost entirely a result of radionuclide uptake by these organisms and consequently bias the results of traditional <sup>234</sup>Th based models by more than one order of magnitude.



Fig. 2. CF-based computation representing the fraction (%) of total <sup>234</sup>Th in the water column associated with different biomasses of crustacean zooplankton (g  $1^{-1}$  wet wt), based on mean CF derived from experiments on Antarctic isopods and amphipods (fine dashed line [2]) or on Mediterranean krill (heavy solid line; present study).

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# HEAVY METALS DISTRIBUTION IN SURFACE SEDIMENTS OF MALIAKOS GULF AND SPERCHIOS RIVER, CENTRAL GREECE

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# Abstract

Surface sediments were collected during July 2005, from Maliakos Gulf and the estuary of Sperchios River. The total concentrations of zinc, copper, manganese, aluminium, iron and lead were determined. Grain size seems to be determinative for the metal load, in combination with the environmental pressures that the area receives. Metal concentrations were higher in the gulf samples. *Keywords : Coastal Systems, Estuaries, Metals, Sediments.* 

## Introduction

Marine sediments provide a long-term record of the anthropogenic rural, industrial and domestic discharges in coastal areas. In contrast to the strong temporal and spatial variability in the aqueous concentrations of pollutants, sediments integrate pollutant concentrations over time. (1) Study area

The area is located in the eastern part of central Greece; it is an area of ecological significance included in the Natura 2000 network. Three different parts can be distinguished in the site: a) Maliakos Bay, b) the estuary of Sperchios River and its surrounding area and c) Sperchios River valley and its springs. Maliakos Bay covers an area of 9,000 ha. It is a small enclosed embayment connected to the Aegean Sea and N. Evoikos Gulf through two small openings to the east. Its depth does not exceed 25 m and its bottom is covered mostly by soft sediments. Sperchios River meets the sea in the SW corner of the bay. The part of the bay close to the mouth of the river is the shallowest one. (2)

#### Methodology

Surface sediments were collected with the use of a grab sampler from five stations in Maliakos Gulf (M1, M2, M3) and the estuary of Sperchios River (S1, S1p), as shown in figure 1. The concentrations of heavy metal were determined in the total fraction after digestion of 0.5 g of the freeze dried samples with  $HNO_3//HCIO_4/HF$ . Metal concentrations were determined by flame (Fe, Mn, Al, Cu, Zn) or flameless (Pb) atomic absorption spectrometry. Each sample was analyzed in triplicates. (3)





#### Results and discussion

All samples from the inner gulf were fine - grained, while samples from the estuary of Sperchios were coarse - grained, with the fraction <0.63 um amounting to less than 10%. The samples from the gulf were mainly composed of grains with diameter <0.63 um.

Each sample was analyzed in triplicate. The rsd% for each sample was; Zn <5.9, Cu <3.2, Pb <12.8, Al <4.6, Mn<2.6, Fe<4.2. A reference material was also digested and the percent recoveries for each metal were; Zn 105.3, Cu 103.2, Pb 75.4, Mn 104.5, Fe 98.8, Al 95.4.

Concentrations of heavy metals are shown in figure 2. Concentrations of Fe, Al, Pb, Zn, Cu increased in the west -east direction (from the estuary to the center of the gulf). This trend occurs due to the sample grain size nature that affects metal concentrations.

Atmospheric deposition of enriched in Pb particles of urban or industrial origin may contribute to the increase of Pb values in the gulf samples. The values of ratio  $C_{Pb}/C_{Al}$  also presented increase from the estuary to the center of the gulf.



Fig. 2. Heavy metal concentrations.

Values of Mn showed a minimum at the station M3, that may be caused by dissolution of manganese oxides in the intermittently anoxic conditions that probably occur into the enriched in organic matter fine grained sediments of the area.

High Fe and Al values in all sediments indicate the terrigenous origin of sediments. The correlation of the values was determined very high ( $R^2 = 0.98$  for linear equation). Moreover, Cu, Zn and Pb presented the same trend in their distribution in the samples. Correlations ( $R^2$ ) of Cu-Zn, Cu-Pb, Zn-Pb are 0.99, 0.87, 0.89.

The values of  $C_{Fe}/C_{Al}$  ratio show a decrease from 0.77 to 0.66 for S1p, S1, M3, M2, M1 samples, revealing that the mineral structure of the samples is not the same but it is closely linked to the grain size of sample.

Comparing our measurements to those of previous studies (4), (5) Zn and Fe values presented an increase in Maliakos Gulf while they show a decrease in the river. Concentrations of Mn are higher both in the River and the Gulf, while Pb values have the opposite trend.

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# LEVELS OF MERCURY, CADMIUM AND LEAD IN THE TISSUE OF *DIPLODUS VULGARIS* (LINNEUS, 1758) (TELEOSTEI SPARIDAE) FROM THE COAST OF SYRIA

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# Abstract

Mercury(Hg), Cadmium(Cd) and Lead(Pb) contents are determined in organs (liver,gonad,muscle tissues) of *Diplodus vulgaris* caught from Tartous,Banias and Lattakia-fishing zones along the coast of Syria during the2000-2001. Mercury concentration reaches maximum in liver ( $0.947\mu g/g dry$  weight) followed by muscle ( $0.640\mu g/g dry$  weight), and gonad ( $0.202\mu g/g dry$  weight). Cadmium content reaches maximum in liver ( $2.318\mu g/g dry$  weight), followed by muscle ( $0.406 \mu g/g dry$  weight), and gonad ( $0.228 \mu g/g dry$  weight) . Lead concentration is highest in liver ( $1.512 \mu g/g dry$  weight), followed by muscle ( $0.616 \mu g/g dry$  weight), and gonad ( $0.185 \mu g/g dry$  weight). The edible tissue of the species was not harmful for human health.

Keywords : Bio-accumulation, Fishes, Levantine Basin, Trace Elements.

#### Introduction

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. Mercury , cadmium and lead are among the most toxic heavy metals [1] because of their ability to be concentrated in the organs of marine organisms [2] In this work we report the levels of these metals in muscle tissue, liver and gonad of the demersal fish *D.vulgaris*, and the relationship between concentration and biological state of fish.

#### Material and Methods

Fish samples were collected at three locations in coast of Syria (Tartous, Banias and Lattakia) during one year Oct.2002-Sept2003). Biometric measurements (weight, length and age) were made according to[3].In the presented study, scales were used for age determination, by counting the number of annual rings on the fish scales.Three organs (muscle, liver and gonad) were taken for analysis. Two or three grams of muscle and gonad tissues and whole liver were processed for analysis. Trace metals (Cd and Pb)were determined by Shimadzu 6800 /6650 AAS coupled with a GFA-EX7graphite furnace [4], Mercury concentration was measured by cold vapor apparatus according to the techniques described in (5).

#### Results and Discussion

The higher lead concentration was in liver tissues 1.512  $\mu g/g$  dry weight ranging from 0.002-4.998  $\mu g/g$  dry weight followed muscle and gonad tissues 0.616- 0.185  $\mu g/g$  dry weight respectively. Cadmium level in gonad tissues is low 0.228  $\mu g/g$  dry weight compared with other tissues such as muscle 0.406  $\mu g/g$  and liver 2.318  $\mu g/g$  [ table 1] . On the other hand liver tissues have high Mercury concentration 0.947  $\mu g/g$  ranging from (0.064-3.125  $\mu g/g$ , then in muscle 0.640  $\mu g/g$  and finally in gonad tissues 0.202  $\mu g/g$  dry weight.Results show no significant difference (P<0.05 ) between the three sampling stations for cadmium and mercury. Banias has a higher concentration of Lead (p<0.05), there are no significant difference between the two sampling stations Lattakia and Tartous for lead concentration, P-value(0.45) P>0.05.

Tab. 1. Average values of Lead ,Cadmium ,and Mercury concentration  $(\mu g/g \text{ dry weight})$  in the selected organs and tissues of *D. vulgaris* from the coast of Syria m: = mean , r: =range of metal concentration , (): = number of samples

| Elements                 | Concentration (ng/g day weight ) in |                               |              |                             |   |  |  |  |  |  |
|--------------------------|-------------------------------------|-------------------------------|--------------|-----------------------------|---|--|--|--|--|--|
|                          | 1                                   | Muscle tissue                 | Liver        | Gonad                       | t |  |  |  |  |  |
| Lead                     |                                     |                               |              |                             | T |  |  |  |  |  |
|                          | m                                   | 0.616 (95)                    | 1.512 (102)  | 0.185 (24)                  | T |  |  |  |  |  |
| 000000                   | f                                   | < 0.002-3.976                 | <0.002-4.998 | <0.002-0.440                | 1 |  |  |  |  |  |
| Cadmium                  |                                     | a providence and a providence |              | Sector Sector Sector Sector | 1 |  |  |  |  |  |
| and Certain Caroon Lines | m                                   | 0.406 (102)                   | 2.318 (95)   | 0.228 (24)                  | 1 |  |  |  |  |  |
|                          | r                                   | <0.002-1.968                  | 0.035-8.335  | <0.002-0.624                | T |  |  |  |  |  |
| Mercury                  |                                     | and the second second         | 100000000    |                             | T |  |  |  |  |  |
| 1                        | m                                   | 0.640 (80)                    | 0.947 (95)   | 0.202 (20)                  | T |  |  |  |  |  |
|                          | r                                   | 0 180-1 980                   | 0.064-3.125  | 0.019-0.436                 | T |  |  |  |  |  |

Lead has no biological function in the fish [1] and its movement across cell membrane is restricted by the fact that solubility of lead salts are low, making its concentration in the muscle tissue few times lower than it in the other organs. This makes such metal be concentrated in the most direct organs such as the gill and liver .

Tab. 2. Trace metals in *D.vulgaris*  $\mu$ g/g wet weight and Sea water  $\mu$ g/l from Lattakia-Banias-and Tartous

| Area     | Samples    | Lead        | Cadmium     | Mercury |
|----------|------------|-------------|-------------|---------|
|          | D.vulgaris | 0.151       | 0.224       | 0.129   |
| Lattakia | Sea Water  | 0.05-0.150  | 0.015-0.022 | -       |
|          | D.vulgaris | 0.257       | 0.213       | 0.158   |
| Banias   | Sea Water  | 0.052-0.500 | 0.003-0.175 | -       |
|          | D.vulgaris | 0.134       | 0.215       | 0.108   |
| Tartous  | C NL       | 0.30.0.75   | 0.02.0.09   |         |

*D.vulgaris* feeds primarily on Crustacea, Mollusca and Echinodermata [6], this type of food concentrate heavy metals directly from waters. Thus, it is likely that the food is the main source of transferring lead to the liver tissue. This reflect the tendency of gonad tissue to accumulate other metals such as zinc and copper but not cadmium, lead or mercury [1].

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# CHEMICAL CHARACTERIZATION OF MUCILAGE SAMPLES FROM THE GULF OF ELEFSIS, GREECE

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### Abstract

Chemical analyses of mucus macroaggregates collected in the gulf of Elefsis, Greece, depicted a low protein content and the presence of degradation products. IR and <sup>1</sup>H-NMR spectroscopy demonstrated the presence of carbohydrates, aliphatic components, characteristic groups such as ester and amide groups and organosilicon compounds. The role of carbohydrate exudates by diatoms in the development and flocculation of diatom blooms was also investigated by observing biological specimens with epifluorescence microscopy using ConA lectine conjugated with fluoresceine.

Keywords : Chemical Analysis, Blooms.

Incidents of marine mucilage appearance, attributed to blooms of phytoplanktonic organisms, represented by gelatinous aggregates suspended in water column, are common in several areas of the Mediterranean, such as the Aegean Sea. However, the chemical composition of mucus aggregates remains only partly elucidated. Regarding their role in marine chemistry, the formation of mucilage participates in the cycling of marine organic matter and contributes to the agglomeration of its dissolved forms (DOM) towards colloidal and successively into particulate forms (POM) [1]. Through their various complexing sites, mucilage may act as a natural surfactant resulting in effective floatation, which could be progressively transformed into a flocculant able to accumulate various substances, among which dissolved metals, influencing their biogeochemical cycling [2]. The present study presents the results of chemical and spectroscopic analyses of mucus macroaggregates collected during an extraordinary phytoplankton bloom event in the summer of 2003 in the gulf of Elefsis, aiming at a systematic approach of the structure and evolution of these aggregates.

Well developed macroaggregates were collected by scuba diving both from the surface and the sea bottom of the western coastal part of the Elefsis gulf. The samples were freeze-dried and subsequently extracted several times with Milli-Q water in order to remove salts. Following centrifugation, they were relyophilized and afterwards used for C, N, heavy metal (Cd, Cu, Zn), IR and <sup>1</sup>H-NMR analyses.

C and N contents of samples were determined using an EA 1180 CHN Fisons Instruments elemental analyser. Heavy metals were determined employing GFAAS following wet digestion of samples. For spectroscopic analyses the dried samples were extracted twice with diethyl ether to remove lipids and pigments and the residue gently evaporated to dryness. IR spectra were obtained by a Perkin Elmer system 883 using KBr pellets and <sup>1</sup>H-NMR spectra by a Unity Plus Varian operating at 299.95 MHz, following solubilization of the sample in a percentage equal to 80-85% in deuterated trifluoroacetic acid (TFA). To observe polysaccharides in specimens, epifluorescence microscopy (Olympus BX51) was used to determine the nature of released polysaccharides by incubating samples for 1 h with 25  $\mu$ g ml<sup>-1</sup> Con-A (Sigma) conjugated with fluoresceine isothiocyanate (FITC), a lectin from *Concanvalia ensiformis*, which specifically binds glucose and mannose residues [3].

Macroaggregates are characterised by a rather high OC/N ratio (Table 1), indicating a relatively low protein content of the samples and the presence of degradation products [4]. However, the higher Cu and Zn concentrations detected in the mucilaginous mass from the sea surface compared to those of the bottom one (Table 1), may be attributed to a combination of atmospheric input of metal particles and the properties of the surface mucus, which formed stable foams floating on the sea surface, in the interface between atmosphere and seawater.

The IR spectra showed an almost identical composition for surface and bottom samples, both characterised by the presence of carbohydrates and proteins as major fractions of the mucilaginous mass. In the <sup>1</sup>H-NMR spectra, following calculation of H integrals, four major classes of compounds are identified: carbohydrates (36%), aliphatic chains (45%), substances with ester and amide groups (14%) and organosilicon compounds deriving from diatoms (4%). The presence of aromatic structures was very limited (1%).

As indicated spectroscopically, mucilaginous macroaggregates consist mainly of carbohydrates which appear in a lower percentage than aliphatic chains, since they degrade faster. Microscopy observations by using labelled lectine demonstrated clearly that the lysis of phytoplankton cells releases in seawater polysaccharides in the form of glue [3], dominating the formation of Transparent Exopolymer Particles (TEP), which possess a critical role in the coagulation of blooms. The increase in the concentration of TEP and the simultaneous decrease in the complexing capacities of dissolved metals during the mucilage appearance [5] point to a possible mechanism according to which TEP contribute to the aggregation, among others, of dissolved organic substances that may, otherwise, act as ligands of metal ions.

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Tab. 1. C, N and heavy metal content of mucilage samples collected from the surface and the bottom of the Elefsis gulf.

| Chemical Parameter | Surface           | Bottom            |
|--------------------|-------------------|-------------------|
| %C                 | $11.5 \pm 0.2$    | $11.3 \pm 0.1$    |
| %OC                | $2.64 \pm 0.10$   | $1.64 \pm 0.01$   |
| %N                 | $0.330 \pm 0.040$ | $0.150 \pm 0.017$ |
| OCAN               | 8.00              | 10.9              |
| N/C                | 0.029             | 0.013             |
| $Cd(\mu z/z)$      | $0.11 \pm 0.03$   | $0.17 \pm 0.02$   |
| Cu (uz/z)          | $12.1 \pm 2.6$    | 3.87±0.90         |
| $Zn(\mu z/z)$      | $69.1 \pm 1.0$    | $34.0 \pm 3.6$    |

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# STABLE ISOTOPIC COMPOSITION (DELTA<sup>13</sup>C AND DELTA<sup>15</sup>N) OF PARTICULATE ORGANIC MATTER IN THE WESTERN GULF OF LIONS

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## Abstract

Two submarine canyons in the southwestern part of the Gulf of Lions (western Mediterranean Sea) are currently studied to understand their role in the cross-margin redistribution of organic material derived from primary production and terrestrial runoff. Carbon and nitrogen stable isotopic composition is determined on the organic fraction of settling particles collected by sediment traps deployed over one year and from marine sediments collected below the array of nine mooring lines. Simultaneously, suspended particles of local rivers are sampled on a monthly basis to trace the terrestrial source and follow its influence within the Gulf of Lions. Keywords : Gulf Of Lions, Organic Matter.

Submarine canyons are key environments on continental margins, known as fast-track corridors for material transferred from the land to the deep sea, major pathways for transportation and burial of organic carbon in the oceans, and hotspots of biodiversity. Thus, canyons are complex systems in terms of their hydrography, sedimentology, biogeochemistry and biology. The better understanding of the biogeochemical drivers that control canyon ecosystems is one of the aims of the HERMES project (Hotspot Ecosystem Research on the Margins of European Seas), launched in April 2005 as part of the 6th European Research Framework Programme.

HERMES has concentrated much effort on the study of the Lacaze-Duthiers and Cap de Creus canyons in the southwestern part of the Gulf of Lions, which are considered as particularly active sediment conduits during present conditions [1]. Previous results obtained on this margin have also shown that sediment transport at the head of these canyons is mainly associated with easterly storms and shelf water cascading events during wintertime [2], which may enhance transfer of organic matter of terrestrial origin into the slope waters. Finally, spectacular communities of deep water corals have been recently found in several places of the Cap de Creus canyon head [3].

The biogeochemical drivers in these two canyons are being studied, focusing on the quality of bulk organic matter, which appears to determine the distribution of key fauna. To provide a general view of the role played by these canyons in the redistribution of carbon derived from primary production and terrestrial runoff, stable carbon and nitrogen isotopes ( $\delta^{13}C$ and  $\delta^{15}$ N) are used to examine the sources of organic material, the biogeochemical processes involved in its transformation, and the physical processes of material transport and mixing. Analysis were conducted in samples collected by sequential sediment traps (12 cups) placed in nine mooring lines deployed over one year, from October 2005 to October 2006 in two consecutive deployments. Moorings were placed along the axis of the Lacaze-Duthiers and Cap de Creus canyons at 300, 1000, 1500 m depth, in the confluence of both canyons at 1900 m depth, and on the adjacent southern slope at 1000 and 1900 m depth (Fig. 1). Traps were placed at 30 m above bottom, together with one current meter equipped with temperature, conductivity, pressure and turbidity sensors at 5 m above bottom. The mooring at 1000 m in Lacaze-Duthiers included one extra sediment trap-current meter pair at 500 m above the bottom.

In addition, particulate matter samples from local rivers and marine sediments are used to characterize the riverine input, asses the amount of riverine organic matter sequestered by the canyons and exported towards the abyssal plain and provide information about the fate of the off-shelf transported particles and their impact on the canyon and deep basin ecosystems.



Fig. 1. Location of the nine mooring and sediment core stations in the southwestern region of the Gulf of Lions.

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# EXPORT OF DISSOLVED ORGANIC CARBON TO DEEP WATERS IN WESTERN MEDITERRANEAN

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# Abstract

Three deep water types were observed in Western Mediterranean Sea in Spring 2005 [1]. These waters showed different DOC concentrations, in relation to their formation site and their age. The highest DOC values (72-58  $\mu$ M) found in the new WMDW, characterized by a higher amount of Atlantic water, confirm the relevance of the deep water formation processes in DOC export to the deep layers. *Keywords : Organic Matter, Deep Waters, Western Mediterranean.* 

Dissolved Organic Carbon (DOC) in the sea represents one of the major reservoir of organic carbon on the Earth [2]. In the past, the role of DOC in deep sea respiration has been underestimated, as demonstrated by Christensen et al. (1989) data on carbon oxidation [3]. They found in Western Mediterranean deep waters (WMDW) values of electronic transport systems (ETS) higher than those measured in the Oceans and proposed that DOC transport, during deep water formation, could rival the sinking particulate flux, in importance for deep-sea metabolism. In general, deep waters of Mediterranean Sea are characterized by higher DOC concentration than Oceans [4,5].

The goal of this work is to study the role of deep water formation in the carbon supply to the deep ecosystem in the Western Mediterranean Sea. In spring 2005 a layer of newly formed WMDW was found in the bottom of Gulf of Lions, Balearic Sea, Algero-provençal basin and northern Algerian basin [1]. In particular three different water types with different physical and chemical characteristics were evidenced by the  $\theta$ -S diagrams (figure 1): resident deep water (type A); newly formed, mainly of open sea origin (type B); newly formed, mainly of surface and costal origin (type C) [1]. DOC showed different concentrations in the core of each water type, with the lowest values (42 $\pm$ 3  $\mu$ M) in type A water, values of about  $49\pm3 \ \mu\text{M}$  in type B water, and the highest values (65 $\pm8 \ \mu\text{M}$ ) in type C water. Assuming 40  $\mu\mathrm{M}$  as the refractory DOC pool in Mediterranean Sea [4], we can deduce that the amount of semi-labile carbon, available for bacteria, was 39 % of DOC in type C water, 18% in type B water and only the 5% in type A water. Studying DOC spatial variation in the core of each water type, water A and B maintain their DOC concentration in all the transects, whereas DOC in type C water showed values of  $72\pm4$  $\mu$ M in the Gulf of Lions and the Algero-Provençal basin and of 58±3  $\mu$ M in the Balearic Sea and Algerian Basin, with a correspondent reduction of its semi-labile fraction from 44% to 31%. Type C water, which is characterized by a major portion of Atlantic water, was formed probably near to the coast, in a region characterized by high productivity [1]. For this reason a very high amount of DOC (>72  $\mu$ M) may be exported to the deep layers. Moreover this water was characterized by a very high dissolved oxygen concentration (212  $\mu$ M) suggesting that little organic matter has been consumed in its core, consequently, the amount of DOC found in this water may give a good estimation of DOC export to depth. The significant DOC spatial variation in the core of type C water may arise from the availability of high amount of semi-labile DOC for bacteria that can be consumed with a short temporal scale. The lowest DOC values found in type A water may be explained by the mineralization of almost all semi-labile DOC exported from the surface. This water in fact is an old resident deep water, as demonstrated by its lower content of DO (196  $\mu$ M, fig.1). Surprisingly also the newly formed type B water was poorer in DOC than type C water (fig.1). This lower DOC content may be explained by the major contribution of LIW (poor in DOC) to type B water and by its probable formation site in the open ocean [5]. In conclusion, WMDW is an important source of Carbon for deep waters ecosystems, but the mechanism of deep waters formation and the DOC production-accumulation processes, occurring at surface, may affect the quantity and quality of DOC transported to the bottom. As the export of different amounts of semi-labile DOC to the bottom may be vital for deep waters ecosystem, DOC represents an important link between surface processes, deep water formation mechanisms and deep water metabolism.



Fig. 1.  $\theta$ -S diagram for deep layer of a representative section. Dissolved organic carbon (DOC) and dissolved oxygen (DO) mean concentrations, in the core of the different water types, are indicated on the diagram. Study area and sampling stations are indicated in the map on the left.

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# TRACE METALS IN ALGAE FROM THE SOUTH-WESTERN COAST OF SARDINIA (ITALY)

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## Abstract

Cadmium, Hg, Pb, and Zn concentrations were determined in 28 species of red, brown, and green algae sampled in the south-western coast of Sardinia (Italy). Elevated concentrations of heavy metals were mainly associated with the presence of smelting activities in the area. *Keywords : Algae, Bio-indicators, Trace Elements.* 

Algae have been considered a valuable indicator for the assessment of trace metals in coastal areas because of their accumulation capacity. Algae bind only free metals ions and they do not reflect total metal loads, as they do not respond to metal associated with organic or inorganic particulate matter [1]. Despite metal uptake can be influenced by several variables (e.g. season, sampling position in the shoreline, coexistence of several metals, salinity, water temperature) algae are suitable to reflect the soluble trace metal content of their ambient surroundings with a high degree of time-integration.

In this survey carried out in 2005 algae were collected in the coast of Sardinia (Italy) south of Portoscuso and in the nearby island of San Pietro. Portoscuso (39° 12' 40" N) is a site of major heavy metal contamination. Its industrial area includes a lead-zinc smelter, a plant producing alumina from bauxite and a coal-fired power generation plant. Furthermore the region was intensively mined. Extremely high concentrations of Cd, Hg, Pb, and Zn were found in the sediments of the industrial harbour [2].

Twenty-eight species of red, brown, and green algae (80 samples) were harvested. The most frequently sampled species were *Padina pavonica, Dictyota dichotoma, Enteromorpha sp., Ulva rigida*, and *Corallina mediterranea*. They were collected by hand in the subtidal zone up to at a depth of about 2 m. A minimum of 3 samples of each occurring species were collected from each station. All thalli were thoroughly cleaned with seawater, followed by running with distilled water to remove adhering particulate matter and epiphyte. The samples were bulked in plastic bags. Materials were oven-dried at 30°C to constant weight and then pulverised to ensure uniform distribution of metal in the samples. Algal materials were determined by atomic absorption spectrometry. Analytical quality control was performed with reference materials NBS 1571 Orchard Leaves.

The levels of trace metals in algae varied widely depending on collection zone and algae species . Generally the order of metal abundance in the algae was Zn>Pb>Cd>Hg . *Dictyota dichotoma* and *Padina pavonia* were the algal species which accumulated more Cd, Pb, and Zn. The highest Hg concentrations were found in *Halopteris scoparia* and *Enteromorpha prolifera*. As expected, the highest levels of all metals were found in the vicinity of Portoscuso (Cd up 58  $\mu$ g g<sup>-1</sup> dry wt Hg up to 151  $\mu$ g g<sup>-1</sup> dry wt; Pb up to 80  $\mu$ g g<sup>-1</sup> dry wt, Zn up to 930  $\mu$ g g<sup>-1</sup> dry wt,). In the island of San Pietro, algae in the coast in front of Portoscuso (distance about 5 miles) contained higher levels of metals than those in the unexposed western part of the island, where reference stations were located (median values in reference stations: Cd 1.2  $\mu$ g g<sup>-1</sup> dry wt; Hg 0.05  $\mu$ g g<sup>-1</sup> dry wt; Pb 16.7  $\mu$ g g<sup>-1</sup> dry wt; Zn 52  $\mu$ g g<sup>-1</sup> dry wt). The occurrence of metals in the investigated area is high if compared with that reported in other coastal areas affected by human activities [3,4,5,6].

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metals in eastern Mediterranean Sea algae. J. Environ. Radioactivity, 67:157-168.

# NUTRIENT DISTRIBUTIONS AND FLUX ESTIMATES IN THE WESTERN MEDITERRANEAN SEA

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## Abstract

In spring 2005 an oceanographic survey was carried out in the central part of the western Mediterranean basin. Hydrological data and nutrient distributions were analyzed along eight transects. The distribution of physical properties evidenced the peculiarity of winter 2004/2005, which was characterized by the formation of a significant amount of new WMDW. The geostrophic transports across each transect were estimated with an inverse box model, allowing the assessment of the exchanges between sub-basins. Mass transport estimations permitted the computation of the biogeochemical fluxes between sub-basins. Finally, nutrient mass balances enabled us to estimate new production in the inner basins.

Keywords : Circulation Models, Hydrology, Inverse Methods, Western Mediterranean.

In spring 2005 the central part of the Western Mediterranean Sea has been investigated, in order to better define the pathway, the physical and the biochemical properties of the water masses involved in the circulation of this basin. Hydrological data and nutrient distributions were analyzed along eight transects.

The aim of this study was the assessment of the nutrient distribution in key regions of the Western Mediterranean Sea (WMED) and the estimation of the biogeochemical fluxes between sub-basins, by means of an inverse box model. This should be a first attempt to quantify the nutrient budgets in different sub-basins of the WMED.

The distribution of physical properties (temperature, salinity and density) evidenced the peculiarity of winter 2004/2005, which was characterized by the formation of a significant amount of new Western Mediterranean Deep Water (WMDW) [1]. The biogeochemical features appear strongly associated with the hydrodynamical patterns, with a close relationship between chemical parameters and water mass distribution.

Two typical nutrients vertical profiles were found in the investigated area (see figure 1). The first profile refers to the southern part of the WMED, where the new WMDW has not been found: concentrations, very low in the surface layer, increase with depth, reaching a maximum in the intermediate layer, occupied by the oldest water mass found in this region, the LIW. In the deep layer nutrient concentrations are relatively high. A different situation is found in the second type, which refers to the northwestern part of the WMED, where significant amounts of the new WMDW were found. The surface concentrations are higher and the intermediate ones lower. The reason may be the convective processes acting in this area during the dense water formation period, which may have lead to a considerable mixing between the two water masses. Further, the deep layer, which was occupied by a newly formed water mass, shows a strong decrease in nutrient concentrations. This is because the *voung* water mass has not had the time to accumulate nutrients and to remineralize the whole amount of organic matter.

The geostrophic currents and mass transports across each transect were estimated with an inverse box model, imposing the conservation of mass, heat and salt in closed volumes of water (5 boxes). Mass transport estimations permitted the computation of the biogeochemical fluxes between sub-basins. If the import exceeds the export there is a nutrient sink inside the box, i.e. the nutrient amount entering the box is higher than the amount leaving it, therefore there has to be a nutrient consuming process (sink). On the other hand, if the export exceeds the import, there is a nutrient producing process inside the box, a source.

Generally there is a nutrient sink in the surface layers, to which corresponds a deep source [2]. A nutrient sink may be attributed to primary production in the euphotic zone, which consumes nutrients, or to vertical fluxes inside the box. The last term has not been quantified by the inverse model. The deep nutrient source, instead, may be attributed to remineralization of organic matter, which has been exported from the euphotic zone, to vertical fluxes of inorganic nutrients, and to horizontal import of organic matter and therefore to the export production of bordering areas. Attributing the deep nutrient sources to the remineralization of organic matter and therefore to the previously exported production, it is possible to estimate the export production of the area [3]. In order to perform this computation we used the classical Redfield ratio (C:N:P = 106:16:1). For the whole box we found an export production of 80 - 90 mg C m<sup>-2</sup> d<sup>-1</sup>. These values agree with the estimated ranges of Béthoux (1989, [3],

corrected by [4]) for the WMED, comprised between 68 and 123 mg C  $m^{-2}\;d^{-1}.$ 



Fig. 1. Station map and two typical nutrient profiles.

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# RANGES OF CONCENTRATION OF "QUALITY CONTROLLED" OCEANOGRAPHIC DATA (INORGANIC NUTRIENTS, DISSOLVED OXYGEN AND CHLOROPHYLL-A ) FROM THE NW MEDITERRANEAN

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### Abstract

Quality control procedures have been applied to oceanographic data collected at the Catalan Sea, NW Mediterranean Sea. The data source ranges from historical data from MEDATLAS and MATER databases, inhouse data from CSIC (IIP, ICM and CEAB) from 1982 to 1997, to recent cruises of ICM, from 1999 to 2003. The effects of sample manipulation and chemometrics on the data have been studied. On this basis the ranges for each variable have been defined. This "quality controlled"data would be used to study ecological and biogeochemical processes at the Catalan Sea (NW Mediterranean), such as seasonal dynamics of nutrients, dissolved oxygen and chlorophyll-a, as well as stoichiometry.

Keywords : Western Mediterranean, Phosphorus, Oxygen, Phytoplankton, Hydrography.

Altough the Catalan Sea (NW Mediterranean Sea) has been largely studied over more than 30 years of oceanographic research (Table 1), the ranges of variation of some crucial data, such as inorganic nutrients, are not yet defined. At the MEDATLES and MATER databases ([1], [2]) there is a quality control of oceanographic data based on [3], which includes gradients and spikes of concentration, however specific ranges of the data in our study area (region DS2) are not given. In this study, procedures for quality control of the data has been adapted from [4] and [5], according to the quantity of data and other factors that control the distribution of the different variables at the Mediterranean and Catalan Sea. Experiments evaluating the effect of freezing nutrient samples from the area of interest have been performed, and the precision has been estimated for those cruises that do not report it. Table 1 shows the regional limits for inorganic nutrients, dissolved oxygen and chlorophyll-a for the Catalan Sea. The ranges have been specially studied for winter, when the highest intensity of vertical mixing processes takes place. The use of this quality controlled data allows us to distinguish structures related to the hydrograpy of the area, to study the seasonality of the variables and to verify the values of the ratios between variables such as stoichiometry. We thank Dra. M. Estrada, Mr. J. Salat, Dr. M. Alcaraz, Dra. A. Sabatés and Dr. A. Palanques for kindly providing the data and funds for this study.

Tab. 1. Ranges of concentration of oceanographic variables at the Catalan Sea, NW Mediterranean. n = quantity of data; year: range of years studied.

|                               | Minimum | Maximum | n     | year        |
|-------------------------------|---------|---------|-------|-------------|
| Phosphate (µM)                | 0.0     | 0.52    | 9266  | 1957 - 2003 |
| Nitrate + nitrite ( $\mu M$ ) | 0.0     | 9.75    | 10053 | 1979 - 2003 |
| Nitrite (µM)                  | 0.0     | 0.60    | 11374 | 1976 - 2003 |
| Ammonia (µM)                  | 0.0     | 2.80    | 2244  | 1982 - 2003 |
| Silicate (µM)                 | 0.0     | 10.75   | 12675 | 1970 - 2003 |
| Dissolved oxygen (ml/l)       | 3.8     | 7.10    | 13360 | 1910 - 2000 |
| Chlorophyll-a (µg/l)          | 0.0     | 2.75    | 6455  | 1976 - 2003 |

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# MOLECULAR DISTRIBUTION OF DICARBOXYLIC ACIDS AND RELATED POLAR COMPOUNDS IN THE RHONE RIVER AND COASTAL MEDITERRANEAN SEA WATER IN RELATION WITH PHOTOCHEMICAL AND BACTERIAL PROCESSES

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## Abstract

We recently developed a new method for extraction and detection of diacids in marine waters and found that such free dissolved organic compounds may comprise up to 2.5% of dissolved organic carbon (DOC) (1). Here, we report for the first time, molecular distribution of diacids and related polar compounds in North western Mediterranean Sea and Rhone River samples. Additional laboratory controlled experiments indicated that biological process largely controlled molecular distribution of diacids in marine DOM although they can be quantitatively produced through photochemical oxidation reactions of unsaturated long chain fatty acids. *Keywords : Organic Matter, Bacteria, Rhone Delta, Chemical Speciation.* 

 $\alpha, \omega$  dicarboxylic acids are abundant short chain intermediate reactions products found in aerosol, rainwater and snow samples. They are produced in the atmosphere by incomplete combustion of fossil fuels or fresh biomass as well as from the ozonolysis and photooxidation of natural and anthropogenic organic compounds in the atmosphere. The main sink of these short chain diacids remains the photomineralization process and in cloud scavenging since shorter chain compounds may act as cloud condensation nuclei (2). This process can in turn affect the radiative earth balance.

We recently developed a new method for extraction and detection of diacids in marine waters and found that such free dissolved organic compounds may comprise up to 2.5% of dissolved organic carbon (DOC) (1). Briefly, the seawater sample was first acidified and then passed through an activated charcoal column to adsorb the dicarboxylic acids. Diacids were then derivatized with BF3/n-butanol to dibutyl esters, and determined using a capillary GC/MS. Here, we report molecular distribution of diacids and related polar compounds in North western Mediterranean Sea and Rhone River samples which is the main supplier of dissolved organic matter to the whole Mediterranean Sea (3).

Our results indicated significant changes in the molecular distribution between atmospheric rainwater and aerosol samples and aquatic samples. Additional laboratory controlled experiments, indicated that biological process largely controlled molecular distribution of diacids in marine DOM although they can be quantitatively produced through photochemical oxidation reactions of unsaturated long chain fatty acids (4).

In natural waters, many photochemical reactions are driven by \_OH radicals, which is one of the most reactive oxidants. Major sources of \_OH radicals in natural waters are the nitrate (NO<sub>3</sub>-) and nitrite (NO<sub>2</sub>-) photolysis, initiated by UV-B and UV-A (315-400 nm), respectively, as well as the photolysis of colored dissolved organic matter (CDOM), initiated by both UV-B and UV-A. Photochemical oxidation reactions may substantially modify molecular distribution and bacterial availability of dissolved organic compounds in natural waters and then play a significant role in aquatic carbon cycle. In this study, we also assessed under laboratory controlled conditions, the direct and hydroxyl radical (\_OH)induced photochemical production of low molecular weight (LMW) dicarboxylic acids and related compounds (C2-C9) from oleic acid (cis-9-octadecenoic, \_9C18) in pure, fresh and marine solutions. Additional laboratory biodegradation experiments indicated that the molecular distribution as well as their relative abundance within the DOC reservoir of dicarboxylic acids are the result of an equilibrium between by bacterial assimilation, phytoplankton releases and photochemistry. Here we discuss about the sources and sinks of dicarboxylic acids in aquatic waters.

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# GEOCHEMISTRY OF SEDIMENTS FROM A DISEQUILIBRIUM, RIVER-DOMINATED ESTUARY: THE RAŠA RIVER ESTUARY (ADRIATIC SEA, CROATIA)

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## Abstract

The geochemical characteristics of fine grained clayey sediments from a small, rock-bounded microtidal, low-wave energy, karstic estuary in the north-eastern Adriatic (Raša River) were studied. The results of field work and of corollary laboratory experiments have indicated the general features of distribution of heavy metals, and characteristics, distribution and the origin of organic matter in estuarine sediments. Both, the distribution of heavy metals and of organic components, are governed by rapid deposition of fine-grained, mostly clayey particles, in the restricted upper part of the estuary, and by prevalent physico-chemical conditions (Ehand pH). *Keywords : Organic Matter, Metals, Adriatic Sea, Estuaries, Sediments.* 

Study Area

The Raša River and its estuary are located at the south-eastern part of the Istrian peninsula, Croatia. The estuary was formed by Holocene sea-level rise when the river valley, carved into carbonate rocks, was flooded by the sea. The Raša river estuary is a region of intensive deposition of fine-grained, mostly clay particles originating from clastic Eocene flysch sediments. It carries more than 90 % of particulates as suspended matter that preferentially accumulates in the low-wave energy environment at the head of the estuary, causing a progradation of the estuary into a category of river-dominated disequilibrium estuaries [1].



Fig. 1. Physico-chemical conditions (Eh, pH) (a), heavy metal concentrations (b), and stable isotope composition of SOM (c) in sediment core taken at the sampling station 2 (water depth 12 m).

#### Materials and Methods

Sediments were collected along the estuary at 4 sampling stations by scuba diving, using hand-held corers 60 cm long. After sampling, sediments were frozen and kept at  $-20^{\circ}$ C until further analyses were performed. The latter included mineralogical, grain-size, surface physico-chemical and trace metal analysis, and furthermore, the determination of the concentration and C and N stable isotope compositions of sedimentary organic matter (SOM).

#### Results and Discussion

The Raša River estuary is a good example of biogeochemical land-sea interactions occurring in a microtidal, low energy environment. Previous investigations have shown that the dynamics of sedimentation in this region is effectuated through abundance of fine-grained particles and by intensive flocculation processes at the salt wedge. These processes result in prograding the estuarine delta and govern the formation of physicochemical, and therefore, geochemical conditions in clayey sediments [1]. Indeed, the horizontal distribution of heavy metals is governed by the presence of fine-grained clayey particles and their sedimentation pattern. On the otherhand, the vertical distribution of heavy metals is governed by prevailing physico-chemical conditions in the sediments. Thus, as example, Fig. 1b shows the distribution of heavy metals in a sediment core taken at sampling station 2. Background concentrations of Zn and Cu are significantly increased in uppermost strata especially at the oxic-anoxic boundary (Fig. 1a). The concentration and stable isotope composition of sedimentary organic carbon ( $\delta^{13}$ C) show little variation with depth (Fig. 1c), indicating that the high sedimentation rate mostly overrides the effects of diagenetic processes on the decomposition of sedimentary organic matter. The sources of the SOM were estimated using C/N ratios and the  $\delta^{13}$ C values [2]. It was found that generally the terrestrial component of the SOM decreases with the distance from the river mouth. However, the operation of the port used for the transport of timber and coal from a nearby coal mine (site 2 - Trget) introduced large amounts of organic material of terrestrial origin into the sediment. The results of these investigations should help in understanding the ultimate environmental capacity of the estuarine sediment system in receiving and disposing of heavy metals and organic materials, and in predicting the pattern of landsea interactions of the river dominated, low-energy environments of the Adriatic region.

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# PARTICLE COMPOSITION AND ORGANIC CARBON FLUX AT DYFAMED: INSIGHT FROM THE SHORT-LIVED NATURAL RADIONUCLIDES <sup>210</sup>PO AND <sup>234</sup>TH

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## Abstract

Trace metals, minerals, organic carbon, nitrogen, and the natural radioisotopes <sup>234</sup>Th, <sup>228</sup>Th, <sup>210</sup>Po, and <sup>210</sup>Pbwere measured in sinking particles collected in sediment traps at 200 min the northwestern Mediterranean. Organic biomarkers were used toidentify the types and sources of particulate organic matter and theresults indicate that the distribution of polonium in sinking marineparticles is influenced by fresh phytoplankton-derived material. Wethen compared POC fluxes estimated using <sup>234</sup>Th/<sup>238</sup>U and <sup>210</sup>Po/<sup>210</sup>Pb disequilbria and sediment traps at the same location. The <sup>210</sup>Po/<sup>210</sup>Pb system provided organic carbon flux estimates closer to the flux caught in sediment traps.

Keywords : Particle Flux, Radionuclides, Ligurian Sea, Carbon.

The disequilibrium between polonium-210 and its grandparent lead-210has been proposed as a tracer of the vertical flux of sinkingparticulate organic matter in the ocean. The mechanism of associationbetween  $^{210}\mathrm{Po}$  and organic matter is, however, still unclear. To investigate this association, we measured trace metals, minerals, organic carbon, nitrogen, and the natural radioisotopes <sup>234</sup>Th, <sup>228</sup>Th, <sup>210</sup>Po, and <sup>210</sup>Pbin sinking particles collected in sediment traps at 200 m in thenorthwestern Mediterranean. Pigments, fatty acids, and amino acids wereused to identify the types and sources of particulate organic matter.Multivariate analyses were used to determine which components ofsinking particulate matter are traced by <sup>210</sup>Po and/or by the <sup>210</sup>Po/<sup>210</sup>Pbratio. Statistical analysis of the results indicate that the distribution of polonium in sinking marine particles is influenced byfresh phytoplankton-derived, nitrogen-rich organic matter as well assulfur-containing amino acids. These findings are consistent withprevious laboratory observations that the distribution of <sup>210</sup>Poin biota parallels the distributions of both sulfur and protein ([1],[2], [3]), and indicate that these associations persist as materialsinks through the water column. While this research generally supports he use of <sup>210</sup>Po as a specific tracer of the flux of organic matter, the signals traced by  $^{210}$ Po/ $^{210}$ Pb and  $^{238}$ U/ $^{234}$ Th are not as distinct in the field as in laboratory experiments. Further work is needed to determine more precisely what <sup>210</sup>Po/<sup>210</sup>Pb traces, and to develop protocols to increase the correspondence of <sup>210</sup>Po/<sup>210</sup>Pb measurements to biogeochemically important rates and quantities.

In order to test the employment of the <sup>210</sup>Po/<sup>210</sup>Pbdisequilibrium, we then compared estimates of particulate organiccarbon (POC) flux determined from polonium and lead to those calculated from the disequilibrium between <sup>234</sup>Th and its parent <sup>238</sup>U. Water column thorium and uranium measurements, coupled with measurements of POC/234 Thratios on filterable or settling particles, have been used extensivelyto assess the sinking flux of POC (e.g. [4], [5]. In contrast, disequilibrium between <sup>210</sup>Po and <sup>210</sup>Pb has been infrequently used (e.g. [6]) to assess POC fluxes despite indications that <sup>210</sup>Po is assimilated into tissue and may be a better indicator of the fate of OC than  $^{234}\mathrm{Th}.\mathrm{Here},$  we compare the POC fluxes estimated from these two isotope pairs with fluxes measured in moored sediment traps below the euphotic zone. The POC flux at 200 m estimated from <sup>234</sup>Th and <sup>210</sup>Podeficits and the POC/Po or POC/Th on >70  $\mu$ m filterable particles measured through three seasons (early spring, late spring, summer)ranged from 3.8 - 17.5 mmol C/m<sup>2</sup>/d using <sup>234</sup>Th/<sup>238</sup>U and from 4.4 - 7.0 mmol C/m<sup>2</sup>/d using <sup>210</sup>Po/<sup>210</sup>Pb disequilibrium. In comparison, sediment trap fluxes of POC at 200 m ranged from 0.3 - 6.0 mmol C/m<sup>2</sup>/dover the same interval. Values of POC/Po and POC/Th ratios in sedimenttrap material collected in time series or separated according tosettling velocity were generally lower than values in the >70  $\mu$ mfilterable particles at 200 m. The variation in POC/Po and POC/Th inmaterial separated according to settling velocity showed no clearrelationship with settling velocity and was controlled more by particlecomposition and degree of degradation. Both <sup>234</sup>Th and <sup>210</sup>Poshowed sustained water column deficits in late spring and summer, despite low carbon fluxes recorded in the trap. Lateral processes(transport of particles along isopycnals or intrusion of shelf watersto the site) and temporal assumptions (steady-state vs. nonsteady-state) may be responsible for this disparity. Based on theresults of this study, we attest that <sup>210</sup>Po/<sup>210</sup>Pb

disequilibrium is as proficient as or better than  $^{234}$ Th/ $^{238}$ U in estimating POC flux in the occan.

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# MARINE MACROALGAE FOR ASSESSMENT OF RADIONUCLIDE AND HEAVY METAL POLLUTION IN THE BLACK SEA

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### Abstract

Radionuclide and heavy metal content have been monitored systematically since 1996 in eleven of the widespread Black Sea macroalgae species from the Bulgarian Black Sea coast by low level gamma spectroscopy and atomic absorption spectrometry. Tendencies in the concentration variations during the studied period are examined and all obtained data give information about different macrophytic species ability to accumulate certain nuclides and trace elements from one and the same sampling location. The obtained data are compared with the results from the regions of the Black Sea, Mediterranean, Tyrrhenian and Atlantic Ocean *Keywords : Algae, Black Sea, Bio-accumulation, Radionuclides, Trace Elements*.

Aquatic organisms, especially macroalgae are widely used as bioindicators for the study of marine contamination by radionuclides and heavy metals. Some species tolerate high levels of pollutants and can success-

fully be used to obtain reliable information of marine ecological status. In order to evaluate the ecological status of coastal habitat and provide valuable data for estimation of contaminants, an environmental monitoring program was started and performed along the Bulgarian Black Sea coast. Radionuclide and heavy metal content was monitored in eleven macroalgae species collected from about 20 reference locations during the period 1996-2005. Data are obtained for the most widespread species from the phylum Chlorophyta (six), Rhodophyta (three) and Phaeophyta (two), accumulation capacities are compared within and between Phylum and species to assess the levels of bio-accumulation and potential application as bio-indicators.

Tab. 1. Radionuclide activity concentrations in macroalgae collected in the Mediterranean and Black Sea. \* present study.

| Algae                | <sup>1.57</sup> Cs<br>Bq/lsg | <sup>40</sup> К<br>ВаЛяд | zoph<br>Bylig | <sup>237</sup> Ra<br>Bq/læ |
|----------------------|------------------------------|--------------------------|---------------|----------------------------|
| Ceramium rubrum[1]   | 0.8                          |                          | 10            | 25                         |
| Cystoseira sp. [2]   | 15                           | 900                      | 16            | 32                         |
| Cladophora sp. [2]   | n.d.                         | 2170                     | 4             | 1/1                        |
| Enteromorpha sp. [2] | 5                            | 1076                     |               | æ                          |
| Chaetomorpha sp. [2] | 11                           | 2525                     | 8             | 107                        |
| Ulvasp. [2]          | 6                            | 930                      | 8             | 25                         |
| Corallina sp. [2     | 5                            | 250                      | 9             | 22                         |
| Ceramium rubrum[2]   | 12                           | 880                      | 9             | 32                         |
| Ulvasp.*             | 3.4                          | 596                      | 6             | 93                         |
| Ceramium sp*         | 9.4                          | 1343                     | 13            | 17                         |
| Cladophora sp. *     | 12                           | 1300                     | 8             | 12                         |
| Enteromorpha sp. *   | 45                           | 690                      | 7             | 10                         |
| Cystoseira sp.*      | 5.4                          | 1400                     | 12            | 11                         |
| Chaetomorpha sp.*    | 23                           | 1860                     | 10            | 7                          |
| Corallina sp. *      | 2.1                          | 140                      | 12            | 10                         |
| Callithannion sp *   | 4.4                          | 1.580                    | 10            | 7                          |
| Ulvasp [3]           | < 1.2                        | 900                      | 3.49          | < 1.7                      |
| Cystoseira sp [3]    | < 1.1                        | 1800                     | 8             | 12                         |

The data for macroalgae, obtained by us are compared also with authors from the Black Sea region - (Romanian, Turkish) and Mediterranean Sea (Syrian) for radionuclides (Table 1) as well as Tyrrhenian (Italian) and Atlantic for trace elements (Table 2).

This work establishes a data base for radioecological status of Bulgarian Black Sea marine ecosystems concerning the radionuclide and trace metal content along the Bulgarian coast. Data were obtained at the chosen 20 locations for the eleven macroalgae species in the period 1996 - 2005 indicating no serious antropogenic pollution along the shore.

The studied macroalgae species are suitable for assessment of nuclide and trace metal behavior in the Black Sea ecosystems and some species can be used as bio-indicators for the status of the marine habitat.

| Tab.  | 2.    | Trace  | element    | conce  | ntrations | in  | macroalgae   | collected | in | the |
|-------|-------|--------|------------|--------|-----------|-----|--------------|-----------|----|-----|
| Tyrrh | eniaı | ı Sea, | Atlantic ( | Dcean, | and Blac  | k S | ea. *present | study.    |    |     |

| Algae                | Cd<br>mg/kg | Cr<br>mg/kg | Cu<br>mg/kg | Mn<br>mg/kg  | Zn<br>mg/kg | Pb<br>mg/kg |
|----------------------|-------------|-------------|-------------|--------------|-------------|-------------|
| Ulva lactuca [4]     | 135         | < 1         | 75          | 0.00         | 34.2        | 65          |
| Cystoseira sp. [4]   | 13          | < 1         | 42          | 3 <u>6</u> 1 | 33          | 53          |
| Ulva lactuca [5]     | 0.5         | 0.5         | 24          | 50           | 24.1        | 23.5        |
| Cystoseira sp. [5]   | 0.75        | 095         | 6.85        | 25           | 97          | 14          |
| Ceramium rubrum[5]   | 0.8         | 15          | 16          | 59           | 62          | 11          |
| Ulvasp.*             | 0.8         | 1.8         | 5.6         | 40           | 24          | 1.7         |
| Ceramium sp*         | 09          | 6           | 7.6         | 120          | 22          | 22          |
| Cladophora sp. *     | 1           | 7           | 6           | 170          | 19          | 35          |
| Enteromorpha sp. *   | 0.8         | 53          | 7           | 47           | 14          | 2.4         |
| Cystoseira sp.*      | 03          | 23          | 4           | 42           | 1.6         | 18          |
| Chaetomorpha sp.*    | 13          | 7           | 5           | 180          | 12          | 2.7         |
| Corallina sp. *      | 0.7         | 4.8         | 15          | 55           | 13          | 1.4         |
| Callithannion sp *   | 0.5         | 3.7         | 5.4         | 87           | 18          | 23          |
| Enteromorpha sp. [6] | 0.07        | 0.54        | 11.4        | 21           | 14          | 1.06        |
| Ulvasp [7]           | 0.18        | 1.63        | 5.8         | 841          | 45          | 194         |
| Padina pavonica [8]  | 1.56        | 3,6         | 13.3        | 851          | 84          | 11.4        |
| Ulvasp [9]           | 0.24        | 4.78        | 4.7         | 194          | 26.1        | 352         |
| Ulvasp [10]          | 0.6         | 1.56        | 55          | 64 L         | 52          | 3.68        |

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# PRIMARY RESULTS OF EUROPEAN COMMUNITY FP6 PROJECT ON MARINE POLLUTION AND SMES-(MAPO)

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# Abstract

World and particularly Europe are concerned with marine pollution which result in instant and long term damages to coastal and marine ecosystems. Various disasters have prove that the current means of struggle were inefficient. Every year around 3000 cases of illegal hydrocarbon dumping are detected in European waters. The amount of hydrocarbons received by European seas has been estimated at 109.000 tons/year. In addition, alien species migration,  $NO_x$  and  $SO_x$  emissions, biocides and ship building/repairing/scrapping activities, land based activities and run off from land are major sources of marine pollution. It is thus increasingly urgent to develop new solutions of fight by combining actors' skills from the maritime field. Struggling against marine pollution is deemed a priority in FP6 and in FP7. Enhancing Research and Development Projects to find Solutions to Struggle against various Marine Pollutions (MAPO) consortium gathers partners experienced in information and assistance to Small and Medium Sized Enterprises (SMEs) with in European Frame Work Programmes , environmental risk and marine pollutions (Researchers and technical consultants). MAPO partners come from 10 European countries (Lithuania, Spain, Germany, UK, France, Italy, Belgium, Turkey, Ukraine and Iceland); which enables to cover all European seas, thus improving dissemination throughout Europe, in order to reduce inequalities among maritime regions. *Keywords : Pesticides, Petroleum, Pollution, Organic Matter, Sewage Pollution.* 

#### Introduction

Worldwide seas and oceans are under treat. It is necessary to develop innovative and efficient means for early prevention, detection, warning and treatment of all types of marine pollution at a European scale. Regarding to the first calls of FP6, projects developed in "Global Change and Ecosystems" programme only 9.7%SMEs is counted. So as to reply this urgent need, the MAPO initiative will provide help and assistance to "Small and Medium Sized Enterprises (SMEs)" in view of their participation in current technological partnerships and in future European RTD projects. The support action is proposed by the MAPO Consortium aims at assisting European SMEs; to become integrated in ongoing Integrated Projects/Networks of Excellence (IP/NoE) and/or to build new technological partnerships and to participate in European Research and Technical Development (RTD) projects focusing on detection, treatment, warning and prevention of all types of marine pollution.



#### Fig. 1. The Map of the MAPO Consortium

#### Methodology

The duration of the MAPO project is two years. The project began on 1 September 2005. The MAPO Consortium has defined an ambitious set of objectives and implements its strategy by using targeted measures and innovative tools. MAPO project is structured into 5 workpackages. First workpackage deals with the management of the project while others dedicated to the technical aspects of the project. Two committees will compose the project management. The MAPO project is dedicated to strengthening SME capacities for technology strategy development through their integration into current IP/NoE and the preparation of the last calls for proposals of FP6 and first calls of FP7. This goal is supported by identification of best practices and trans-national experts meetings, training measures dedicated to SMEs. The MAPO project helps SMEs to gather the right partners for successful RTD co-operation and technological collaboration. This goal is supported by the following measures; European map of SMEs, large audience events, use of internet and on-line resources. The final aim is to find SMEs replying to requests of 20-30 Integrated Projects and Networks of Excellence within the FP6 and to build about 30 new Consortia intending to submit a European research proposal on a topic related to marine pollutions. To foster network, while identifying and training the most skilled European SMEs and isolating needs from relevant IP/NoE, MAPO consortium will analyse and share latest information on scientific and technological developments in the field of marine pollutions, and then gather RTD needs in this field. Identified SMEs will be encouraged to reply to new developments by participating in ongoing IP/NoE and/or in emerging and future European RTD projects.

#### Primary Results

The rate of the leaflet translated in the language of MAPO consortium influence area is 82%. 13 documents have been created by partners. 33 articles related to MAPO have been published by partners. Each partner has to organise of training meetings for first match-making and awareness to FP6and FP7 (Total 26 events). During the first year only two meetings have been organised. MAPO efforts within the initiative supporting recent FP6 calls should be considered as unsuccessful. MAPO initiative resulted in 20 contacted IP/NoE/STREP projects, among them; 10 project coordinators did not need any additional SMEs for project consortia, 3 projects were not quite relevant to marine pollution field, 5 project coordinators were aimed to apply to the new calls but they did not need MAPO help in search for SMEs and finally 2 projects were received MAPO assistance. At the first year of the project 980 SMEs have been contacted and 378 of them were identified. In additionally, 604 large companies and research centers which were related to marine pollution have been identified all along the European countries. 4 new project proposal for FP7 first calls were published on MAPO web site. The web site of the MAPO project is http://www.marine-pollutions.org

#### Conclusion

In general, people tend to focus on the direct consequences of marine pollution but the actual effect of marine pollution can go further this. It does not only jeopardize the environment but also have important effects on the country's economy and on the quality of life of its inhabitants. The MAPO project take into account all the various implications of marine pollution. Thus, it will enable the mobilization of European SMEs's skills and capacity to innovate and to play a key role in the protection of the marine environment.

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# EFFECTS OF OIL POLLUTION ON THE PHYTOPLANKTON COMMUNITY IN THE KUCUKCEKMECE BAY (NORTH-EASTERN SEA OF MARMARA, TURKEY)

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# Abstract

Volgoneft tanker accident occurred at 29 December 1999. It was spilled 3.086 t of heavy fuel oil in the Küçükçekmece Bay. This area heavily affected by oil pollution. The phytoplankton community was investigated in water sample during January 2000 and April 2003. Its density was decreased after the oil spill and two years later, when oil concentration level felt the phytoplankton abundance and number of species increased.

Keywords : Phytoplankton, Petroleum, Pollution, Sea Of Marmara.

Küçükçekmece Bay located at the northeastern Sea of Marmara Sea. The analyses of phytoplankton were made in one liter sea water sample taken at surface and 10 m deep water in 7 stations during two years after spill (Figure 1).

In this study were identified 77 taxa at 5 taxonomic classes on the phytoplankton community. These taxa were constituted diatoms (52%), dinoflagellates (41.5%), silicoflagellates (4%), cyanobacterium and euglenophyte (2.5%). After the accident were identified 24 phytoplankton species, while two years later increased to 40. The highest phytoplankton density in the surface water was reached  $87 \times 10^3$  cells  $1^{-1}$  in year 2000,  $29.5 \times 10^3$  cells  $1^{-1}$  in 2001,  $195 \times 10^3$  cells  $1^{-1}$  in 2002 and 5.4 x  $10^6$  cells 1<sup>-1</sup> in 2003. In January 2002, a diatom Pseudo-nitzschia delicatissima and in April 2003 an euglenophyte Eutreptiella sp. were dominated in the community. During the study period phytoplankton was mostly composed of dinoflagellates and diatom. In January 2000 dinoflagellates were the dominant groups, however diatoms were almost not observed. In the May 2000 dinoflagellates *Prorocentrum micans* (70 x  $10^3$  cells  $1^{-1}$ ) and in August 2000 Ceratium fusus (53 x  $10^3$  cells  $1^{-1}$ ) are dominant species. These results were indicated that dinoflagellates more tolerant than other phytoplankton.

The highest oil concentration at surface water was measured as 2178.5  $\mu g/L$  in December 1999 and it was decreased to 0.06  $\mu g/L$  in April 2003 [1]. It was reported that petroleum hydrocarbons reduced up to 36-40% photosynthesis in phytoplankton [2, 3]. The high oil concentration was inhibited the growth of *Prorocentrum micans*, while low concentrations stimulated [3]. The findings on the Sea Empress and the Tsesis oil spill no significant effect on phytoplankton due to decrease of zooplankton grazing pressure [4, 5]. We found that similar results with [2, 3], contrary to [4, 5] as high oil concentrations the growth of *Prorocentrum micans* was decreased, while at the low concentrations increased.

Figure 2 shows the relation of the oil pollution with the phytoplankton level. As can be seen in this graphical representation, when the oil concentration was increased the phytoplankton level decreased. According to these findings, it was concluded that the phytoplankton was reduced depending on the oil pollution level in sea water.



Fig. 1. The sampling stations.





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# DISTRIBUTION OF CARBOHYDRATES IN THE KARSTIC ESTUARY OF THE KRKA RIVER

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# Abstract

Seasonal and spatial distributions of dissolved (DTCHO) and particulate carbohydrates (PTCHO) were investigated in the highly stratified estuary of the Krka River over a period of one year. The observed longitudinal and vertical and concentration profiles indicate that the strongest accumulation of DTCHO occurs in the surface layer of during summer, reaching 1 mg C/L in the most eutrophic part of the estuary. The results are discussed in relation to hydrographic characteristics and nutrient dynamics of the estuary. *Keywords : Adriatic Sea, Estuaries, Carbon.* 

#### Introduction

Carbohydrates (CHO) represent one of the largest reservoirs of the organic carbon in the sea and play an important role in various processes of the biogeochemical cycle of marine organic matter. In some areas, affected by anthropogenically-enhanced eutrophication, such as northern Adriatic, CHO are involved in the aggregation processes, leading to massive mucilage events [1]. The aim of this study was to investigate carbohydrate distribution in a highly stratified estuary, situated in the central part of the eastern Ariatic coast, as related to hydrographic conditions and nutrient dynamics.

#### Materials and methods

Carbohydrates, including both dissolved and particulate fractions, were determined by MBTH method [2] after hydrolysis with HCl (1.7 M). Hydrographical parameters were measured in situ by a CTD probe (Seabird, USA), while nutrients were determined by standard methods. This paper covers the dataset from February to October 2000, including 6 sampling campaigns at four stations, situated along the longitudinal profile of the estuary, thus comprising high variability of hydrological and nutrient conditions.

#### Results and discussion

Seasonal and spatial distributions of PTCHO and DTCHO showed high variability of both CHO fractions. The total CHO concentrations spanned between 55 and 1107  $\mu$ g C/l, with DTCH/PTCHO ratios varying over wide ranges. However, the concentration of PTCHO was always significantly lower than that of DTCHO, which typically contributed more than 80 %. One of the most important characteristics of the Krka estuary is a very stable stratification throughout the year, and this feature was clearly reflected in the distribution of all hydrographic and biogeochemical parameters, including CHO (Figure 1).



Fig. 1. Vertical concentration profiles of PTCHO and DTCHO (A) and salinity and temperature (B) in the Krka estuary (E4A; July 2000).

Typically, the concentration of CHO was higher in the brackish surface layer than in the underlying marine layer, which is due to the stronger phytoplankton activity, fostered through river- and wastewater-borne nutrients. The distribution of CHO along the longitudinal profile of the estuary showed that enhanced CHO concentrations in the brackish layer were observed on all stations, however the effect was more clearly pronounced on the most eutrophic station E4A, situated in the lower part of the estuary. Seasonal distribution of CHO indicated that significant accumulation of DTCHO (up to 1 mg C/L) occurred in summer, which can be explained by increased production of carbon-rich phytoplankton materials under severe nitrogen-depleted conditions. Despite such a high CHO concentrations, formation of macroaggregates, similar to those in the northern Adriatic, was not observed, probably due to the relatively short residence-time of the brackish layer in the Krka estuary.



Fig. 2. Seasonal distribution of CHO and nutrients in the brackish layer of the Krka estuary (E4A).

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# PROTECTING ROLE OF POLYAMINES ON DNA UNDER THE COPPER STRESS; DETERMINED BY RAPD-PCR METHODS IN ULVA LACTUCA

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# Abstract

RAPD (Random Amplified Polymorphic DNA) analysis is used for the detection of DNA alternations after treatment of many genotoxical agents. Copper is essential to living organisms, but at elevated concentrations, copper may become toxic for living systems. In this study, the effects of copper were evaluated at the molecular levels in a marine green algae *Ulva lactuca* L. In addition, the protection role of polyamines against DNA mutations and strand breaks against the copper treatment searched by RAPD analysis. The main changes observed in the RADP profiles have been resulted both in appearance or disappearance of different bands and variation of their intensity. *Keywords : Algae, Genetics, Metals.* 

#### Introduction

Copper is essential for living systems, because of its role in electron transport system, respiration, growth, etc. However, many studies have also reported that copper induces toxicity. For instance, the binding of copper to DNA bases unwinds the double helix and DNA damage can be generated. Also in another study it was shown that the binding of copper to DNA is necessary for the generation of double- strand breaks, 8- hy-drodeoxyguanosine and intrastrand crosslinks in Fenton reactions.

Plant cells can be protected against the oxidative damage by a broad spectrum of radical-scavenger systems including antioxidant enzymes and a number of biologically active substance that may prevent the free radical induced cellular damage ([5]). To date, polyamines (PA) have been reported as efficient antioxidants in many experimental systems and various kind of environmental stresses ([8]). In addition, the biological activity of PAs is attributed to the cationic nature of these molecules. Furthermore, PA protects DNA damage by neutralizing charge and conformational changes of DNA ([3]). However, the PA role in the protection systems still remains unclear.

RAPD (Random Amplified Polymorphic DNA-Polymerase Chain Reaction) polymorphisms can occur due to base substitutions at the primer binding site sor to indels in the regions between the sites. The main purpose of this research is to investigate whether the protective role of polyamines on DNA mutation rate under copper stress in *U. lactuca* L. To test the above hypothesis, we employed molecular techniques and from our findings it seems that copper stress indeed causes damages to DNA and the damages caused to DNA could be conveniently and rapidly assessed by RAPD-PCR technique.

#### Materials and Methods

*U. lactuca* L. samples were collected from Izmir Bay and kept in ice during transportation to the laboratory. After cleaning with sterile distilled water the thallus divided into 5 pieces.

Samples were incubated for two hours with solutions of  $CuSO_4$  (30 mM) and compared with control samples soaked in sea water medium. In a separate trial, thalli were treated with CuSO4 30 mM and polyamines putrescine, spermidine and spermine (1 mM) for 2h. The light density measured by luxmeter and reported as 210 lux.

After incubation DNA isolated from *U. lactuca* L. samples by CTAB method.

RAPD-PCR was performed by 10 RAPD primers after checking the DNAs by agarose gel electrophoresis. PCR bands were checked again by agarose gel electrophoresis after PCR. The PCR analysis performed three times as control.

#### Results and Discussion

The effects of polyamines on the protection of DNA strand breaks by  $CuSO_4$  treatment searched by RAPD primers. There are band differenties between samples which are treated with different solitions; sea water medium, sea water medium with  $CuSO_4$ , sea water medium with  $CuSO_4$  and spermine, sea water medium and  $CuSO_4$  putrescine, sea water medium with  $CuSO_4$  and spermidine, respectively.

In the case of ROS generated by transition metals, most of the studies about the influence of polyamines on DNA damage have been based on the effect that these polyacations produce on DNA strand breakage rather than in the changes elicited on DNA bases. However, Pedreño et al. (2005) found that at higher metal concentrations spermine stimulated DNA damage by increasing the formation of single and double strand breaks and even causing the disappearance of the supercoiled, open circular and linear forms of the  $\Phi$ X174 DNA. Similarly, Mozdzan et al. (2006) showed that spermidin and spermine did not protect DNA and spermine even enchanced the DNA degradation by Cu<sup>+2</sup>-H<sub>2</sub>O<sub>2</sub> oxidizing system. On the other hand, spermidine and spermine were excellent protected to DNA from Cu<sup>+2</sup>-H<sub>2</sub>O<sub>2</sub>-ascorbic acid and Fe<sup>+2</sup>- H<sub>2</sub>O<sub>2</sub>-ascorbic acid-induced damage. Our results were showed that DNA damage occurs in *U. lactuca* L. after copper treatment.

The main changes observed in the RADP profiles have been resulted both in appearance or disappearance of different bands and variation of their intensity. The differentiation in band intensity and appearance or disappearance of some bands may correlate with level of photoproducts in DNA template and DNA structural changes such as deletions, insertions or breaks after copper treatment as genotoxic agent. When compairing the band variation between the samples incubated with only CuSO4, incubated with CuSO4 and polyamines putrescine, spermidine and spermine, and non-treated sample, it's seen that non-treated and spd treated samples didn't give any bands on agarose gel electrophoresis. But CuSO4 treated sample gave several clear bands. When we checked the polyamine treated samples spm and put treated samples have band variations among each other. Also intensity of the bands are variable. The RAPD analysis by other RAPD primers with these samples gave similar band profiles. Non of the samples gave same band patterns. On the bases of the results, it is conceivable, polyamines have some roles on protecting DNA base alternations against copper. Obviously, sensitivity of the RAPD assay depends on the mutation levels and it needs further investigations. We assume that this study may be help for the further searches on protective roles of polyamines on DNA strand breaks against genotoxic agents.

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# HEAVY METALS LEVELS IN SOME FISHES AND MOLLUSCS FROM SİNOP PENINSULA OF THE SOUTHERN BLACK SEA, TURKEY

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## Abstract

In the present study five heavy metal (zinc, copper, cadmium, lead and cobalt) concentrations in bottom fishes, *Mullus barbatus* L., 1758, *Merlangius merlangius euxinus* (Nordmann, 1840), *Spicara smaris* (L., 1758), *Raja clavata* L., 1758 and in the Mediterranean mussel *Mytilus galloprovincialis* Lamarck, 1819, the sea snail *Rapana venosa* (Valenciennes, 1846) from the Sinop coasts of the Black Sea have been measured by atomic absorption spectrophotometer for monitoring metal pollution in the coastal water. Significant differences in metal concentrations were found between the species (P<0.05). Similar significant differences were found with regard to different metals (P<0.05). The concentrations of Pb, Cd and Co were not detected in fish species. The same it can be said for Co and Pb in molluscs species. The other metal levels in the Mediterranean mussel and the sea snail were significantly higher than those in fishes. *Keywords : Metals, Fishes, Mollusca, Black Sea*.

#### Introduction

Heavy metals are a major anthropogenic contaminant of estuarin and coastal waters. Their inputs include urban run-off, industrial efluents, mining of operations and atmospheric depositions, and may be in particulate or dissolved forms. Most living organisms need small amounts of some essential metals such as iron, manganese, copper and zinc for their vital processes [2]. However these metals become toxic when they exceeded certain limits [4]. The non-essential metals cadmium, lead, mercury and silver are toxic even at relatively low concentrations [2]. Heavy metal pollution of marine biota is of environmental concern worldwide. [3] pointed out that for an organism to be a useful indicator of heavy metal pollution, there should be a simple relationship between heavy metal levels in the environment and in the organism. Both bivalve molluscs and gastropod molluscs represent organisms commonly employed as bioindicators, and used as a monitor of baseline environmental metal concentrations. Fish, also, are widely used as sentinels of contamination in the aquatic environment. Some fish species, in particular, may accumulate metals many orders of magnitude above background concentrations and thus, demonstrate their potential as bioindicators of pollution [5].

Material and Methods

#### Study Area

Samples of fishes and molluscs species were collected monthly by trawl, dredge and scuba diving equipment from the upper-infra littoral zone of the Black Sea, at depth of 20 meters or less from during the period January 2005-February 2006.

Six to fifteen individuals from each species were collected from each sampling stations and were rinsed in clean sea water and then placed in plastic bags and frozen at -21°C until their analysis. The tissues of the fish and molluses were prepared for analysis according to the method described by [1]. Whole fillets and liver were prepared separately from individual fish which were then cut into small pieces and homogenised. Five to ten gram samples of wet muscle tissue and liver tissue were placed in silica flasks and wet digested with 20 ml of HClO<sub>4</sub>:HNO<sub>3</sub> at 105 °C for 24 h. The filtered extracts were brought to 25 ml with HNO<sub>3</sub> (70%) and diluted [1]. The solutions were analysed by using a 929 UNICAM Atomic Absorption Spectrophotometer for metals.

#### Results and discussion

The concentrations of heavy metals in edible parts of demersal fishes ranged between; 1758; 0,380-2,714  $\mu$ g Cu/g ; 1,424-63,290  $\mu$ g Zn/g for *Mullus barbatus*, 0,913-8,952  $\mu$ g Cu/g ; 8,862-163,277 $\mu$ g Zn/g for *Merlangius merlangius euxinus*, 0,610-4,161 $\mu$ g Cu/g ; 6,234-57,743  $\mu$ g Zn/g for *Spicara smaris* and 0,496-9,356  $\mu$ g Cu/g, 6,601-35,873  $\mu$ g Zn/g for *Raja clavata*, all values being expressed on dry wt basis.

The concentrations of heavy metals in edible parts of mollusc species *Mytilus galloprovincilis* and *Rapana venosa* ranged between; 4,301-10,960  $\mu$ g Cu/g; 0,305-4,878  $\mu$ g Cd/g; 24,862-519,701  $\mu$ g Zn/g and 10,458-79,167  $\mu$ g Cu/g; 0,273-11,535  $\mu$ g Cd/g; 2,678-104,025  $\mu$ g Zn/g, respectively, all values being expressed on dry wt basis.

These results showed that the concentrations of heavy metals in organism depend on not only organism and metal but also different geographical location. The levels of metals for all fish species were well below the permitted levels, while the Mediterranean mussel and the sea snail showed higher levels. In conclusion, the heavy metal concentrations of fish in the Black Sea do not present any danger to human health or human consumption. Whereas, this cannot be said for molluscs.

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# DISTRIBUTION OF NUTRIENTS AND CHLOROPHYLL-A IN SAROS BAY

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## Abstract

The distribution of inorganic nutrients and chlorophyll-a were investigated in relation to the hydrography of the Saros bay in the Northern Aegean Sea. The data were collected during cruises in the period of March 2002 and December 2003, in the framework of a National project of TUBITAK. Levels of nutrients were generally lowest in the surface waters, they increased with depth. Elemental ratios of N:P and S:P were calculated to be 0.39-81.5 and 4.18-107.0, respectively. Besides high chlorophyll-a levels in surface waters, there were other maximum chlorophyll-a depths varied at 25-100 m interval in some periods.

Keywords : Aegean Sea, Coastal Systems, Eutrophication, Primary Production.

The Aegean Sea is one of the Eastern Mediterranean sub-basins located between the Greek and Turkish coasts and the islands of Crete and Rhodes. North Aegean Sea takes the mass inputs of Black Sea surface waters through the Bosphorus and the Dardanelles. The Saros bay is a part of the Northern Agean Sea and has maximum 650 m mean depth (Fig. 1). This study was carried out to determine the seasonal variations of nutrient and chlorophyll-a in relation to some CTD in the Saros Bay in period of 15 March 2002 and 30 December 2003. In this study, depths of 0.5, 10, 25, 50, 75, 100, 150, 200, 300, 400 and 500 m were accepted for standard sample depths. It was collected 54 samples for chlorophyll-a and 84 samples for nutrient in seasonal and vertical profile. CTD parameters such as temperature and salinity, nutrient and chlorophyll-a were measured by using YSI 556 MPS, Technicon Model Two Channel Autoanalizor and Jasco V-530 UV/VIS spectrophotometer, respectively [1].



Fig. 1. Saros Bay (North Aegean Sea) and sampling stations

Temperature and salinity were ranged between 11.26-24.82 °C and 30.35-38.99 ppt, respectively. Dissolved oxygen concentrations changed from 5.09 to 12.69 mg  $L^{-1}$  in the Saros Bay. Vertical temperature stratification was clear in spring and summer period in Saros Bay. There was also vertical stratification in salinity profile due to the Black Sea originated low salinity surface waters. Concentrations of NO<sup>-</sup><sub>2</sub>+NO<sup>-</sup><sub>3</sub>, PO<sup>-3</sup><sub>4</sub> and SiO<sub>4</sub>were between 0.07-4.21, 0.02-0.19 and 0.75-6.32  $\mu$ M, respectively. Concentration of NO-2+ NO-3(0.06-1.38 mM) in surface waters were lower than deep water values (0.05-1.60 mM) between March 2002 and December 2003 (Fig. 2). On the other hand,  $PO^{-3}_4$  concentrations were also higher in the surface waters (0.02-1.53 mM) when compared to deep waters (0.02-1.36 mM) in the same period. Similar to NO<sup>-2</sup> + NO<sup>-3</sup>, SiO<sub>4</sub> values were lower in the surface waters (0.53-3.77 mM) than deep waters (0.67-4.48 mM) (Fig. 2). N:P and S:P ratios ranged between 0.09-81.5 and 0.76-107, respectively in the Saros bay. The lowest N:P values were observed in the surface waters in March and May 2002. Generally, there was a regular increase with depth in N:P and S:P ratios. These ratios in this study were much higher than both the Redfield ratios (N:P=16:1; S:P=15:1) and a previous study [2]. Similar to the Dardanelles nitrate was more limiting nutrient than phosphate in Saros Bay.



Fig. 2. Vertical distribution of nutrient and chlorophyll-a in different season in the Saros bay (North Aegean Sea, Turkey) (A1-A4: Offshore station; B1-B4: Inshore Station)

The vertical distribution of chlorophyll-a showed that it ranged between 0,2029 mg  $L^{-1}$  (in May 2002) and 6,0424 mg  $L^{-1}$  (in April 2003) for the surface waters (0-10m) in Saros Bay. Surface chlorophyll-a level of both inshore and offshore station were higher (1.2145-6.0424  $\mu$ g L<sup>-1</sup>) in April 2003 and August 2003 than the other seasons 0.0845-1.8932  $\mu g$  L<sup>-</sup> (Fig. 2-A4, B4). Particularly, maximum chlorophyll-a depths were between 25-100 m in offshore station in surface chlorophyll-a lower periods. Chlorophyll-a levels were generally lowest ( $\leq 1.0 \ \mu g \ L^{-1}$ ) in March and May 2002. Chlorophyll-a levels in December 2003 were already much higher than March and May 2002 (Fig. 2). High chlorophyll-a levels in the Saros bay were related to phytoplankton blooms in same period. On the other hand, there was decrease with depth according to vertical profiles of both inshore and offshore stations due to high chlorophyll-a levels in surface waters. Besides high chlorophyll-a concentrations in surface waters, there were other maximum chlorophyll-a depths (50 m) out off surface (0-10 m) in some periods (especially in April and August 2003) (Fig. 2). It is known that maximum chlorophyll-a depths are found at 50-100 interval in the Mediterranean due to very lowest the concentrations in surface waters [2]. However, chlorophyll-a levels were high in surface (0.5 m) and sub-surface (10 m) waters of the Saros bay due to Black Sea originated surface waters and vertical mixing in the area.

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# $^{210}{\rm PO}$ and $^{210}{\rm PB}$ in the turkish coast of the Aegean sea ecosystem

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## Abstract

Samples of sea water, coastal sediment and other organisms have been collected from Turkish Coast of the Aegean Sea. Concentrations of <sup>210</sup>Po and <sup>210</sup>Pb in all the samples were analyzed by the chemical method and alpha counting technique. This paper presents the results of these investigations and compares them with Mediterranean marine radioactivity levels reported by others *Keywords : Aegean Sea, Sediments, Fishes, Mollusca, Radionuclides.* 

It is very well known that the importance of the protection of the marine environment for sustainable development and economy of coastal countries, like Turkey.

So far, the background radioactivity in the marine coastal environment of Turkish Coast Aegean Sea has not been studied very extensively. Since the coastal area is well develop, with beaches being utilised for recreation and also as large amounts of fish and seafood are harvested from the coastal water, the study of radioactivity in this area is of great interest.

The present work reports on an investigation carried out into concentrations of  $^{210}$ Po and  $^{210}$ Pb in marine environmental samples collected from near-shore region of the Turkish Aegean Coast.

The Aegean Sea, arm of Mediterranean Sea, 640 km long and 320 km wide and having a surface area approximately 214 000 km<sup>2</sup> is located off SE Europe between Greece and Turkey, Crete and Rhodes mark its southern limit. The Aegean Sea greatest depth is 2500m. The Dardanelles strait connects the Aegean Sea with the Sea of Marmara and Black Sea.



Fig. 1. Map of sampling locations.

The Turkish coastal zone of the Aegean Sea has been heavily industrialized in the last 25 years resulting in a considerable input of wastes to the coastal marine ecosystem. Fish and other edible marine organisms consumption is relatively higher in the region than at other parts of Turkey. Therefore it is important to determine the additional dietary radiation dose received by population originating from seafood. The information on levels and on distribution of natural radionuclides is however sparse due to limited number of investigations conducted on this coast line (Uğur, Yener & Başsarı, 2002; Tanbay (Uğur) & Yener, 2001; Tanbay (Uğur) et al., 1999).

Six sampling location (Çanakkale, Dikili, Foça, Çeşme, Didim and Bodrum) were selected and indicated in Figure 1. Sediment samples from the locations were recovered using a Van-Veen grab (5 lt) near the shore of the stations. In the case of sea water, samples of ?l were collected and filtered through  $0.45\mu$ m filters and acidified before analysis. Fish samples were collected from the fresh catch sold in the local market. Mussels (*Mytilus galloprovincialis*) were also taken from the same sampling stations. <sup>210</sup>Po spontaneously deposited on cupper disc was counted in an alpha spectrometer containing a PIPS detector.

In the bottom sediments, <sup>210</sup>Po concentration varies between 21±1 and 214±24 Bq kg<sup>-1</sup> dry wt with an average value of 70±7 Bq kg<sup>-1</sup>. The concentrations in surface water of the sea during the sampling period are around 0.016±0.001 Bq l<sup>-1</sup>. Amongst the fishes, small pelagic plankton feding fish like anchovy (*Engraulis encrasicolus*) and sardine (*Sardine plichardus*) tend to accumulate more <sup>210</sup>Po. The concentration of <sup>210</sup>Po in mussels (*Mytilus galloprovincialis*) varies between 55±5 and 2288±124 Bq kg<sup>-1</sup> which is in general higher than those given in literature for other countries. The highest <sup>210</sup>Po concentration belongs to Didim mussels for winter time with a shell length of 4-6 cm.

#### Acknowledgements

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# A NOVEL RAPD-PCR BASED DNA DAMAGE ASSESSMENT APPROACH FOR 'MUSSEL WATCH'

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### Abstract

Detection of DNA damage can be a good genotoxicity biomonitoring tool that may find various levels of applications under *in vivo* conditions. In this work a novel RAPD-PCR approach has been proposed to assess the level of DNA damage in various exposed and less-exposed mussel (*Mytilus galloprovincialis*) samples from the Sea of Marmara for the more exposed and Bay of Saros, Aegean Sea for the less exposed.

Keywords : Bio-indicators, Bivalves, Biotechnologies, Monitoring, Pollution.

The increasing genotoxic risk in aquatic systems calls for novel strategies of biomonitoring. The detection of DNA damage could reflect the level of marine pollution by genotoxicants. In monitoring genotoxicity, it is important to have sensitive, but non-specific assays to indicate a wide range of DNA damage mechanisms. RAPD-PCR based assays have been shown to detect genotoxic effect by comparative changes occuring in RAPD profiles as variation in band intensities as well as gain or loss of bands following genotoxin exposures [1].To our knowledge, there is not a routine application that can assess the direct adverse effects of marine pollution on DNA.

Mussel species have been extensively utilized as a biological indicator of pollution in 'Mussel Watch' programs [2]. With the presumption that DNA of this organism becomes a mosaic in different cell and tissue types due to different genotoxic exposures and attacks that bioaccumulates throughout an organism's lifetime, a novel 'DNA mosaicism detection assay', RAMD-PCR (Random Amplified Mosaic DNA-PCR) based on RAPD-PCR analyses with as little as 2-5% of the cells having the same effected genotype to reveal unpredictable DNAdamage has been proposed [3],[4],[5].

DNA isolation was carried out using the Macherey & Nagel Nucleospin tissue DNA isolation kit according to the supplier's instructions. DNA concentrations and sizes were estimated by comparing them with a standard sample (GeneRulerTM 100bp DNA Ladder, ready-to-use, MBI Fermentas) in an agarose gel (fragment, (bp) and DNA quantity in band, (ng) were given, respectively, for 10 bands in descending order of the fragment sizes 1: 1031-169, 2: 900 - 147, 3: 800 - 131, 4: 700 - 115, 5: 600 - 98, 6: 500 - 164, 7: 400 - 65, 8: 300 - 49, 9: 200 - 33, and 10: 100-16). RAPD amplification was done with a 25  $\mu$ l PCR mix, containing 1x PCR buffer (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>, 0.2 mM from each dNTP (2 mM dNTP mix), 1µM of primer OPB-18 5'-CCACAGCAGT-3' from QIAGEN Operon RAPD 10mer Kits, 200-400 ng of genomic DNA, and 0.5 units of Taq DNA polymerase, and filled up with sterile deionized water to the final volume. nx RAPD-PCR that we have introduced the term RAMD-PCR (Random Amplified Mosaic DNA) was performed according to previous reference [6] with the preparation of a master mix with every component of the standard RAPD-PCR [7], including the DNA and subdividing it into several aliquots for amplification at the same PCR conditions. This novel approach enabled the visualization of the amplification products from the very same organism on the same gel, clearly showing the variation of the organism's genome (innate, induced or spontaneous). The RAPD profiles of the improved assay were evaluated on the same 2% agarose gel run for 30 min. at 150 volts.

In our approach RAPD-PCR is exploited as RAMD-PCR to see the extend of DNA mosaicism due to intrinsic genomic nature and life-long pollution exposed and less-exposed mussel (*Mytilus galloprovincialis*) samples from the Sea of Marmara and Bay of Saros, Aegean Sea respectively. The same organism's whole tissue DNA that is assumed to be a mosaic due to both intrinsic and extrinsic factors and RAPD-PCR profile variations within the same individual was used to assess the level of DNA change qualitatively. The originality of the approach is in the preparation of a nxPCR mastermix using the same DNA of the same organism and aliquoting it into n PCR tubes for standart RAPD-PCR, to evaluate the same organism's DNA change without a further need for checking reproducibility (Fig.1). The method has proved to be cheap, easy, useful and could be routinely applicable under *in vivo* conditions for genotoxicity biomonitoring of any aquatic systems when suitable model organism of watch is chosen.



Fig. 1. Comparison of 3xRAMD-PCR profiles of small sized mussels (approximately 1.0 cm) collected from Saros Bay and Unkapani Shore, Haliç. Lanes 2-4, 5-7 and 8-10 are for 3 mussel samples collected from less polluted Saros Bay and Lanes 11-13 are for a mussel from highly polluted Unkapani shore, Haliç. Lane 1 is the DNA size marker. Arrows indicate the different patterns obtained for the same mussel DNA whereas for the other three mussels no RAPD-PCR profile changes are observed.

To the memory of Prof. Dr. Erdogan Okus without whom this study would not be possible.

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# ORGANIC MATTER AND MUCILAGE FORMATION IN THE NORTH ADRIATIC SEA

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### Abstract

In the recent period, the massive formation of aggregates reported as "mucilage phenomenon" occurred in the north Adriatic Sea. Here we compared the data of dissolved organic carbon (DOC) content and the concentration of its reactive part with surface active properties obtained in the north Adriatic Sea during intensive mucilage event of 2002, and of 1994 in the absence of such event. *Keywords : Adriatic Sea, Mucus Aggregates, Organic Matter.* 

The shallow semi-closed basin of the north Adriatic Sea is characterised by significant seasonal and long-term oscillations of oceanographic and biological conditions such as a complex and different pattern of circulation, River Po discharges, and intrusion of high saline waters. Since 1988, the hypertrophic production of huge mucilaginous aggregates forming layers along seawater column has occurred in the north Adriatic Sea with increased frequency and intensity (summers of 1988, 1989, 1991, 1997, 2002-2004) [1].

Understanding of the phenomenon of formation of aggregates requires better knowledge of the nature and physico-chemical properties of organic matter, particularly of surface active substances mostly produced by phytoplankton activities.

This work was therefore aimed to determine the distribution and reactivity of organic matter in the north Adriatic Sea in two characteristic years as 2002 with and 1994 without mucilage formation.

Surface active substances were analysed in the samples collected from the depth of 0.5 m at the sampling positions in the north Adriatic Sea situated along the transect between Rovinj and mouth of the River Po. For quantitative determination of SAS measured in nonflitered (SAS NF) and filtered (SAS F) samples by electrochemical method (a.c. polarography) the calibration curve of model nonionic SAS, Triton-X-100 was used [2].

During both periods of investigations, 1994 and 2002, the lowest values of SAS concentrations were observed in winter (0.025-0.093 mg/L), while higher concentrations (0.024-0.285 mg/L) were detected in the period from spring to autumn. DOC values showed similar trends of seasonal variations with lower values in winter (0.93-1.69 mg/L) and higher values (1.02-2.91 mg/L) in the period from spring to autumn.

Markedly higher concentrations of DOC (29 % to 40 %) were obtained during 2002 in which massive formation of huge aggregates occurred, in contrast to the concentrations obtained for 1994 without the mucilage phenomena. However, in 1994, concentrations of surface active substances were higher, 6,5 % to 27 %.



Fig. 1. Correlation of SAS concentrations eq. to Triton-X-100 and DOC values obtained in the north Adriatic Sea samples collected at depth of 0.5m during 1994 and 2002. Dashed lines correspond to model SAS: 1) fulvic acid, 2) polysaccharide dextran T-500 and 3) xanthan.

Surface active properties of organic substances obtained in the selected month (March) were characterized by normalized surfactant activities

(NSA), which have been calculated by dividing the obtained surfactant activities by the belonging organic carbon content [2]. Comparison was made with model substances as representative for naturally occurring organic materials, fulvic acid, polysaccharides Dextrane T-500 and Xanthan. As shown in Fig.1 the most data obtained in March of 2002, in which both SAS and DOC values significantly increased, are grouped close to the lines of Xanthan, i.e. organic matter with high organic carbon content showed similar reactivity to those of high molecular weight polysaccharide Xanthan (Mw  $2x10^6$ ). In contrast, the data obtained in 1994 with lower and almost constant DOC concentrations are shifted towards the lines of more reactive lower molecular weight organics such as polysaccharide T-500, and fulvic acid (Mw up to  $10^5$ ).

The obtained results suggest that in the north Adriatic Sea in early spring of 2002 dominated reactive organic material with high content of organic carbon, which probably had an important role in the massive accumulation of organic carbon and in triggering the mucilage occurrence.

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# STUDY OF THE ORIGIN OF CERTAIN METALS IN SURFACE SEDIMENTS OF PAGASSITIKOS GULF, AEGEAN SEA

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# Abstract

Major and trace elements were determined in the surface sediments of Pagassitikos Gulf, Greece. Higher concentrations of the anthropogenic metals (Cu, Zn, Pb, As, Cd and Hg) were found near Volos port, whereas the unusually elevated Ni and Cr concentrations were attributed to rock weathering. The significantly high Mn concentrations determined in the eastern gulf, according to previous studies, were attributed to authigenic manganese formations.

Keywords : Aegean Sea, Eastern Mediterranean, Pollution, Sediments, Trace Elements.

#### Introduction

Pagassitikos Gulf is a semi-enclosed bay covering approximately 520 km<sup>2</sup>. It is connected to the open Aegean Sea through Trikeri Channel (5.5 km wide and 82 m deep). Small streams and rivers discharge mainly into its western part. The city of Volos (population more than 100,000) and its port are located in the northern part of the gulf. The industrial zone of Volos is well developed, while the Volos Wastewater Treatment Plant (VWTP) operates since 1985, whereas, since 1992, industrial and domestic wastes undergo chemical and biological treatment. The present study is a part of the ongoing MED POL Monitoring Project and aims at investigating possible changes in the quality of the surface sediments of the gulf compared to previous studies.

#### Materials and Methods

Major and trace elements,  $CaCO_3$  and C organic were determined in the <631ijm grain size fraction of the surface sediments collected from seven stations in Pagassitikos gulf [Fig. 1]. For the major and trace element analysis the X-ray Fluorescence (XRF) technique was used [1]. Cadmium and Hg were determined by Graphite Furnace AAS and Cold Vapor AAS, respectively, after total dissolution of the sediment samples. Organic carbon and carbonate content were determined using a CHN elemental analyzer type EA-1108, following published procedures [2].



Fig. 1. Map of the study area and the sampling stations. The distributions of some element concentrations in the different stations are also shown on the map.

### Results and Discussion

Element concentrations ranged as follows: Corg 0.67-1.11 %; S 0.069-0.459 %; Cu 25.3-60.6 ppm; Zn 89.5-171 ppm; Pb 37.1-114 ppm; Cd 0.129-0.681 ppb; Hg 0.106-0.643 ppb; Cr 125-267 ppm; Ni 70-270 ppm; Mn 520-2879 ppm; Fe 4.36-5.44 %; Al 6.68-9.74%. The distribution of representative elements is shown schematically on the map [Fig. 1]. Station 2 is found the most enriched in anthropogenic metals (Cu, Zn, Pb, As, Cd and Hg) as well as in organic C and S. Station 1, located also in the port, is not equally polluted due to the coarse character of its surface sediment. The elevated concentrations of Mn in Stations 5 and 6 (more than 2000 ppm) are attributed to diagenetic formation of manganese carbon-

ates, a phenomenon described in previous studies [3]. The unusually high concentrations of Ni and Cr were not identified in areas directly influenced by anthropogenic activities. They were determined in the deeper stations and so they are attributed to the weathering of ultra-basic peridotites and ophiolites present in the Pilio mountain catchment area [4]. Correlations between the geochemical parameters showed mainly the terrigenous origin of Ni and Cr, whereas the remaining heavy metals (Cu, Zn, Pb, As, Cd and Hg) are strongly correlated to C and S and thus directly related to pollution sources [Fig. 2].



Fig. 2. Linear correlations between the different elements.

Direct comparison with previous studies in Pagassitikos Gulf is not feasible, since they were conducted neither on the same grain size fraction of the sediments [3] nor using the same analytical methods [5]. However, all studies showed that anthropogenic metal concentrations were significantly higher in the northern part of the gulf, except Cr and Ni that were found increased mostly in the deeper sediments. The anomalously elevated Mn concentrations in the eastern part of the gulf, determined in this study, were also found in the past and explained in detail [3]. All these findings lead to the conclusion that anthropogenic activities concentrated in the port and the city of Volos constitute the major pollution source in the area.

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# STATE OF POLLUTION ALONG THE MEDITERRANEAN COAST OF TURKEY

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# Abstract

After the development of regional seas programme to protect the Mediterranean sea against pollution (UNEP, 1982; UNEP, 1985) the member countries begin to regulate and take measures against discharging and damping the pollutants in the Sea. This work comprises the determination of pollutant levels at hotspots, in effluents, river water, biota and sediment from the Turkish coasts of the Mediterranean Sea. The work mainly includes results from the monitoring of some pollutants loads. *Keywords : Fishes, Sediments, Metals.* 

Introduction

This work is carried out as a part of the MED POL. The aim of this manuscript is to give a summary of the work carried out so far between 1998-2006 in the Northern Levantine Basin. The paper is based on the compilation of the data obtained from the work done:

a) in the North-Eastern Mediterranean from the so called coastal stations,b) at land-based sources (rivers, industrial effluents, and sewage) along the southern coast of Turkey,

#### Material and Methods

Determination of the temporal variability of the river fluxes is very difficult, for this reason the flux calculations was done by using average yearly flux values. A simple relationship is used to calculate the material and pollutant fluxes (Yemenicioglu et al. 1996). The sampling periods follows seasonal frequency including both low water stage and flood periods. The collection and analysis of the fish and the sediment samples is achieved according to "UNEP/FAO/ IOC/IAEA: Ref. Method No. 7, No: 26, No: 27, No: 29 and No: 39". The mercury in the water samples were analyzed as soon as possible by using cold vapor method (Hatch and Ott, 1968, Yemenicioglu and Salihoglu 1994). The other parameters (BOD, COD, DO, TSS) were determined by the procedure given by Grasshoff, (1999). Nutrients were measured by using Bran Lueppe AA.

Tab. 1. Fluxes of relevant water parameters (A, B) and contaminants (B) at stations in the Northern Levantine Basin.

| Station         | Water Flux m <sup>3</sup> /y | TP t/y  | TIN t/y  | Si t/y   |
|-----------------|------------------------------|---------|----------|----------|
| Ceyhan River    | 6.4062E+09                   | 693.69  | 7498.26  | 31101.55 |
| SeyhanRiver     | 5.2701E+09                   | 1849.42 | 5407.27  | 12562.07 |
| Berdan River    | 3.9763E+08                   | 14.62   | 275.25   | 754.16   |
| Lamas River     | 1.7514E+08                   | 1.71    | 195.37   | 607.87   |
| Goksu River     | 3.6291E+09                   | 229.54  | 2924.37  | 13387.08 |
| Mersin Dis.     | 1.8900E+07                   | 136.32  | 467.33   | 136.78   |
| Antalya Dis.    | 1.4300E+07                   | 55.55   | 105.64   | 106.29   |
| Marmaris Dis.   | 5.1000E+06                   | 20.01   | 25.79    | 77.84    |
| lskenderun Dis. | 8.3300E+06                   | 44.35   | 41.03    | 121.89   |
| Total           | 1.5925E+10                   | 3045.21 | 16940.31 | 58855.52 |
| River           | 1.5878E+10                   | 2788.98 | 16300.52 | 58412.72 |
| Discharge       | 4.6630E+07                   | 256.23  | 639.79   | 442.80   |

| Station         | BOD <sub>5</sub> t/y | TSS t/y   | COD t/y   | Hg kg/y | COD/BOD |
|-----------------|----------------------|-----------|-----------|---------|---------|
| Ceyhan River    | 8696.41              | 203572.79 | 137733.15 | 24.53   | 15.84   |
| SeyhanRiver     | 19934.23             | 149038.97 | 163373.70 | 25.65   | 8.20    |
| Berdan River    | 1413.56              | 3725.75   | 11531.15  | 1.54    | 8.16    |
| Lamas River     | 152.81               | 371.74    | 1138.44   | 0.49    | 7.45    |
| Goksu River     | 6414.48              | 226965.41 | 89820.82  | 8.35    | 14.00   |
| Mersin Dis.     | 3204.97              | 4827.53   | 8453.03   | 0.07    | 2.64    |
| Antalya Dis.    | 297.44               | 93.74     | 597.03    | 0.06    | 2.01    |
| Marmaris Dis.   | 374.34               | 28.28     | 198.90    | 0.02    | 0.53    |
| lskenderun Dis. | 93.71                | 68.31     | 333.20    | 0.03    | 3.56    |
| Total           | 40581.94             | 588692.53 | 413179.40 | 60.74   | 62.38   |
| River           | 36611.48             | 583674.68 | 403597.25 | 60.56   | 53.64   |
| Discharge       | 3970.46              | 5017.85   | 9582.15   | 0.18    | 8.73    |

#### Results

The heavy metal concentrations (Hg, Zn, Cd, Cr, Cu) are measured in fish (*M. barbatus*) and sediment samples. The Hg concentration in *fish* is ranging between 28.63-969 ng/g; Zn 1.54-89.55  $\mu$ g/g; Cu 0,87-208  $\mu$ g/g; Cr 3.6-6045  $\mu$ g/g and Cd 15-851 ng/g on dry weight bases. In sediment

samples the Cd concentration varies between 52-485 ng/g, Cr 45-690  $\mu$ g/g, Cu 12.5-467  $\mu$ g/g, Hg 15.21-174.5 ng/g and Zn 27-287  $\mu$ g/g on dry weight bases.

The biochemical parameter's (TSS, COD, BOD<sub>5</sub>, Hg, DO, nutrients) concentrations in river and sewage water samples were also measured. The results are summarized in Table 1. The rivers feeding Mediterranean were generally poor in phosphate ions (0.1-1.0 $\mu$ M). But these rivers were always rich in nitrate ions (40-85  $\mu$ M). That is, the main source of the nitrate were the rivers and the domestic waste waters were the main source of phosphorous.

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# BIOGEOCHEMICAL CYCLING AND MULTILAYER PRODUCTION IN THE BLACK SEA

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# Abstract

In the present study, the photo- and chemoautotrophic organic carbon productions have been determined in the Black Sea multilayer system for 1998-2001 period. Relative importance of NO<sub>3</sub>, NO<sub>2</sub> and NH<sub>4</sub> uptakes on the new production were estimated using <sup>15</sup>N isotope technique. Carbon and nitrogen natural isotopic ratios ( $\delta^{15}$ N,  $\delta^{13}$ C) of suspended particulate organic matter (SPOM) were determined to trace the productivity in the euphotic zone, bacterial decomposition in the oxycline, chemoauto- and heterotrophic activities in the suboxic and anoxic layers.

Keywords : Black Sea, Primary Production, Geochemistry.

The Black Sea is a unique marine environment representing the largest land-locked/semi-enclosed and deep anoxic basin in the world. The coastal waters of the Black Sea are principally fed by the rivers and by the lateral/vertical nutrient transport mechanisms including sediment coupling. In the open ecosystem, which is dominated by the cyclonic eddies, primary production is mainly sustained by the influx of nutrients from the oxic/suboxic lower layers mainly by vertical mixing processes. However, the input from the anoxic layer is limited due to the presence of a permanent pycnocline in the Black Sea which coincides with the oxic-anoxic transition zone. Intense denitrification, redox-dependent processes within this zone also limit nitrogen and phosphorus input to the productive layer (Fig. 1).



Fig. 1. Conceptional model of the biogeochemistry in Black Sea multilayer system.

Integrated photoautotrophic production rates ranged from 112 and 640 mg C m<sup>-2</sup>d<sup>-1</sup> in the study period. The lowest values were determined in the central gyre and the highest values were found at the shelf break station near the Bosporus, the NW shelf/shelf break area. Bioassay experiments showed that under optimum light conditions, photoautotrophic production was nitrogen limited [1, 2]. Planktonic nitrogen productivity and relative importance of NO<sub>3</sub>, NO<sub>2</sub> and NH<sub>4</sub> on productivity in the Black Sea were estimated using <sup>15</sup>N isotopic technique. Though the main nitrogen source utilised by phytoplankton was NH<sub>4</sub>, annual f-ratio was estimated as high as 0.3-0.5.

Multilayer systems having anoxia support multiple layers of biological production. In addition to photosynthetic production at the surface layer, microbial communities at the oxic-anoxic interface live on the residual chemical energy originate from anoxic waters. Present data showed that, chemo-autotrophic production at  $O_2$ -H<sub>2</sub>S interface is relatively high in the Black Sea and it is potential mid-water source of sedimentary biogenic particles for the basin related to the microbial activities and red-ox processes. Chemoautotrophic production increased in the redox transition zone and coincided with the lower boundary of the fine particle layer. The maximum values were shallower (at 16.25 Sigma-theta) in the central gyre

and deeper (at 16.5 Sigma-theta) in the shelf break region near Sakarya Canyon. Integrated chemoautotrophic production rates were 63 and 1930 mg C m<sup>-2</sup>d<sup>-1</sup> which were equivalent to 30 and 89 % of the overall water column production for the central gyre and Sakarya Canyon regions, respectively. Lateral transport of Mediterranean origin oxygenated waters from the continental slope possibly enhanced the chemoautotrphic production in the canyon region. Indeed, the organic carbon produced at midwater depths exceeded the surface photo-autotrophic production and this made quantitative contribution to sinking particles [2].

Carbon and nitrogen natural isotopic ratios ( $\delta^{15}$ N and  $\delta^{13}$ C) of suspended particulate organic matter (SPOM) produced in the water column of the Black Sea were also determined in the Black Sea. The results revealed important vertical and regional variations in terms of isotopic composition while the seasonality was less remarkable. SPOM of each layer possessed distinct isotopic composition associated with microbial decomposition and formation of organic matter [3]. C and N isotopic composition of Black Sea SPOM collected revealed that planktonic production and rapid recycling in the nutrient-poor surface layers. Old and partially decomposed fragments of SPOM are dominated in the oxycline. Intense microbial activity was observed in the suboxic/anoxic transition layer of especially coastal regions where there is partial aeration by Mediterranean waters (Fig. 1).

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# MODELLING OF MERCURY CYCLING IN THE MEDITERRANEAN SEA

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## Abstract

The 3D hydrodynamic and transport model PCFLOW3D was upgraded with a biogoechemical module and linked to the atmospheric model RAMS-Hg to simulate mercury cycling in the Mediterranean Basin. Transport, transformations and fluxes of three mercury species in the water compartment were simulated: elemental mercury  $(Hg^0)$ , divalent mercury  $(Hg^{2+})$  and monomethyl-mercury (MMHg). The model results show acceptable agreement with measurements for elemental and total Hg. Further improvements of the model and additional measurements are needed to improve the agreement of monomethyl-mercury behaviour. On the basis of measurements and modelling a mass balance of mercury for the Mediterranean Sea was calculated.

Keywords : Air-sea Interactions, Circulation Models, Geochemical Cycles, Pollution, Mercury.

During the last decades several studies have been conducted in the Mediterranean area in order to assess the state of Hg pollution. The atmospheric processes and fluxes between the air and the sea were mostly studied [1, 2]. Among many different Hg species, the mono-methylmercury is the most dangerous. It can be bioaccumulated and biomagnified and as such it is harmful to the entire food-web. The problem is assessed by measurements and modelling. In the frame of the EU project MER-CYMS (Contr.No. EVK3-CT-2002-00070) several coastal and deep-sea measurement campaigns were performed to gather the data needed for the modelling purpose. Measurements from previous campaigns [3] were also used. The appropriate approach for simulating Hg processes in the water compartment requires the use of a hydrodynamic model with additional modules for transport-dispersion and biogeochemistry. The model PCFLOW3D [4, 5] has been upgraded with a biogeochemical module and used for simulations of Hg transport and transformation processes. The circulation for the four seasons due to wind, thermohaline forcing and inflow momentum of the main rivers and through the straits has been calculated. The results were compared with the measurements and the results of another model (POM - Princeton Ocean Model). An acceptable agreement has been achieved. The obtained seasonally averaged velocity fields were used to simulate transport and dispersion of mercury.

The new biogeochemical module deals with three mercury species: elemental (Hg<sup>0</sup>), divalent (Hg<sup>2+</sup>), and mono-methylmercury (MMHg) in dissolved and particulate form. Exchange of Hg at the boundaries (sediment/water and water/atmosphere) and transformation processes (methylation, demethylation, reduction and oxidation) were simulated. The transformation rates between the mercury species are described using simple equations, thus the time and space variable reaction coefficients should be determined from in-situ measurements. Instead, machine learning tools were used to connect the measured sets of geophysical / environmental parameters and the concentrations of Hg species. The established provisional annual Hg mass balance for the Mediterranean showed that the exchange with atmosphere is the most important source / sink of mercury for the water compartment. The model has been further upgraded with a gas exchange module for Hg<sup>0</sup>. To improve the results of simulations the PCFLOW3D model was linked to the RAMS-Hg atmospheric model [6] which provided real-time meteorological data, deposition and concentrations of mercury in the atmosphere.

The results of the integrated air-water model simulations were compared to the measurements. An acceptable agreement of the average concentrations along the water column for both total mercury (HgT) and elemental mercury (Hg<sup>0</sup>) was achieved. Agreement of Hg<sup>0</sup> concentrations near the surface was good, thus, exchange with the atmosphere can be simulated with relatively high reliability. Agreement of simulated MMHg concentrations with measurements was not satisfactory, which is probably due to poor understanding of processes for MMHg formation and its dependence on environmental factors, which have, so far, not been taken into account in the modelling.

Due to acceptable modelling results obtained for HgT, simulation of management scenarios, particularly the policy target scenarios for 2010 and 2020 was performed. These results were used to determine the mass balance of Hg in the Mediterranean Sea and to simulate future trends of mercury contamination in the area. The following terms were taken into account: sources of mercury from major rivers and from point sources, exchange with the Atlantic Ocean and the Black Sea, estimated natural sources from geotectonic active areas in the sea, exchange with bottom sediments, and evasion to and deposition from the atmosphere. The main conclusions are summarized as follows:

(a) Based on the measurements. HgT concentrations in the

(a) Based on the measurements, HgT concentrations in the Mediterranean Sea in 2005 was about 1.5 pM. Thus the total mass of HgT in the Sea was about 5400 kmol (1080 tons).

(b) The outflow of HgT exceeds the inflow for about 46 kmol/yr. This indicates that the Mediterranean Sea is slowly recovering from mercury pollution. However, this also shows that the Mediterranean is a net source of HgT for the atmosphere and the connecting seas.

(c) The main sources are (in kmol/yr): atmospheric deposition (115), river inflow (68.5), and the bottom sediment (75, includes estimated contribution of underwater geotectonic sources), while point sources of mercury are estimated to 12.5 kmol/yr. The main outputs are: evasion to atmosphere (249), and burial in the bottom sediments (55). The net outflow through Gibraltar is about 8.5 kmol/yr, while the Black Sea seems to be a very small source of HgT to the Mediterranean.

(d) Some of the important terms in the mass balance equation were obtained by rough estimates. For this reason the prediction for 2020, based on policy target scenarios, can only be given in a wide range. It is expected that HgT concentration will decrease for about 3 to 12 % compared to 2005.

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# ÉTUDE DE LA MATIÈRE ORGANIQUE ET LA POLLUTION PAR LES HYDROCARBURES DANS LES SÉDIMENTS RÉCENTS DU CHENAL SFAX-KERKENNAH (TUNISIE, MER MÉDITERRANÉE)

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# Résumé

Les concentrations en carbone et azote organique et la distribution des traceurs (hydrocarbures non aromatiques (HNA) et aromatiques polycycliques (HAP)) ont été déterminées sur 20 sédiments superficiels du Golfe de Gabès, afin de définir l'origine et le degré d'évolution de la matière organique. Une contribution terrigène importante est mise en évidence par des valeurs élevées du C/N et les distributions des n-alcanes lourds. Une contribution marine, algaire et bactérienne, est révélée par l'analyse élémentaire et les n-alcanes légers. Les concentrations mesurées varient de 31 à 742 µg/g pour les HNA et de 113 à 10 720 ng/g pour les HAP totaux. L'analyse détaillée met en évidence des contributions de diverses sources associées à des produits pétroliers, à des processus de pyrolyse et à des déchets urbains. Mots clès : Gulf Of Gabes, Pah, Sediments.

#### Introduction

L'analyse élémentaire et l'étude des traceurs hydrocarbonés des sédiments superficiels permet d'établir un diagnostic sur l'origine et le degré d'évolution de la matière organique et de l'état de contamination du milieu en vue d'intervenir dans la dynamique de protection de l'environnement du Golfe de Gabès (littoral de Sfax), une région soumise à d'importantes pressions industrielles et pétrolières [1]. En effet une relation étroite existe généralement entre les caractéristiques du support sédimentaire (nature, granulométrie), la sédimentogénèse et les paramètres d'accumulation et d'évolution diagénétique de la matière organique.

#### Matériels et Méthodes

Une investigation du littoral de Sfax, Tunisie, s'est faite à partir de 20 stations selon deux radiales entre le littoral de Sfax et l'île de Kerkennah. Le 1er centimètre a été collecté avec l'aide d'un plongeur et analysé.

L'analyse élémentaire (C, H, N, 0, S) et du Carbone Organique Total (COT) ont été réalisées au service central d'analyses du CNRS (Vernaison) à l'aide d' analyseurs LECO SC144 et SCHIMADZU TOC 5050. Les hydrocarbures ont été analysés par chromatographie en phase gazeuse (CG-FID) et couplage (CG/SM) [2]. La quantification est obtenue à l'aide des standards internes deutériés.

#### Résultats et discussion

La contribution au carbonate total des algues vertes de type Halimidae, se développant sur un substrat meuble et dans des zones de forte insolation, oscille entre 26 et 76% [1]. Elle prédomine sur les contributions par les foraminifères benthiques et les organismes coquilliers.

Les teneurs en COT dans le Golfe de Gabès/Chenal Sfax-Kekennah varient entre 2,2 et 11,9% (en pourcentage du sédiment sec), la valeur moyenne étant de 5% (Table). Ces teneurs sont élevées par rapport à celles notées dans la plupart des estuaires [4].

Les valeurs élevées du rapport C/N (>10) notées dans la majorité des stations, traduit une origine terrestre prononcée.

L'analyse des variations spatiales des teneurs en biomarqueurs donne des indications complémentaires quant à l'origine de la matière organique dans le golfe de Gabès.

Les concentrations totales en hydrocarbures non aromatiques (HNA) varient de 31 à  $742\mu g/g$  de poids sec (Table). Les plus teneurs les plus élevées, signes d'une forte pollution pétrolière, sont relevées au port de Sfax et au port de Kerkennah. Les chromatogrammes présentent une distribution bimodale ; le premier mode est centré vers n-C18-C25 et le second vers n-C29-C33. Les n-alcanes impairs prédominent dans certaines stations, traduisant ainsi des apports de cires cuticulaires de végétaux supérieurs [3]. L'approche multi-diagnostique établie par le calcul du CPI (Carbon Preference Index), la présences des doublets n-C17 pristane et n-C18 phytane et de l'UCM (Unresolved Complex Mixture) dans la majorité des chromatogrammes, mettent en évidence une source anthropique pétrolière, résultat probable de l'implantation de l'importante zone pétrochimique et de l'activité pétrolière présente dans le Golfe.

Les teneurs en hydrocarbures polyaromatiques (HAP) totaux évoluent de 113 à 10 720 ng/g. les stations situées près de la côte présentent toutefois des concentrations élevées. Les composés polyaromatiques identifiés sont au nombre de 16 : composés méthylés (méthyl-1 naphtalène, éthyl-1 naphtalène, méthyl-2 phénanthrène, méthyl-1 phénanthrène, diméthyl 3-6 phénanthrène et méthyl-1 pyrène) et parents (naphtalène, acénaphthylène, phénanthrène, anthracène, fluoranthène, pyrène, chrysène et pérylène, benzo(a)pyrène). Ces derniers prédominent dans l'ensemble du golfe.

Tab. 1. Distribution de la matière organique et des hydrocarbures dans le Chenal Sfax-Kerkennah.

|                        | Site | COT %<br>du<br>ofdauent<br>sec | CN    | HNA<br>toteux<br>(µg.g <sup>1</sup> ) | HAP<br>toteux<br>(ng g <sup>1</sup> ) | CPI  | PaPh |
|------------------------|------|--------------------------------|-------|---------------------------------------|---------------------------------------|------|------|
| Port de Sfax           | R201 | 11,59                          | 9,42  | 741.78                                | 10720                                 | 1.24 | 1.23 |
| 1                      | R202 | 2,17                           | 11,42 | 98.02                                 | 3516                                  | 1.23 | 0.64 |
| L                      | R203 | 2,52                           | 13,26 | 65.53                                 | 1500                                  | 0.78 | 0.34 |
| 1                      | R204 | 3,46                           | 15,73 | 60.84                                 | 440                                   | 0.87 | 0.82 |
| L                      | R205 | 3,98                           | 15,31 | 57.49                                 | 150                                   | 0.76 | 0.73 |
| L                      | R207 | 2,9                            | 13,81 | 72.25                                 | 237                                   | 0.98 | 0.52 |
| L                      | R208 | 3,16                           | 13,74 | 58.57                                 | 113                                   | 1.61 | 1,47 |
| L                      | R209 | 3,67                           | 13,64 | 71.19                                 | 390                                   | 1.39 | 1.25 |
| Kerkennah              | R210 | 3,77                           | 13,96 | 69.51                                 | 3113                                  | 0.95 | 0.69 |
| Nord de<br>Sfax (15km) | R101 | 3,23                           | 10,77 | 77.54                                 | 616                                   | 1.50 | 0.36 |
| L                      | R102 | 4                              | 12,50 | 35.27                                 | 560                                   | 1.40 | 0.59 |
| L                      | R103 | 5,46                           | 14,00 | 42.14                                 | 453                                   | 1.41 | 0.73 |
| L                      | R104 | 7,29                           | 14,88 | 108.14                                | 1387                                  | 0.85 | 0.49 |
| L                      | R105 | 3,49                           | 15,17 | 30.94                                 | 942                                   | 0.98 | 0.68 |
| L                      | R106 | 3,46                           | 15,73 | 33.15                                 | 406                                   | 1.05 | 0.38 |
| I.                     | R107 | 11,89                          | 56,62 | 48.33                                 | 716                                   | 0.63 | 0.91 |
| 1.                     | R108 | 4,49                           | 16,04 | 61.12                                 | 610                                   | 0.90 | 0.65 |
| 1.                     | R109 | 3,87                           | 13,34 | 67.86                                 | 955                                   | 1.00 | 0.43 |
| L                      | R110 | 6,29                           | 17,97 | 70.08                                 | 2100                                  | 1.35 | 1.10 |
| Kerkennah              | R111 | 7.16                           | 22.24 | 226.52                                | 8902                                  | 1.15 | 0.26 |

L'importance du mono-méthyl phénanthrène et du di-métylphénantrène en regard du composé parent et dans toutes les stations du golfe, confirme la forte influence des rejets pétroliers dans la zone. L'analyse multi diagnostique suggère que le Golfe de Gabès est sous l'influence conjuguée des rejets directs d'origine pétrolière et indirects d'origine pyrolytique [4].

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# IODINE SPECIATION IN ANCHIHALINE CAVE-WATERS - THE FIRST EVER OBSERVATION OF IODIDE OXIDATION IN A MARINE SYSTEM?

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## Abstract

An exceptional combination of the estuarine- and deep-sea like speciations of dissolved inorganic iodine is found in waters of anchihaline cave Bjejajka (Island Mljet, East Adriatic Coast). Low iodide concentrations below the halocline suggest that the processes of iodide oxidation, which commonly prevail in deep ocean waters, may also exist in these caves. *Keywords : Chemical Speciation, Vertical Profile, Adriatic Sea.* 

#### Study area & methodology

Bjejajka Cave is cut in late Jurassic and early Cretaceous dolomites with limestone lenses on the island of Mljet. It is one hundred meters from the shore in the Bjejajka Bay, and is 22 m high and 40 m long, with water depth of 12 m. The level of water in the cave approximates that of the sea. It is not known whether the subterranean lake exchanges water with the sea through only porous karsts or larger passages. The waters were sampled in April and September 2006 by scuba diver. Temperature was determined *in situ* while salinity, pH and dissolved oxygen were measured immediately after sample collection. Iodide and iodate were determined directly by voltammetric methods.

#### Results & discussion

The temperature of the cave water in April and September was similar; a gradual increase from 13°C at the surface to 14.5°C at the bottom in April and from 14.3°C to 15.1°C in September (Figure 1). A 3 m mixed surface-layer of lower salinity existed in both seasons. In the 9m below this, salinity increased from 7-25 and 9-37 in April and September, respectively, suggesting lateral flow at depth. Dissolved oxygen and pH depth-profiles in September were similar, with approximately 81  $\mu$ mol L<sup>-1</sup> and pH=7.23 at the surface, and 73  $\mu$ mol L<sup>-1</sup> and pH=7.17 at the bottom and a slightly lower values of 67  $\mu$ mol L<sup>-1</sup> at all depths in both seasons while iodate followed a similar profile to salinity.



Fig. 1. Vertical profiles of temperature, salinity, iodate and iodide in Bjejajka Cave.

In a combined plot of five anchihaline caves along the Adriatic shore, the iodate results suggest the mixing of two end- members; freshwater with low iodate and high salinity water with high iodate (Figure 2). Regression of the data for iodate against salinity (d.f. =17) gave a robust linear plot ( $r^2$ =0.957) with gradient and intercept ( $\pm$  std. errors) of 10.2 ( $\pm$  0.5) nmol L<sup>-1</sup> and 24 ( $\pm$  12) nmol L<sup>-1</sup>, respectively. An intercept of zero is therefore within the 95% confidence limits. The upper end of this line tallies with the total inorganic iodine concentrations reported for the Adriatic (450 nmol L<sup>-1</sup>) where, however, the iodate to iodide ratio is around 4 [1]. Meanwhile, the iodide concentration (mean=10 nmol L<sup>-1</sup>) was essentially independent of salinity.



Fig. 2. Relationship between iodate and iodide concentrations and salinity in five anchihaline caves along the Adriatic Coast. Bigger symbols refer to Bjejajka Cave.

The presence of high iodate, low iodide water in Bjejajka Cave at 10 m in September is a very interesting observation, perhaps of far-reaching importance. The salinity of 37 together with the total iodine concentration of  $(469 \pm 23) \text{ nmol } \text{L}^{-1}$  is consistent with the entry of coastal seawater into the base of the cave, as would be expected hydrologically. However, this can only be so if the high concentration of iodate in the cave-water also represents oxidation of the iodide in the seawater as it enters the system. No observations of the oxidation of iodide in the occans are recorded; where it occurs, how quickly, and under what conditions [2]. Potentially then, this is the first observation of iodide oxidation in a marine system.

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# Comité 4

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# Microbiologie marine

*Président* : Gerhard Herndl

# EFFECTS OF PHOTOCHEMICAL TRANSFORMATIONS OF DISSOLVED ORGANIC MATTER ON BACTERIAL METABOLISM AND DIVERSITY

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## Abstract

The effect of solar radiation on the bioavailability of dissolved organic matter (DOM) was investigated for two lagoons and one coastal water samples from the northwestern Mediterranean Sea differing markedly in DOM and chlorophyll concentrations and salinity. Solar irradiation of DOM had contrasting effects on bacterial production and respiration, depending of the water origin. This resulted in increase in bacterial growth efficiency for the coastal water sample and a decrease for the lagoons. Bacterioplankton growth on irradiated DOM resulted in changes in microbial community structure.

Keywords : Bacteria, Biodiversity, Lagoons, Western Mediterranean.

#### Introduction

Natural solar radiation, primarily ultraviolet radiation (UVR, <400nm), has been found to induce chemical transformations of DOM with the production of a variety of photoproducts (CO<sub>2</sub>, CO, NH<sub>4</sub>, PO<sub>3</sub>, numerous low-molecular-weight organic compounds). The origin and chemical composition of DOM strongly influences its photoreactivity and its subsequent bioavailability for bacteria [1]. In coastal environments DOM is derived from diverse allochthonous and autochthonous sources. The aims of this study were to investigate the effects of the photochemical transformation of DOM on (1) bacterial production, (2) respiration, (3) growth efficiency, and (4) diversity in two coastal lagoons (Canet and Leucate, France) and one coastal water (Sola station) sample in the NW Mediterranean Sea.

#### Materials and methods

Surface water samples were collected in June 2005 filtered through 0.2  $\mu$ m membranes, distributed into quartz tubes and exposed to the natural sunlight for 8h in a circulating water bath  $(18 \pm 10^{\circ})$ . Three light treatments were applied: full sun (PAR+UVR), PAR, dark. Dissolved organic carbon and fluorescence of chromophoric DOM were measured before and after irradiation. Subsamples from both irradiated and dark treatments were inoculated (10% final volume) with a bacterial community from the same origin (0.8  $\mu$ m-filtered water) and incubated in the dark at 18  $\pm$ 1C°. Bacterial respiration (BR) was measured after 38h by potentiometric titration of O<sub>2</sub>. Bacterial production (BP) was measured by <sup>3</sup>H-leucine incorporation for 4 to 5 days (i.e. until bacterial cell numbers stabilized). Bacterial community structure was measured by CE-SSCP fingerprinting for both 16S-rDNA and 16S-rRNA PCR products at the start and at the end of biodegradation. Bacterial growth efficiency (BGE) was calculated using BP and BR measurements (BGE=BP/(BP+BR)) integrated over 38h incubation.

Tab. 1. Integrated bacterial production (BP) and respiration (BR) over 38h incubation. Numbers in parentheses are  $\pm 1$  SD of mean. Bacterial growth efficiencies (BGE) were calculated as BP/(BP+BR).

| Sample         | Light treatment | BP(µg C/L) | BR (µg C/L)  | BGE%       |
|----------------|-----------------|------------|--------------|------------|
| Coastal water  | Dark            | 4.3 (0.2)  | 49.5 (21.1)  | 9.8 (5.7)  |
| (SOLA)         | PAR             | 5.8 (0.2)  | 50.1 (14.5)  | 12.5 (5.0) |
|                | Full sun        | 9.2 (0.2)  | 39.6 (3.4)   | 22.5 (4.3) |
| Coastal lagoon | Dark            | 26.4(2.0)  | 74.3 (33.7)  | 30.7(13.0) |
| (Leucate)      | PAR             | 10.1(0.4)  | 52.9 (16.2)  | 19.2 (6.1) |
|                | Full sun        | 14.4(2.6)  | 81.9 (19.7)  | 18.1 (5.9) |
| Coastal lagoon | Dark            | 29.0 (0.5) | 62,8 (20.8)  | 36.6 (9.8) |
| (Canet)        | PAR             | 30.3 (0.4) | 91.4 (17.6)  | 29.3 (5.1) |
|                | Full sun        | 39.3 (7.8) | 126.4 (19.3) | 27.9 (7.7) |

Results and discussion The water samples are characterized by large variation in DOC and Chl *a* concentrations (892, 234 and 80  $\mu$ M DOC, 70, 2.2, 0.3  $\mu$ g Chl *a* /l for Canet, Leucate and SOLA station, respectively). DOC-specific fluorescence at 350 nm was similar between the two lagoons (0.041-0.051 QSU/ $\mu$ M DOC) and lower at the SOLA station (0.014 QSU/ $\mu$ M DOC). The exposure to full sun resulted in a decrease of this index (bleaching of DOM) by 15, 21 and 38% for Leucate and Canet lagoons, and SOLA station, respectively.

During biodegradation, we observed that DOM exposed to full sun resulted in an increase of BP for the Canet lagoon and the SOLA station, and a decrease for the Leucate lagoon (Tab. 1). In contrast, BR was modified only for the Canet lagoon, with an increase by a factor of 2 in the full sun treatment compared to the dark control treatment (Tab. 1). The sunlight exposure (mainly from the UVR part of the spectrum) of the DOM resulted in a decrease of the BGE in the coastal lagoons and an increase in the coastal waters (Tab. 1). Bacterial diversity was modified by the light treatment (again mainly from the UVR part of the spectrum) in the Canet lagoon and the SOLA station (Fig. 1). These modifications were observed both for total community (16S-DNA fingerprints) and for the active part of the community (16S-RNA fingerprints), with an emphasis for the latter (Fig. 1).



Fig. 1. Cluster analysis dendrogram based on comparison of 16S rDNA and 16 rRNA patterns from the bacterial communities before (Init) and after growth on DOM unexposed (Dark) or pre-irradiated to full sun (FS) or PAR. The numbers of ribotypes are indicated in parentheses.

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# BACTERIAL AND ARCHAEAL DIVERSITY IN THE MESO- AND BATHYPELAGIC WATERS OF THE EASTERN NORTH ATLANTIC BASIN

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# Abstract

The biogeography and diversity of bacterial and archaeal deep-water communities was investigated in the eastern North Atlantic basin. The internal transcribed spacer (ITS) region was used as a relevant marker for this study. ITS gene fragments provide higher taxonomic resolution than the 16S rRNA gene and served as a molecular indicator for prokaryotic diversity in the deep water masses of the North Atlantic. The aim of this study was to determine whether patterns of prokaryotic diversity correspond to individual water masses or whether the depth is a more important determinant of prokaryotic community composition. Based on our analyses we conclude that for deep water prokaryotic biogeography the water masses exert more influence on the prokaryotic community composition than simply depth. *Keywords : Bacteria, Biodiversity, Biogeography, Deep Waters, Intermediate Waters.* 

We investigated the composition of the meso- and bathypelagic prokaryotic community at 31 stations in the Canary and Cape Verde basin of the eastern North Atlantic Ocean. Temperature, salinity, density and oxygen concentration were used to identify distinct water masses. The mesopelagic waters (200-1000 m depth) were characterized by two distinct water masses depending of the location of the station: the more saline Mediterranean Sea Outflow Water (MSOW) and the relatively fresh Antarctic Intermediate Water (AAIW). The Lower Deep Water (LDW) (3000-4500 m depth) is characterized by a lower salinity than MSOW and a low temperature. To examine the variation between bacterial and archaeal assemblage at different stations, depths and water masses, we studied the less conserved internal transcribed spacer (ITS) region of the ribosomal operon, which is characterized by a significant variability in the length (from 150 to 1200 bp) among different bacterial and archaeal genotypes [1, 2].

Within a same water mass, the composition of bacterial community was relatively homogenous among stations (Figure 1). Bacterioplankton communities of the MSOW were slightly different from communities of the AAIW although both water masses occupied the same depth range. Specific bacterial and archaeal taxa were specific for distinct water mass while others are ubiquitously distributed over the entire water column. Bacterioplankton communities exhibited the highest richness in taxa intermediate waters (MSOW and AAIW) and the lowest richness in the LDW. Archaeal communities were generally less diverse than bacterial communities. For Archaea, the OTU (operational taxonomic unit) composition varied among stations even within the same water mass.

Jaccard (Opt5.00%) (Tol1.0%-10%) (H=0.0% S=00%) [0.0%-100.0%]



Fig. 1. Cluster analysis of bacterioplankton communities based upon all operational taxonomic units (OTUs) detected. Similarity is expressed as the Jaccard coefficient which compares the presence or absence of OTU when making pairwise comparison between communities. Cluster analysis was performed with the unweighted-pair-group mean average (UPGMA). For each sample, the water mass (MSOW, AAIW or LDW) and the station are indicated.

Bacterioplankton assemblages seem to be spatially more homogenously

distributed over large portions of bathypelagic ocean than the archaeal assemblages. These data show that the phylogenetic composition of prokaryotes is not only based on depth but also on water masses which are physically and chemically distinct entities. The composition of prokaryotic communities in the same water masses is largely maintained even over large distances. Thus, for assessing the biogeography of deep water prokaryotic communities the water masses have to be identified and incorporated into analysis.

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# MOLECULAR ANALYSIS OF THE PROKARYOTIC COMMUNITY IN THE SURFACE SEDIMENTS OF AN EASTERN MEDITERRANEAN DELTA FRONT AREA

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## Abstract

The prokaryotic diversity in the muddy sediments of a Mediterranean delta front area (Maliakos Gulf, Greece) was examined by sequence analysis of 16S rDNA clone library. The analysis of 160 clones revealed 54 unique non-chimaeric sequences mainly belonging to the  $\alpha$ ,  $\gamma$  and  $\delta$  subdivisions of *Proteobacteria* (5.5, 9.2 and 30%, respectively) and the divisions of *Acidobacteria* (5.5%), and *Chloroflexi*, *Verrucomicrobia, Planctomyces*, each accounting for 3.7% of the phylotypes found. High contribution of phylotypes closely related to bacteria involved in sulfur compounds and terrestrial organic matter cycling was observed. This indicates that in the submarine deltaic sediments adjacent to small rivers sulphur cycle and terrestrially derived organic matter may be important in diagenetic and biogeochemical processes.

Keywords : Aegean Sea, Bacteria, Coastal Systems, Deltas, Sediments.

#### Introduction

Large amounts of terrestrially derived organic material discharge through river runoff in coastal systems. Although much of this material is refractory and initially resistant to microbial degradation [1], in the submarine deltas of large tropical rivers, the remineralization of both terrestrial and marine organic carbon is comparably more efficient than in other marine environments [2]. Similarly, evidence of relatively high sediment community metabolic rates comes from the submarine depositions of smaller rivers in the Mediterranean and the Black Sea [3, 4]. However, little is known about the taxonomic and functional diversity of microorganisms involved in decomposition processes of terrestrially derived material in the suboxic deltaic sediments. In the present study, a culture-independent examination of microbial diversity in the muddy deltaic sediments of inner Maliakos Gulf (Aegean Sea, Greece) near Spercheios river mouth was carried out using sequence analysis of 16S rDNA clone library. This allows not only the assessment of prokaryotic diversity and community structure but also inferences to be made about the metabolic pathways used for the decomposition of organic material and the biogeochemical processes, in coastal systems influenced by riverine discharges.

#### Material and Methods

Sediment from the top 1 cm was collected under sterile conditions in May 2005 near Spercheios river mouth and remained for 2 months in -80°C. Total DNA was isolated using the Ultar Clean Soil DNA isolation kit (MOBIO, USA). The PCR products, derived using special bacterial primers (8Forward and 1492Reverse), were cloned with the TOPO XL kit (Invitrogen USA). 160 clones were randomly selected form the library and the sequences retrieved (Macrogen) were aligned using CLUSTALX, and compared to the 16S GenBank database by the BLAST (http://www.ncbi.nlm.nih.gov) and FASTA programs. The phylogenetic tree was constructed using distance analysis with Jukes-Cantor corrections and maximum-likelihood from the PHYLIP package (http://evolution.genetics.washington.edu/phylip.html).

#### Results and Discussion

Of 160 clones randomly selected in the library, 65 contained nonchimaeric sequences. These belonged to 54 unique phylotypes, thus indicating high prokaryotic diversity in the delta front sediments of Maliakos Gulf. Bacterial sequences belonging to the following major divisions were identified:  $\delta$ - Proteobacteria (30%),  $\gamma$ - Proteobacteria (9.2%), a- Proteobacteria (5.5%), Acidobacteria (5.5%), Planctomyces (3.7%), Chloroflexi (3.7%), Verrucomicrobia (3.7%). Phylotypes from the divisions Flexibacteraceae, Bacteroidetes, Fusobacteria and Spirochaetes contributed only up to 1.8% each while unidentified sequences accounted for 33% of the found unique sequences. Considerable similarity (ranging from 85 to 98%) was observed with phylotypes previously isolated from a variety of environments, including terrestrial wetlands and soils, as well as mud volcanoes and deep sea hydrothermal vents. The coexistence of phylotypes previously known from a variety of biotopes, both terrestrial and marine, may reflect not only material transportation and deposition processes through riverine and marine water circulation, but also high functional diversity of the deltaic prokaryotic community. Relatively high similarity (88-94%) of the present study sequences were observed

with bacteria characterized as sulphate reducers (i.e. *Desulfosarcina variabilis*) and species known to degrade hydroaromatic compounds, such as *Desulfobacterium aniline* and *Ilyobacter insuetus* sp. nov., as well as the sulphur oxidizer *Mesorhizobium thiogangeticum*, the nitriphier *Rhodopseudomonas julia* and the cellulolytic *Clostridium thermocellum*. This indicates that in the subaqueous deltaic sediments adjacent to small rivers sulphur cycle and terrestrially derived organic matter may be important in biogeochemical processes. The results of the present study are in accordance with findings in the submarine deltaic sediments deposited by large tropical rivers, in terms of bacterial diversity and community composition [5].

#### Acknowledgements

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# OCCURRENCE OF PROROCENTRUM SPP. IN IZMIT BAY AND RELATED ENVIRONMENTAL FACTORS

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# Abstract

*Prorocentrum* has been characterized as a genus that thrives in temperate waters and in the case of eutrophication and can occur in very high concentrations in coastal waters. The aim of this study was to examine the temporal occurrence of *Prorocentrum* spp. together with factors affecting its regional distribution in Izmit Bay. In total, five species were identified as *Prorocentrum micans*, *P. scutellum*, *P. triestinum*, *P. minimum* and *P. compressum*. A trend toward decreasing density and biomass with distance from the bay to Marmara Sea was found.

Keywords : Sea Of Marmara, Phytoplankton, Eutrophication, Dinoflagellates.

#### Introduction

*Prorocentrum* spp. are widespread in many marine areas and grow in extensive blooms and cause negative effects on environment [1]. Pollution problems have gradually become more serious in Izmit Bay since 1960 [2, 3]. Red tides and fish mortalities have been showed result from *Prorocentrum* spp blooms.

### Methods

Izmit Bay, located in the northeastern part of the Marmara Sea, is one of the most polluted areas in the Marmara Sea and an important, rapidly developing industry centre in Turkey. Besides the impact of streams, Izmit Bay, particularly the inner part of the bay, receives mainly continuous domestic and industrial input.

Samples were taken bimonthly from February 1999 to September 2000 at 10 sampling sites in the euphotic zone, representing to the bay and at four depths. Phytoplankton abundance was studied by the Uthermohl's technique. Biomass was estimated by biovolumes and chlorophyll *a*. Also, main physical and chemical parameters were determined using standard methods.

#### Results and Discussion

During the research period, five species were identified as *Prorocentrum* micans, *P. scutellum, P. triestinum, P. minimum* and *P. compressum.* The higher values in density and biomass were recorded in December 1999 (285337 cells  $1^{-1}$  and 3.94 mg m<sup>-3</sup>) and in April 1999 (237675 cells  $1^{-1}$  and 2.48 mg m<sup>-3</sup>), respectively (Figure 1).



Fig. 1. Seasonal variations of *Prorocentrum* spp. and other phytoplankton density in the three parts of Izmit Bay.

A trend towards decreasing density and biomass with distance from the bay to Marmara Sea was found. Nutrient concentrations (especially  $NO_3+NO_2-N$ ,  $PO_4-P$ ) in the upper layer of the bay were determined to be high, especially in the parts of eastern and middle, however, the highest values were recorded at the depth of 20 m (Table 1).

Tab. 1. Main average physico-chemical parameters (with standard deviation) in Izmit Bay.

| Parameters                                                  | Eastern     | Middle     | Western     |  |
|-------------------------------------------------------------|-------------|------------|-------------|--|
| Temperature (°C)                                            | 13.7±3.3    | 14.5±4.4   | 12.8±4.4    |  |
| Dissolved oxygen (mg l·1)                                   | 9.4±3.8     | 9.7±2.9    | 9.2±2.4     |  |
| SPM (mg l <sup>·1</sup> )                                   | 22.7±1.9    | 22.9±1.1   | 23.8±4.4    |  |
| NO <sub>2</sub> +NO <sub>3</sub> -N (μg N l <sup>-1</sup> ) | 14.5±7.2    | 9.4±4.7    | 8.9±6.2     |  |
| PO <sub>4</sub> -Ρ (μg Ρ l <sup>-1</sup> )                  | 12.7±8      | 6.8±5      | 4.9±4.5     |  |
| Total Nitrogen (µg N ŀ¹)                                    | 306.8±122.7 | 297.9±97.5 | 284.5±82.5  |  |
| Total Phosphorus (µg P ŀ¹)                                  | 38.9±40.6   | 29.8±34.8  | 17.2±13.5   |  |
| SiO <sub>2</sub> (μg Si ŀ¹)                                 | 299±317.4   | 220±232.5  | 201.7±187.8 |  |
| Total Organic Carbon (mg ŀ¹)                                | 2.96±0.31   | 2.63±0.29  | 2.37±0.1    |  |
| Total Chlorophyll a (mg m³)                                 | 5.2±4.5     | 3.5±3.6    | 1.9±1.8     |  |
| Total Density (x10³cell l-1)                                | 123±112     | 106±98     | 31±17       |  |
| Total Biomass (mg l·1)                                      | 1.63±1.64   | 1.48±1.5   | 0.68±0.6    |  |
| Diversity (H') (bits ind 1)                                 | 1.4±0.3     | 1.7±0.2    | 2.1±0.4     |  |
| Secchi disc depth (m)                                       | 2.3±0.61    | 3.7±0.95   | 4.7±0.85    |  |

During the increase of phytoplankton biomass, nutrient concentrations in the surface water of the bay were low. The transparency of the water column decreased towards the eastern part of the bay related to lower productivity and amount of terrestrial solid material in the water.

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# FREQUENCY OF HEAVY METALS AND BETA-LACTAM ANTIBIOTIC RESISTANCE OF ENTEROBACTERIACEAE MEMBERS ISOLATED FROM DIFFERENT AQUATIC ENVIRONMENTS

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# Abstract

The frequency of some beta-lactam antibiotics and heavy metal resistance of members of the *Enterobacteriaceae* family was investigated in the surface water from the Oludeniz Lagoon (the Aegean Sea), the Sea of Marmara, the Golden Horn Estuary and the Istanbul Strait, Turkey. In all selected isolates, the highest resistance was found to Ceftazidim as 48 %. Fifty five % of the strains resistant to antibiotics were also resistant to heavy metal salts.

Keywords : Bacteria, Metals, Antibiotics.

## Introduction

Metal resistant bacteria have developed very efficient and varying mechanisms for tolerating high levels of toxic metals and thus hold potential for controlling heavy metal pollution [1 - 5]. If a bacterial pathogen is able to develop or acquire resistance to an antibiotic, then that substance becomes useless in the treatment of infectious disease caused by that pathogen [6]. The study herein was planned in order to assess and compare the frequency of heavy metals and beta lactam antibiotics resistance of *Enterobacteriaceaea* members isolated from surface water of the Istanbul Strait, the Golden Horn Estuary, the Sea of Marmara and the Oludeniz Lagoon (the Aegean Sea), Turkey.

#### Materials and Methods

Antibiotic resistance was measured on Nutrient Agar plates supplemented with IPM, AMP, CTX, CRO, and CAZ. The bacteria belonging to *Enter-obacteriaceae* were isolated using the MPN Method and membrane filtration techniques. NiCl<sub>2</sub>.6H<sub>2</sub>O, CuSO<sub>4</sub>.5H<sub>2</sub>O, CdCl<sub>2</sub>.H<sub>2</sub>O, ZnSO<sub>4</sub>.7H<sub>2</sub>O and Pb(NO<sub>3</sub>)<sub>2</sub> were used for heavy metal resistance tests ([4], [7]).

## Results and Discussion

In all selected isolates, the highest resistance was found against Zn amounting to 35 %. We hypothesized that bacteria resistant to high concentrations of heavy metal salts would have potential capacities to tolerate or possibly degrade a variety of toxic materials and thus, would be important in environmental pollution bioremediation. Also indirect influences of bacterial pollution and negative environmental conditionals may be assumed to be related to antibiotic-resistant strains. The fact that 55% of the bacteria resistant to antibiotics are also resistant to heavy metals suggests that transfer of resistance takes place via plasmids.



Fig. 1. Frequency of antibiotic resistance of *Enterobacteriaceae* which were isolated from the surface water of the Istanbul Strait (1), the Sea of Marmara and (2) the Golden Horn Estuary (3) and Oludeniz Lagoon (4), Aegean Sea, TurkeyIPM: Imipenem, AMP: Ampicillin, CTX: Cefotaxim, CRO: Ceftriaxon, CAZ: Ceftazidim

Resistant strains will be used in the further plasmid-curing assays with the aim to ascertain resistance to antibiotics and toxic xenobiotics mediated by chromosomally borne genes and/or transposable elements rather than by plasmids.

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# THE LEVELS OF INDICATOR AND PATHOGEN BACTERIA IN MOLLUSK *UNIO PICTORUM* (LINNAEUS 1758) AND SURFACE WATER

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### Abstract

Indicator and some pathogen bacteria were investigated in both freshwater mussel, *Unio pictorum* (Linnaeus 1758) and water from five stations in the Buyukcekmece Lake, Turkey. *Helicobacter pylori, Staphylococcus aureus* and *Salmonella* spp. were isolated in three samples of 36 *Unio pictorum* samples over a one year period. The highest *Enterobacteriaceae* numbers were found in August and September in both *Unio pictorum* and water samples.

Keywords : Bacteria, Bio-indicators, Mollusca.

#### Introduction

*Unio pictorum* (Common name: Painter's mussel) is relatively tolerant to polluted waters and can be the sole unionoid present in waters immediately downstream of sewage outfalls [1]. The Buyukcekmece Lake has been isolated via a coastal barrier from the Marmara Sea in 1985 for the purpose of providing water supply and drinking water. In this study, the level of bacteriological pollution was evaluated in this specific indicator organism (*Unio pictorum*) and surface water collected from the Buyukcekmece Lake.

#### Material and Methods

*Unio pictorum* samples were collected at approximately 5-10 meters depth at selected stations and transported to the laboratory between January to December 2005. Water samples were taken [2] from the surface (0-20 cm). Analyses were carried out according to previously described methods [3-5].

#### Results and Discussion

The highest bacterial abundance was  $24 \times 10^3$  cfu/100 mL in *Unio pictorum* samples in August and September.



Fig. 1. Levels of total coliforms, *Esherichia coli* and *H. pylori* in samples of *Unio pictorum* collected in the Buyukcekmece Lake, Turkey during one year (2005).

The highest total *coliform* was found in water samples amounting to  $18 \times 10^2$  MPN/100 mL in September.

There were no significant differences in the values among the sampling stations. However, mussel samples contained more *coliform, E. coli and pathogen bacteria* than the surrounding water during the sampling period. This situation has led to the thought that there is more accumulation in organisms with respect to their environment, due to the sensitiveness of organisms to environmental contamination and their accumulation feature [6, 7].



Fig. 2. Levels of Total Coliforms, *E. coli*, in water samples collected in the Buyukcekmece Lake, Turkey. MPN/100 mL (2005).

It is also related to the probability that when the bacterial number in aquatic environment decreases, the number of CFU/ml in the medium also decreases because of the high substrate concentration [8]. There are no preliminary studies with which we can compare and discuss our determinations in this area. Monitoring microbial qualities of these areas is important in terms of saving natural resources and usage of the products which have economical importance.

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# THE DISTRIBUTION AND THE PROTOZOAN GRAZING EFFECT ON THE SURVIVAL OF BACTERIOLOGICAL INDICATORS OF POLLUTION AT DISCHARGE POLLUTED MARINE SEDIMENTS

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# Abstract

The monthly distribution of indicator bacteria were studied at the Black Sea exit of the Strait of Istanbul. The fecal coliform counts were lower than the fecal streptococci indicating that most of the culturable fecal coliform were lost. According to the sediment assays, the sediment microbiota consumed over 50 % of the fecal coliform and fecal streptococci. Although *C. perfringens* was also consumed by the predators, the counts during incubation period remained rather constant. According to these results, *C. perfringens* should be included to the sediment pollution monitoring studies since it has the highest survival rate.

Keywords : Bacteria, Bosphorus, Sewage Pollution, Sediments.

#### Introduction

The bacteriological indicators of water column pollution are generally used for estimating the sediment pollution [1], [2], [3]. The most common bacteriological indicators are fecal coliform and fecal streptococci [4] and *Clostridium perfingens* [5]. There are many deep discharge points through the Strait of Istanbul and therefore the lower current flow carry wastewaters to the Black Sea exit most of the year [6]. Studies showed that the macrobenthic diversity was adversely affected by discharging of wastewaters without any treatment in the Marmara Sea [7].

The distribution of fecal coliform, fecal streptococci and *C. perfringens* at the sediment of the northern exit of the Strait of Istanbul was studied for twelve months. The sediment samples were diluted by sterile seawater and sonicated as described [2]. For the estimation of the survival of bacteria, the sediment samples were incubated in 1 L jars with filtered (1.2  $\mu$ m) and non-filtered sediment surface water of the station and sterile seawater for control at 20 C° for seven days. The bacterial survival was detected by sampling form the incubation jars every 24 hours.

The fecal coliform counts were lower than the fecal streptococci counts throughout the year. The spores of *C. perfringens* were lower than the total *C. perfringens* counts, however, the number of spores were close to that of total *C. perfringens*.





The survival ability of fecal coliform was the lowest of all groups studied both in the filtered and non-filtered seawater. The fecal coliform counts decreased in non-filtered assay from 80000 CFU/100 g to 600 CFU/100 g within 7 d. Fecal streptococci also decreased remarkably from 100000 CFU/100 g to1800 CFU/100 g. Both fecal coliform and fecal streptococci counts were higher in filtered assav at the end of the first day. The fecal coliform decreased from 100000 CFU/100 g to 1000 CFU/100 g and fecal streptococci decreased from 230000 CFU/100 g to 10000 CFU/100 g after 7 d. According to the data of the first three days, 70 % of the initial fecal coliform and 50 % of the initial fecal streptococci was lost in non-filtered samples. Besides, the cells were lost more slowly at the filtered samples (20%). The size selective grazing as described [1], might be the result of a more rapid decrease in fecal coliform compared to other indicators. Although the C. perfringens counts were higher in the filtered samples, the vegetative and spores counts remained rather constant in both assays throughout the study.



Fig. 2. Survival of indicator bacteria in the marine sediment.

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# SPATIAL DISTRIBUTION OF ETS ACTIVITY AND ATP ALONG A TRANSECT FROM ANTARCTICA TO NEW ZEALAND

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# Abstract

Two proxies of microbial respiration (ETS) and biomass (ATP) were measured at the surface in early autumn 2001 from  $51^{\circ}$  to  $74^{\circ}$ S along  $175^{\circ}$ E across the Antarctic Polar Front (APF). An increasing of ETS activity and a concomitant decreasing of ATP was detected within the APF. This last has revealed itself a site of oxidation of organic matter and consequently a potential oceanic CO<sub>2</sub> source. *Keywords : Biomass, Plankton, Open Sea.* 

Respiration is controlled by the electron transport system (ETS), which is nearly ubiquitours in living organisms, hence the use of ETS method [1] as a proxy for microbial respiration is a valid way. The transfer of electrons along the ETS chain to oxygen generates adenosine-5'-triphosphate (ATP). Because ATP is rapidly destroyed after the death of organisms, the amount present in seawater can be used as a measure of living biomass [2]. ETS activity and ATP were studied in the superficial waters along a transect from Ross Sea to New Zealand with the aim of studying the influence of the Antarctic Polar Front (APF) on microbial biomass and respiration.

During the XVI Italian Antarctic Research expedition (BIOSESO II project, BIOsiliceous Sedimentation in the Southern Ocean), surface seawater samples (2.5 m) were collected on board the R/V *Italica* from underway continuous pump at every latitudinal degree (from 74° to 51°) along the Antarctica-New Zealand transect in early autumn of 2001. Microbial respiratory activity (<200  $\mu$ m) and biomass (Total=0.2-200 $\mu$ m; Pico=0.2-2  $\mu$ m; Nano=2-10  $\mu$ m; Micro 10-200  $\mu$ m) were determined according to the ETS and ATP methods [3].

ETS activity and ATP values registered in this study are close in the same range reported by other authors in the Southern Ocean [4, 5]. ETS activity ranged from 0.24 to 1.4  $\mu$ l O<sub>2</sub> h<sup>-1</sup> l<sup>-1</sup>. and showed a positive gradient from 74° to 51°S (Fig.1).



Fig. 1. ETS activity and ATP values along the sampled transect.

The highest and the lowest ETS values were determined in APF (from  $63^{\circ}$  to  $60^{\circ}$  S) and in the southern part of the transect, respectively. Intermediate activities were registered from  $59^{\circ}$  to  $51^{\circ}$ S.

ATP varied from 14.63 to 69.41 ng  $l^{-1}$  and the highest values were found from 64° to 75°S (Fig.1). Biomass decreased in APF and from 60° increased until to 49°S. In general the microplanktonic fraction dominated the transect (>55 %), with the maximum values from 64° to 66°S (>85 %).

ETS activity and ATP values were negatively correlated from  $76^{\circ}$  to  $60^{\circ}$ S and positively correlated from  $61^{\circ}$  to  $51^{\circ}$ , showing along the transect an uncouple and a couple of biomass and activity, respectively. In conclusion Antarctic polar front has revealed itself a site of oxidation of organic matter and consequently a potential oceanic CO<sub>2</sub> source.

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# BACTERIAL AND ARCHEAL COMMUNITIES IN THE ANOXIC SEDIMENTS OF THE VENICE LAGOON

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## Abstract

Sediments were sampled in nine stations representative of different ecosystems of the lagoon. The metabolic profile of each sediment was screened with AN-BiologâĎć for anaerobic bacteria. The structure of the bacterial communities was also analysed by Automated Ribosomal Intergenic Spacer Analysis (ARISA) allowing grouping the samples according to their similarity in community composition. One sample for each group was described in detail by the screening of 16S rRNA libraries, showing the dominance of Alteromonadales and Vibrionales, indicators of urban pollution around the city of Venice and Chioggia. Gamma-, Delta-Proteobacteria, Bacteroidetes and other minor taxa dominated the other stations. Among archaea, uncultivated and unidentified Euryarchaeota belonging to the Thermoplasmatales and Methanomicrobium groups were detected.

Keywords : Sediments, Anoxia, Bacteria, Biodiversity, Genetics.

#### Introduction

The lagoon of Venice is a large shallow water system (550 km2, mean depth 1m). It surrounds the city of Venice (Italy) and has been exploited for several purposes. During the last 20 years, the attention focused on the restoration of the lagoon equilibrium, planning a drastic decrease of nutrients and pollutants with a sensible beneficial effect on sediments, water, and biota quality. Lagoon sediments are are colonized mainly by anaerobic microorganisms. The aim of the work was to characterise the microbial communities of the lagoon sediments. This characterisation served to establish be a "state of reference" of the microbial sediment colonisation, useful to predict water anoxia, one of the most undesirable occurrences.

#### Methodology

The sediments were taken with a corer and the first 3 cm of three different cores were mixed to obtain a more representative sample of the station. Some environmental parameters such as pH and Eh were determined in situ, whereas the abundance of microbes were determined in the laboratory by microscope and total DNA analysis. Metabolic profiles of the microbial communities were screened with AN-BiologTM for anaerobes and analysed by Principal Component Analysis (PCA). The structure of the bacterial populations was analyzed with the PCR-fingerprinting technique Automated Ribosomal Intergenic Space Analysis (ARISA) [1]. PCA applied to the obtained fingerprints grouped the samples in three groups hosting similar bacterial communities. From selected stations, 16S rRNA libraries were constructed using bacteria- and archaea-specific primers.

#### Results and discussion

Seven out of nine stations were anoxic while 2 were hypoxic and all exhibited high microbial abundance ranging between 8.3x10exp7 and 5.7x10exp9 per volume??. Metabolic profiles of sediment microbial communities were screened from 10 stations of the lagoon of Venice with AN-BiologTM for anaerobes. PCA analysis of the profiles distinguished the samples in two different groups only on the basis of the microbial fermenting activity. Anaerobic respiration was not a differential metabolic feature among the samples. The structure of the bacterial populations was analyzed by ARISA fingerprinting. All the samples exhibited high species richness and Shannon index (respectively between 60 and 80, and 3.03 and 4.12) and very low dominance indexes (ranging from 0.021 to 0.081). PCA analysis of the fingerprints allowed to identify 3 stations representative of the groups of samples showing similar bacterial populations, that were subsequently described in detail by the screening of bacterial and archaeal 16S rRNA clone libraries (Figure 1). The composition of the bacterial communities differed between the three samples confirming the results obtained by ARISA. The bacterial communities appeared to be strongly influenced by anthropogenic activity. Areas adjacent to Venice and Chioggia showed the presence of Alteromonadales and Vibrionales, strong indicators of urban pollution. Gamma-, Delta-Proteobacteria, Bacteroidetes and other minor taxa dominated the other stations, where the gamma-Proteobacteria composition showed high concentrations of Chromatiales. These purple bacteria produce intracellular polymeric sulphur during the anoxygenic photosynthesis and probably were responsible in the past of "white waters" in the Venice Lagoon. Archaea were present in all the sediments of the lagoon. Most of the sequences present in the 16S rRNA libraries showed homology only with unidentified and uncultivated species retrieved from aquatic environments, belonging to the *Thermo*plasmatales and *Methanomicrobiales* groups of the *Euryarchaeota* order.



Fig. 1. Identification of representative phylogenetic groups detected from 16S rRNA clone libraries in 3 stations (B2, B8, B16) of the lagoon of Venice.

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# PHYTOPLANKTON BLOOMING IN THE MEDITERRANEAN SEA AS SEEN BY SEAWIFS (1998-2003)

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## Abstract

Assessments of SeaWiFS-derived (1998-2003) chlorophyll-like pigment concentration (Chl) were used to survey phytoplankton growth patterns in the Mediterranean Sea. The Chl average basin value, computed from yearly and monthly mean images, shows a decreasing trend, modulated by bimodal seasonal patterns, with maxima in late winter and minima in late summer. Chl anomalies, computed as the normalized difference between yearly/monthly means and corresponding climatology, become smaller with time over most of the basin. Both these elements point to a decrease of blooming intensity in the period considered, suggesting a more stable stratification and a reduced nutrient input by vertical mixing in the basin, in line with its reported warming trend. Larger and larger anomalies appear in hot spots along the Catalan and the Egyptian-Israeli-Lebanese coast, possibly owing to local factors such increased runoff. *Keywords : Remote Sensing, Ocean Colours, Pigments, Phytoplankton, Blooms.* 

Systematic ocean colour observations allow the monitoring of algal blooming at basin scales and over seasonal to multi-annual periods. Assessments of SeaWiFS-derived (1998-2003) chlorophyll-like pigment concentration (Chl) were used to survey phytoplankton growth patterns in the Mediterranean Sea. The image data were processed to correct for atmospheric contamination and to compute Chl values. After re-mapping to a common geographical grid, Chl yearly and monthly means (as well as climatological means) were derived by averaging individual images for the 6 years. Chl anomalies were obtained subtracting from each yearly/monthly mean image the corresponding climatological image.

The Chl climatological yearly mean is shown in Fig. 1. The Chl average basin value (Chl/abv), derived from the 6 yearly means composing this picture (Fig.2a), shows a decreasing trend over the period of SeaWiFS coverage, on the order of 20% of the climatological value (0.2 mg/m3). The Chl/aby, derived from the sequence of 72 monthly means (Fig. 2c), shows a bimodal seasonal pattern, with maxima from late winter to early spring, followed by minima from late summer to early fall. A liner fit to this curve displays a decreasing trend similar to that of the yearly case. The climatological seasonal pattern, obtained computing the sequence of 12 Chl/abv derived from the climatological monthly means (Fig. 2c), suggests that the Mediterranean Sea has a behavior similar to that of a sub-tropical basin - where the light level is never a limiting factor (so that its decrease in winter does not inhibit algal growth), but the nutrient level always is (so that vertical mixing, regulated by stratification of the water column, becomes the bloom trigger). Some regions have a different seasonality, due to particular boundary conditions (namely the north-western sub-basin, due to the deep convection driven by extreme wind forcing), which affects basin statistics, when the integrated Chl/abv values are used to describe the behavior of the basin as a whole.



Fig. 1. Climatological yearly mean of the SeaWiFS-derived (1998-2003) chlorophyll-like pigment concentration (Chl) in the Mediterranean Sea.

The Chl anomalies trend was analyzed by means of a pixel-by-pixel linear fit to the (monthly) images. Negative slopes, with positive intercepts, prevail almost everywhere, suggesting that, between 1998 and 2003, anomalies have been getting smaller and smaller over most of the basin interior. This implies a general decrease of the blooming intensity, in good agreement with the decreasing trend of Chl/abv seen in the yearly and monthly means. Both these elements point to a more stable stratification of the basin and a reduced nutrient input by vertical mixing, in line with the general warming trend of the Mediterranean Sea, appearing in the sea surface temperature record of the last three decades [1]. The residual positive slopes, with negative intercepts, suggest that anomalies have been getting larger and larger in selected hot spots, such as open water gyres and, mostly, recurring coastal plumes.



Fig. 2. Inter-annual (a), seasonal (b) and climatological (c) trend of the SeaWiFS-derived (1998-2003) chlorophyll-like pigment concentration (Chl), average basin value, in the Mediterranean Sea.

The major hot spots occur along the Catalan coast and the Egyptian-Israeli-Lebanese coast, and present a number of similarities: patterns of high Chl, rooted at particular coastal sites; likely large nutrient sources of continental origin; strong current systems, inducing the offshore spreading of plumes. The positive trend of Chl anomalies, appearing in both these areas between 1998 and 2003, tallies with a growing biological dynamism at these sites, i.e. with the intensification of harmful algal blooms, in the north-west, and the increase of coastal fisheries, in the south-east, recently reported in the literature [2,3].

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# MONTHLY CHANGES IN THE ABUNDANCE AND BIOMASS OF CYANOBACTERIA SYNECHOCOCCUS IN THE CILICIAN BASIN

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## Abstract

The aim of the present study is to understand the changes in the abundance and biomass of marine cyanobacteria *Synechococcus* with respect to multitude of ambient physical, chemical and biological factors. Monthly samples over a period of one year at a shelf station in the Cilician Basin (Eastern Mediterranean) were collected and analyzed. Due to winter mixing water column was nearly homogeneous. High temperature, salinity and low nutrient values together with maximum abundance and biomass of *Synechococcus* were recorded during late summer - autumn period at surface waters.

Keywords : Biomass, Eastern Mediterranean, Primary Production, Cyanobacteria.

Synechococcus were the first picoplankton discovered in world oceans [1]. Belonging to division evanophyta, they are important as a primary producer especially in oligotrophic waters and the open ocean [2]. This group of organisms are also one of the main components of the microbial loop [3].It is also regarded as one of the important phytoplankton in ultraoligotrophic Mediterranean Sea [4]. Having high sea surface temperatures and high salinity. Levantine Surface Water (LSW) is the dominant water mass in Cilician Basin during warm season [5]. Basin is also under the effect of river run offs influencing the nutrient budget as well as the salinity fluctuations [6]. The aim of the present study is to understand the changes in the biomass and abundance of Synechococcus with respect to multitude of ambient physical, chemical and biological factors. Monthly samples were collected from standard depths over a period of twelve months (February 2005-January 2006) at a single station (total depth is 200m) in the Cilician basin. Physical parameters, namely temperature, salinity, and density were measured via SeaBird-SBE 9 Oceanographics CTD profiler. Secchi disk depths were recorded. For the nutrient analysis (phosphate, nitrate, nitrite) water samples were collected from the standard depths by Nansen bottles [7]. Synechococcus abundances were found from the direct counts of the filtered samples [6]. Direct counts were made under a Nikon epifluorescent microscope at 1500X with a filter combination of B-2A (blue excitation-DM 505, EX 450-490, BA 520) and G-1A(green excitation-DM 575, EX 546/10, BA 580). For cell size measurements and further biomass estimations an image analysis system consisted of a digital camera, computer and a software were utilized. Cell volumes were determined using the volume formula for an ellipsoid [8]. To calculate carbon content of Synechococcus 123 fg carbon per cubic micron was used [9]. In order to find out the correlation between ambient parameters and Synechococcus abundance and biomass, Spearman rank-order correlation test was applied. The maximum, minimum, and average values found for all parameters during this study are summarized in Table 1.

Tab. 1. Maximum and minimum values of the biological, physical, and chemical parameters at surface and 200m depths of the station observed during year.

| Station (3626N 3421E)           |         |         |         |         |                |  |
|---------------------------------|---------|---------|---------|---------|----------------|--|
| Depth                           | 0       | m       | 20      | 0m      |                |  |
|                                 | maximum | minimum | maximum | minimum | Annual avarege |  |
| Synechochoccus Abundance (#/ml) | 340087  | 118663  | 247113  | 2746    | 151737.9       |  |
| Synechochoccus Biomass (µgC/I)  | 25.16   | 4.88    | 10.77   | 0.03    | 8.45           |  |
| Temperature (°C)                | 26.67   | 17.18   | 16.94   | 15.32   | 18.06          |  |
| Saliniy (psu)                   | 39.47   | 38.37   | 38.96   | 38.75   | 39.03          |  |
| Density                         | 28.51   | 24.89   | 28.97   | 28.62   | 28.33          |  |
| PO4 (µM)                        | 0.04    | 0.02    | 0.07    | 0.02    | 0.03           |  |
| NO3+NO2 (µM)                    | 0.2     | 0.05    | 3.4     | 0.18    | 0.57           |  |

Throughout the study, surface water was coldest in February and warmest in August. The lowest and highest salinities were observed on January and October at surface, respectively. The Secchi disk depths varied between 19m (in June) and 32m (in September). Over the year, mean PO<sub>4</sub> concentration for the water column was 0,03  $\mu$ M whereas the maximal levels were achieved during winter. Despite the low levels of NO<sub>3</sub>+NO<sub>2</sub> observed at surface significant fluctuations were observed in the water column. Concentration of total oxidized nitrogen showed a minimum during winter (0,05  $\mu$ M) and a maximum at 200m in November (3,40  $\mu$ M). To a minimum and maximum abundance of *Synechococcus* were reached in November at 80m as 865 cells ml<sup>-1</sup> and as 340087 cells ml<sup>-1</sup> during November at surface. In addition, to a maximum biomass (30,79  $\mu$ gC l<sup>-1</sup>) was reached in March at 40m depth and to a minimum value of 0,03  $\mu$ gC l<sup>-1</sup> in November at 200m depth. Both *Synechococcus* abundance and biomass showed highly significant positive correlations (P<0,01) with temperature, salinity, and negative correlation (P<0,01) with density, NO<sub>3</sub> + NO<sub>2</sub>, and depth. No correlation was observed with PO<sub>4</sub>.

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# PHYTOPLANKTON BLOOMS IN SAMSUN BAY OF THE SOUTHERN BLACK SEA

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# Abstract

This study has been planned to determine monthly variations in the phytoplankton composition and nutrients present in the least studied south shores of the Black Sea, known one of the most eutrophic seas in the world. During the course of this research, carried out between October 2002 and October 2003, three peaks in the total phytoplankton were observed. *Pseudo-nitzschia pungens* (Grunow) Hasle and *Eutreptiella gymnastica* Throndsen, *Proboscia alata* (Brightwell) Sundström and *Skeletonema costatum* (Greville) Cleve, *Dactyliosolen fragilissimus* (Bergon) Hasle bloomed in October, May and July, respectively. These findings were also supported by Chl *a* values and the biodiversity index of Shannon-Wiener (H).

Keywords : Biodiversity, Black Sea, Blooms, Eutrophication, Phytoplankton.

#### Introduction

Anthropogenic forcing and climatic changes are considered to be responsible of a worldwide increase in nuisance phytoplankton blooms which threatens ecosystem and public health. Besides, some fish kills due to these blooms can be spectacular in size. One of the most impacted seas in the world, the Black Sea has been eutrophied since 1960's. In this sea, a great deal of river discharge with proliferated nutriens caused a destabilized marine ecosystem which lead to HAB phenomena especially along the coasts.

## Methods

This study was performed at five stations in the neritic waters of the Samsun Bay, located between estuaries of the Kizilirmak and the Yesilirmak, two big rivers flowing in the southern Black Sea region of Turkey. Samples were collected monthly by a 2 l Hydro-Bios Water Sampler (0.5 m depth) and fixed with lugol solution and counted by phase-contrast microscopy. The below-mentioned values were analysed according to standard methods [1]. Taxonomic identifications were performed according to the following authors: Rampi and Bernhard (1978), Hasle and Syvertsen (1997), and Lange-Bertalot (2000).The most stable index of Shannon-Wiener (H) was preferred for the estimation of diversity [2].

#### Results

Temperature and N / P ratio was given in the fig.1. Total phytoplankton reached their maximal values in July 2003 (1200 x  $10^3$  cells L<sup>-1</sup>). In addition to July 2003, three more peaks were detected in October 2002 (382 x  $10^3$  cells L<sup>-1</sup>), May 2003 (689 x  $10^3$  cells L<sup>-1</sup>) and June 2003 (4.05 x  $10^3$  cells L<sup>-1</sup>), respectively (Fig. 2). Chl *a* levels were determined to be between 0.24 mg m<sup>-3</sup> in October 2003 and 0.25 mg m<sup>-3</sup> in May 2003. The highest diversity was determined at a depth of 0.5 m in August 2003 (*H*'=4.42). October 2002, on the other hand, was recorded as the month with the lowest diversity values found at a depth of 2.5 m (*H*'=1.28).



Fig. 1. Temperature and N/P ratios in Samsun Bay.



Fig. 2. Monthly variations of phytoplankton cell density, Shannon-Wiener's biodiversity index and Chl-a.

Discussion

Three unusual peaks of total cell density were detected in October 2002, May 2003 and July 2003. *P. pungens - E. gymnastica, P. alata - S. costatum* and *D. fragilissimus* bloomed respectively in these months. The results of Shannon-Wiener's diversity index have shown that the index decreased in October, May and July. Therefore, Chl *a* values increased in the months mentioned above. This is what allows, if not authorises, us to define the neritic waters of the Samsun coastline as eutrophic according to these findings.

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# ANALYSE DES COMMUNAUTÉS BACTÉRIENNES DES SÉDIMENTS DE LA LAGUNE DE BIZERTE (TUNISIE)

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## Résumé

Malgré les rejets de xénobiotiques, la lagune de Bizerte (Tunisie) possède une stabilité biologique montrant sa capacité d'auto-épuration. Afin d'estimer le rôle des microorganismes dans l'auto-épuration, l'impact des HAPs et l'effet des paramètres du milieu sur la diversité bactérienne ont été étudiés. En mai 2004 plusieurs prélèvements d'eaux et de sédiments ont été réalisés dans la lagune. La diversité bactérienne a été estimée par *Terminal-Restriction Fragment Length Polymorphism* (T-RFLP) basée sur l'analyse des gènes codant pour les ARNr 16S. Les Analyses Canoniques de Correspondance (ACC) en combinant les paramètres hydrobiologiques, la teneur en HAPs et les empreintes génétiques des communautés bactériennes par T-RFLP ont montré que la communauté bactérienne des sédiments de la station la plus contaminée par les HAPs se différencie clairement de celles des autres stations. *Mots clès : Bacteria, Biodiversity, Lagoons, Pah, Sediments.* 

Les hydrocarbures aromatiques polycycliques (HAPs) sont parmi les polluants les plus fréquemment rencontrés dans les zones côtières. Les microorganismes jouent un rôle capital dans la dégradation des polluants. Les communautés microbiennes des sédiments constituent un processus clé de l'atténuation naturelle, de plus en plus couramment envisagé comme alternative aux procédés actifs de réhabilitation de sites contaminés [1]. La lagune de Bizerte (nord de la Tunisie) reçoit des quantités importantes d'eaux usées urbaines et industrielles. Elle est chroniquement exposée à des composés tels les HAPs et les métaux lourds ([2]). Plusieurs stations ont été choisies tout autour de la lagune afin d'étudier l'impact des HAPs ainsi que l'effet du milieu sur la diversité bactérienne.

Des échantillons d'eaux et de sédiments ont été prélevés. 16 HAPs retenus comme polluants prioritaires ont été dosés par chromatographie en phase gazeuse couplée à la spectrométrie de masse. Après extraction des ADN génomiques des sédiments, les produits d'amplification par PCR de la séquence codant pour l'ARNr 16S ont été digérés par une endonucléase. La taille des différents fragments terminaux de restrictions (TRFs) a été déterminée par GeneScan. Après normalisation, les analyses canoniques de correspondance (ACC) des données de T-RFLP ont été réalisées par MVSP.

A partir des profils de T-RFLP, la Figure 1 montre que les communautés bactériennes de la station  $E_{12}$  sont sous la dépendance de la salinité et de divers éléments nutritifs.



Fig. 1. ACC entre les paramètres environnementaux et les communautés bactériennes.  $E_X$ : station d'échantillonnage, T: température, S: salinité, PO<sub>4</sub>: phosphore, N: azote, NH<sub>4</sub>: ammonium, NO<sub>3</sub>: nitrate, NO<sub>2</sub>: nitrite.

De même, la Figure 2 montre que les communautés bactériennes des sédiments de la station  $E_{12}$  sont influencées par la présence des HAPs. Les ACC des T-RFs a permis de corréler certaines populations avec la présence de polluant. Les populations caractérisées par le T-RF de 56 pb sont fortement influencées par le fluoranthène et le pyrène. Toutefois,

cette population est minoritaire dans les sédiments. Les populations caractérisées par le T-RF de 256 pb sont corrélées avec la présence de fluorène, de dibenzo(a,h)anthracène et de benzo(g,h,i)perylène. Ces populations sont majoritaires dans les communautés des sédiments des stations  $E_{123}$ et  $E_{35}$ . En conclusion, il semblerait que les communautés bactériennes des stations de canal (stations  $E_{12}$ ,  $E_{124}$ ,  $E_1$ ) et celles autour de la lagune (stations  $E_4$ ,  $E_6$ ,  $E_{35}$ ,  $E_{114}$ ,  $E_{123}$ ) sont soumises à des conditions environnementales différentes. Les communautés bactériennes des sédiments de la station  $E_{12}$  sont fortement influencées par la présence des HAPs suggérant que ces communautés bactériennes possèdent un potentiel important de dégradation des HAPs.



Fig. 2. ACC entre les populations bactériennes (TRFs) et les concentrations en HAPs. F: fluorène, FL: fluoranthène, PY: pyrène, DB: Dibenzo(ah)anthracène, BPE: Benzo(g,h,i)perylène.

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# THE NEW PHYTOPLANKTON RECORDS FROM TURKEY

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# Abstract

From the samples taken from during the period of 1998-1999 in the frame of TUBITAK (the scientific and technological research council of Turkey) project, 37 phytoplankton species were recorded for the first time. Among these organisms as a toxic phytoplankton *Prorocentrum mexicanum* which causes "ciguatera" have been recorded for the first time in Izmir Bay, Turkey. The other toxic species; *Heterosigma* cf. *akashiwo* and *Gymnodinium* cf. *mikimotoi* which have well-known ichthyotoxic effects were reported in the scientific journal. Whether toxic or not all species were particularly abundant in the hypereutrophic Inner section and eutrophic Middle section of the Izmir Bay in April and September 1998.

Keywords : Aegean Sea, Phytoplankton, Eutrophication, Coastal Waters.

Despite the researches on phytoplankton have been carried out in Turkey for almost half a century, the contunuity of researches and publishment of results obtained have been restricted by a series of different reasons and hence, the information to be collected and or harvested from these studies have been inheritedly a hard task to be dealt with because of locality, incompleteness and incontinuity and discreteness. However, Koray and his colleques has achieved to review and gather those information in great deal and they have established a database on phytoplankton of turkish seas (http://bornova.ege.edu.tr/ korayt/plankweb). Koray and his colleques have a prominent roles in establishment of such a comprehensive. Regarding the sampling area the present study, a total of about 187 phytoplankton species (94 Dinoflagellate, 84 Diatom, 2 Dictyochaphyceae, 2 Euglenophyceae, 1 Cryptophyceae, 3 Ebriidae, 1 Raphidophyceae) have been reported in Izmir Bay.

Izmir Bay is one of the most polluted estuaries in the Mediterranean Sea [1, 2]. The untreated waste waters originating from the increasing population (exceeding 3 million) together with substantial industrial development, intensive harbor activities and agriculture in and surrounding areas of the bay have exerted considerable pollution loads particularly to the Inner Section. Therefore, significant phosphorus (P), nitrogen (N) and iron (Fe) enrichments syncronously and/or similtaneously have been observed in this section [1]. Phytoplankton blooms every year starting from spring to the late autumn including harmful red tides that are currently spreading and increasing. The first record for red tide in the bay was given in the middle of 1950's [3,4]. In this first report given by Numann (1955), mass fish mortality was noted. The frequency of red tide events are in increasing trend in the last two decades. The frequency of occurence of red tides is closely related to progressive increasing in the level of eutrophication, as stated by Honjo (1993) [5]. In the bay, Noctiluca scintillans forms very commonly red tide, but Prorocentrum micans, P. triestinum, Ceratium sp., Nitzschia sp., Pseudo-nitzschia seriata group, Thalassiosira sp., Eutreptiella sp. and Mesodinium rubrum are also potent causative organisms [6].

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# ÉTUDE DE LA DISTRIBUTION DES *ESCHERICHIA COLI* ENTEROPATHOGÈNES DANS LA LAGUNE DE BIZERTE (NORD-TUNISIE)

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# Résumé

La présente étude a été effectuée en vue d'estimer la distribution d' *Escherichia coli* dans la lagune de Bizerte. Les résultats obtenus montrent que cette entérobactérie est présente dans les eaux aussi bien que dans les sédiments avec une charge importante sur la périphérie de la lagune. Sur l'ensemble des souches étudiées c'est le sérotype O111B4 qui est le plus fréquent. Tous les sérotypes présentent une multirésistance à plus de 10 antibiotiques différents.

Mots clès : Bacteria, Lagoons, Antibiotics.

#### Introduction

*Escherichia coli* constitue l'espèce entéropathogéne la plus souvent rencontrée en pathologie entérique. En Tunisie, une étude récente [1] sur 204 échantillons alimentaires a révélé un foyer épidémique à *Escherichia coli* vecteur de shiga-toxine (STEC). La lagune de Bizerte qui représente notre site d'étude, est un milieu économiquement important grâce à sa richesse halieutique et conchylicole. Plusieurs cours d'eau qui débouchent principalement au niveau de ses bordures sud et ouest, représentent des points d'apport des rejets hydriques. Dans la présente étude, nous nous proposons d'évaluer l'état de la contamination de la lagune par les entérobactéries (*E. coli*), de déterminer leur distribution spatiale et de caractériser les sérotypes pathogènes.

### Matériels et méthodes

Des prélèvements d'eau de surface et de sédiments ont été effectués au niveau de 41 stations réparties sur la lagune de Bizerte (Fig.1) durant la période de mai 2005. Tous les échantillons ont été conservés à 0°C au préalable des différentes analyses effectuées dans les 24 heures qui suivent leur prélèvement. Les entérobactéries ont été dénombrées par PCA (Plate Counting Agar) sur un milieu gélosé au Désoxycholate après une incubation de 24 heures à 37°C. Les isolats d' *E. coli* ont été identifiés par tests morphologiques, métaboliques et biochimiques. Le sérotypage a été réalisé par test d'agglutination à l'Institut Pasteur de Tunis. L'étude antibiotypique a été établie (en duplicat) par méthode de diffusion sur gélose Mueller-Hinton (Société Française de Microbiologie), en utilisant 15 disques d'antibiotiques.



Fig. 1. Répartition des stations d'échantillonnage dans la lagune de Bizerte.(a) Les grandes villes.(b) Stations de prélèvement.

#### Résultats et discussion

La distribution spatiale des entérobactéries a été effectuée par logiciel Surfer version 7 (Surface Mapping System, Golden Software Inc.) (Fig.2). Ainsi, dans les eaux de surface les entérobactéries sont concentrées sur la périphérie de la lagune (zones d'agglomération urbaines et d'activité conchylicole). Ces zones représentent des points de rejets hydriques véhiculés par les oueds en périodes de pluies. Au niveau du sédiment, la charge en entérobactéries est plus importante, et elle est concentrée essentiellement du coté nord-est de la lagune. Il est à noter que ces charges sont inférieures aux normes (<100 cfu/ml) décrites par la directive européenne (76/160/CEE) qui définit la qualité des eaux de baignade et des coquillages.



Fig. 2. Variation spatiale des abondances des coliformes totaux dans les échantillons de sédiments (a) et d'eaux (b) dans la lagune de Bizerte.

Un ensemble de 21 souches d' E. coli (19 souches de prélèvements d'eau et 2 de sédiment) ont été isolées et identifiées. Les colonies d' E. coli sur milieu gélosé au Désoxycholate lactosé sont roses et larges. Ce sont des bacilles gram négative, mobile, produisant la beta-galactosidase et l'indole, fermentant le lactose, le glucose et le mannitol, mais elles n'utilisent pas le citrate. L'ensemble des souches s'agrégent en trois sérotypes pathogènes: O111B4 (80%), O26B6 (10%) et O55B5 (10%). Les résultats montrent que plus de 70% de ces sérotypes sont concentrés du coté nord-est de la lagune. C'est le sérotype O111B4 qui est le plus fréquent. Une étude ultérieure décrit le sérotype O55B5 le plus répondu en agroalimentaire [1]. Une autre étude menée sur des clovisses provenant du complexe Ichkeul-Bizerte a identifié cinq sèrotypes différents d' E. coli pathogènes : O126B16, O111B4, O55B5, O86B7 et O128B12 [2]. Les profil antibiotypiques pour l'ensemble des souches trouvées montre que les sérotypes isolés présentent le même profil antibiotypique. Le taux de résistance est de 90 à 100% des souches totales pour 10 antibiotiques : pénicilline, ampicilline, oxacilline, cèfoxitine, kanamycine, néomycine, tétracycline, erythromycine, triméthoprime-sulfamides et l'acide nalidixique. Cette résistance multiple serait due aux rejets de bactéries multirésistantes et l'utilisation anarchique d'antibiotiques en aquaculture [3, 4].

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# FUNCTIONAL DIVERSITY AND PHOTORESPONSES OF PHYTOPLANKTON COMMUNITY IN THE NORTH-WESTERN MEDITERRANEAN SEA DURING THE SPRING BLOOM 2003

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# Abstract

The spring bloom evolution was investigated in 2003 in the North-Western Mediterranean Sea, using HPLC pigment analysis on fractionated samples (<3 mm and >3  $\mu$ m) and flow cytometry. The physical and biological properties of the water mass were followed using a Lagrangian approach during 3 cruises of one week each. The onset of thermal stratification induced vertical group segregation, with cyanobacteria and prymnesiophytes at surface and green algae and diatoms at depth. The diatoms dominated larger phytoplankton during the initial phases, while also pico-sized diatoms were abundant during the peak phase of the bloom. Pigment cell content of picophytoplankton was estimated and lied in the range of values observed for another oligotrophic site of the Mediterranean Sea. *Keywords : Phytoplankton, Pigments, Blooms, Physiology.* 

The North-Western Mediterranean Sea is characterized by a recurrent, intense phytoplankton spring bloom, lasting more than two months and clearly visible by ocean color remote sensing. This area is characterized by a high variability in the hydrodynamics at micro- and meso-scale that is determining such elevated biological production.

During the spring 2003, two sampling cruises took place, with the aim of investigating phytoplankton dynamics as related to mesoscale physical structures. During the cruises, three Lagrangian experiments were conducted in the area interested by the algal bloom, two in March (between the 6 and 25, LExp-1 and 2) and the third one in April (18-24, LExp-3) 2003. These experiments, lasting one week each, were performed at different moments of the bloom succession and allowed to investigate phytoplankton dynamics at different time scales, from circadian to weekly. Also the vertical variability during the bloom was investigated. Light and hydrological profiles were also performed at high time frequency during the experiments and discrete samples were taken from two to five times per day at 5 depths (ranged between 2 to 70 meters) for HPLC pigment analysis on fractionated samples (<3  $\mu$ m and >3  $\mu$ m) and flow cytometry. The combination of size-fractionated pigment analysis and flow cytometry allowed to deeply investigate the acclimation status of this small cell size community to the environment, and to estimate their cellular pigment content. At the same time, on-board incubations on filter-fractionated samples taken at 10 meters depth were realized, in order to estimate the kinetics of photophysiological responses of the phytoplankton community (e.g. Brunet et al., 2003). The water column was mixed and no change of water mass physical properties was detected, except in April when an increase in temperature in the first 25 m marked the onset of thermal stratification.

Chla biomass ranged between 1 and 5  $\mu$ g chla  $l^{-1}$  and the contribution of picoplankton was between 20 and 70 %, lowest during the LExp-2 and the highest during the LExp-3 (April), and generally dominated by green algae. The peak of the bloom was attained during the LExp-2 (late March). Diatoms dominated in the larger fraction, but were also abundant in the smaller, contrasting with what observed initially, when they contributed only to the larger phytoplankton. As related to the increasing stratification, biological segregation was visible within the picoplankton, with cyanophytes in the upper layer and picoeukaryotes at depth. In the nano- and micro-plankton (>3 $\mu$ m), Prymnesiophytes thrived at surface and diatoms at depth.

This distribution was probably due to the decrease in nutrient concentrations in the surface layer as well coupled with the increase in light and decrease in mixing. The increase in irradiance induced a significant higher photoprotection in the surface layer as marked by the increased diatoxanthin/chla ratio as well as by the de-epoxidation state of phytoplankton (DES, ratio the two components of the photoprotective xanthophyll cycle, diatoxanthin and diadinoxanthin). These indicators showed higher values in the larger size class than in the picophytoplankton, probably due to higher content of pigment per cell. The weak vertical gradient of cell chlorophyll fluorescence of *Synechococcus* observed by flow cytometry indicated low photoacclimation process along the water column, in relation with the beginning of the stratification during LExp-3. Also picoeukaryotes showed no clear signal of photoacclimation, probably due to species or group replacement, as confirmed by the large pigment diversity found in the smaller size fraction. Estimations of chla per cell of picoeukaryote ranged between 40 and 120 fg chla cell<sup>-1</sup>, while the zeaxanthin content of *Synechococcus* cells was of 0.80 fg cell<sup>-1</sup>, both being in the range of values estimated by Brunet et al. (2006) in the Strait of Sicily.

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# ISOLATION AND IDENTIFICATION OF A THERMOPHILIC CYANOBACTERIUM FROM BALCOVA, IZMIR, TURKEY

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# Abstract

Hydrothermal systems have prevailed throughout geological history on earth, and ancient Archaean hydrothermal deposits could provide clues to understanding earth's earliest biosphere. A cyanobacterium living at 50°C was isolated from Balcova geothermal field. 16s rDNA was extracted and amplified for sequence analysis.

Keywords : Cyanobacteria, Biodiversity, Genetics.

### Introduction

Thermophiles are microorganisms that live and grow in extremely hot environments that would kill most other microorganisms. They can be isolated from a number of marine and terrestrial geothermally-heated habitats including shallow terrestrial hot springs, hydrothermal vent systems, sediment from volcanic islands, and deep sea hydrothermal vents. They grow best at temperatures that are between 50-70°C. They will not grow if the temperature reaches  $20^{\circ}C$  [5].

Microorganisms thriving in high-temperature terrestrial and deep-sea hydrothermal systems have investigated by several authors. A thermophilic cyanobacteria *Synechococcus elongatus* in the temperature range  $60-80^{\circ}$  C was found [1]. Papke and colleagues [4] studied two groups of thermophilic cyanobacteria: the unicellular *Synechococcus* and the colonial, filamentous *Oscillatoria*. The thermophilic cyanobacteria *Thermosynechococcus elongatus* and *T. vulcanus*, which were isolated from a Japanese hot spring, grow optimally at ca.  $57^{\circ}$ C (3). In these extreme environments, the microbial and geochemical interactions are tightly interwoven, providing many of the basic constituents for the primordial synthesis of organic molecules and for the evolution of fundamental metabolic processes (5). Whether life originated at vents in the archaean age (3.8-2.5 Ga) and whether chemolithoautotrophic thermophiles are ancestors of life is unresolved; however, hydrothermal environments probably did support the early evolution of chemolithoautotrophs and thermophiles (5).

Turkey is the seventh-richest country in the world in geothermal potential. Balçova geothermal district, called Agamemnon Spas in ancient times, is one of the geothermal districts in Izmir City. There are 8 production wells in Balçova with a temperature interval between 86-138°C. In this research, a thermophilic cyanobacterium was isolated from Balcova geothermal field and 16s rDNA was extracted and amplified for sequence analysis.

### Materials and Methods

Balçova is located at the western tip of Anatolia. Samples were collected from outflows of the hot spring pipes,  $38^{\circ}23'21.29"$  N and  $27^{\circ}01'58.97"$ E of Balçova. Water sample was transported to the laboratory by hot line in 30-60 min. Two different cyanobacteria mediums were prepared for cultivation (7). Samples from hot spring were inoculated into the mediums and incubated at  $65^{\circ}C$  and at  $45^{\circ}C$  for two weeks. The isolate was purified by serial dilution. The material was refrigerated ( $4^{\circ}C$ ) until analysis.

DNA was extracted by Bio Basic commercial kit (BS423-50) according to manufacture's instructions. DNAs' quality was checked by agarose gel electrophoresis and spectrophotometer.

PCR amplifications were performed with PE Applied Biosystem, GeneAmp PCR System 9700 using universal bacteria primers. Fifty picomols of each primer, 25 nmol of each deoxynucleosidetriphosphate, 25  $\mu$ l of 10x PCR buffer, 0.5 U of Taq polymerase and 20 ng template DNA mixed in volume of 50  $\mu$ l in a 0.5-ml test tubes. Two different primer pairs used for amplification of 16S rDNA of *Schizothrix sp*. DNA amplified under following conditions: 5 min at 95°C for initial denaturation, 94°C for 30 s, 50°C for 30 s, 72°C for 2 min for 10 cycle. 92°C for 30 s, 50°C for 30 s, 72°C for 2.5 min for 20 cycle and 72°C for 5 min for final extension step. Amplified DNA checked by agarose gel electrophoresis and photographed.

#### Results and Discussion

An organism that thrives in an extreme environment is an extremophile: in more than one extreme it is a polyextremophile. Examples of the latter would include Sulfolobus acidocaldarius, an archaea that flourishes at pH 3 and 80°C. 'Extremes' include physical extremes (for example, temperature, radiation or pressure) and geochemical extremes (for example, desiccation, salinity, pH, oxygen species or redox potential)[6]. In this study the cyanobacteria was isolated from a 96°C geothermal fluid leakage near the hydrothermal well. The fluid was formed a pond at 45° insisting cyanobacterial formations. Microscopic identification revealed that only one genus existed in the sample identified as Schizothrix sp. The isolate was cultivated in two media at 50°C. It has been suggested that the photosynthetic apparatus itself is the most temperature-sensitive component of the cyanobacteria with the highest temperature tolerances (i.e., 73 to 74 °C). The photosynthetic apparatus of thermophilic cyanobacteria is similar to that of higher plants; however, it is resistant to high temperatures at the subcellular level [1]. In this study 16S rRNA region of the isolated cyanobacteria was amplified by universal cyanobacteria primers successfully [2]. The sequence of 16S rRNA region of the cyanobacterium will be used to constract phylogenetic trees between related taxa in further studies. The discovery of extreme environments and the organisms that inhabit them has made more plausible the search for life outside the Earth, and even the possibility of panspermia (the transport of life from one planet to another).

#### Acknowledgment

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# HYDROGRAPHY AND PLANKTONIC DIATOMS IN THE MARINE LAKE MIR (EASTERN ADRIATIC SEA, CROATIA)

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## Abstract

Due to its geomorphologic isolation and shallow depths, the lake Mir is a peculiar biotope, with highly specific water dynamics driven by the considerable temperature amplitudes and high salinity (max. 44.36). Diatoms dominated the phytoplankton abundance in the lake almost throughout the entire investigated period. The greatest number of diatom taxa correlated positively with temperature or salinity. The most abundant and most frequent diatom taxon was *Actinocyclus* sp., with abundances exceeding  $10^5$  cells L<sup>-1</sup>. *Keywords : Temperature, Salinity, Diatoms, Adriatic Sea.* 

### Introduction

Lake Mir is a landlocked marine environment, situated on the southern edge of Dugi Otok Island (Middle Adriatic). It is an enclosed water-body with special geomorphological phenomenon, where communication with the surrounding sea takes place through a system of subterranean caves and siphons. The lake is elongated, 910 x 280 m in size, with a surface area of 0.23 km<sup>2</sup>. This is the first study carried out on the ecology of diatoms in karstic Lake Mir, the most saline marine lake on the Adriatic coast.

#### Materials and Methods

Samples for temperature, salinity and phytoplankton analyses were collected between November 1999 and December 2000 at monthly intervals. Samples were taken using 5 L Niskin bottles at one station, from the surface to the bottom (7 m), at one meter intervals. Temperature and salinity were determined using standard oceanographic methods [1]. Phytoplankton abundance was determined using an inverted microscope Olympus IX71 [2]. Correlation analysis was performed on collected data in order to determine the relationship between diatom abundance, and temperature and salinity, using STATISTICA 4.5 software.

#### Results

The annual distribution of temperature and salinity in the marine Lake Mir is shown in Figure 1. Temperatures in the lake oscillated between  $3.65 \,^{\circ}$ C (January) to  $27.5 \,^{\circ}$ C (June). The water column throughout the year was mostly isothermal. Salinity ranged from 37.90 to 44.36, with a peak in September.



Fig. 1. Distribution of temperature (T) and salinity (S) (values are expressed as water column mean).

Microphytoplankton (MICRO) abundances varied from 1.3 x 10<sup>3</sup> cells L<sup>-1</sup> (March) to 4.5 x 10<sup>5</sup> cells L<sup>-1</sup> (November). Altogether, 63 taxa of MICRO were identified in the samples, of which 36 were diatoms. Thereof, 15 diatom species were identified in  $\geq$ 10% of the total sample number. *Actinocyclus* sp. was the most abundant and most frequent diatom taxa that reached intensive development in November 1999 (6.8 x 10<sup>5</sup> cells L<sup>-1</sup>).

Correlations between the most frequent diatom taxa (presented  $\geq 10\%$  in total number of samples) and temperature and salinity variables are shown

in Table 1. The greatest number of taxa correlated, positively, with temperature or salinity. A total of four taxa correlated with these two variables at the same time. *Actinocyclus* sp., the most abundant taxon, significantly and positively correlated with those two variables.

Tab. 1. Correlations between the most frequent diatom species and temperature and salinity. Only significant correlations are shown (P<0.05, N=78).

|                              | Variables | TEMP | SAL |
|------------------------------|-----------|------|-----|
| Taxa                         |           |      |     |
| Actinocyclus sp.             |           | .30  | .42 |
| Amphora ostrearia            |           |      | .23 |
| Amphora                      |           | .26  | .50 |
| Coscinodiscus sp.            |           |      |     |
| Diploneis sp.                |           |      |     |
| Entomoneis pulchra           |           |      |     |
| Navicula spp.                |           |      | .46 |
| Naviculoid cells             |           | .23  | .47 |
| Nitzschia incerta            |           |      |     |
| Nitzschia sp.                |           |      |     |
| Paralia sulcata              |           | .32  |     |
| Pleurosigma angulatum        |           | .27  |     |
| Pleurosigma sp.              |           |      |     |
| Tropidoneis sp.              |           |      |     |
| Undetermined pennate diatoms | 5         | .29  | .34 |

#### Conclusions

There were no temperature and salinity stratification in the lake throughout the observed period. The increase in the temperature and salinity during the summer period could be caused by the isolation of Lake Mir and evaporation processes. MICRO as well as diatom populations were represented by a relatively small number of species, however, some of them with high abundances ( $10^4$ - $10^5$  cells L<sup>-1</sup>). Diatoms, both in terms of taxa number and abundances, were the dominant MICRO group throughout the year. Distribution of diatoms coincided with the distribution of temperature and salinity, which was confirmed by correlation analysis.

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# ABUNDANCE AND COLONIZATION OF ATTACHED DIATOMS IN THE ZRMANJA ESTUARY, ADRIATIC SEA

SEA

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## Abstract

The colonisation of a periphyton community on Plexiglas plates was observed in the oligotrophic karstic Zrmanja Estuary (eastern Adriatic coast), during the summer of 2000. Maximum periphyton biomass was detected at days 19-25 (chlorophyll *a* 1630-1674 ng cm<sup>-2</sup>). The dominant periphitic microalgae were diatoms (maximum concentration of fucoxanthin 1371.4 ng cm<sup>-2</sup>, maximum abundance 1.8 x 10<sup>7</sup> cells cm<sup>-2</sup>). Among the 69 determined taxa, the highest species diversity was found in the genera *Navicula* (13 taxa), *Nitzschia* (12 taxa) and *Achnanthes* (6 taxa). The diatom *Amphora coffeaeformis* var. *coffeaeformis* (C.A. Agardh) Kützing dominated throughout the entire colonisation period (100% frequency of appearance, abundance up to 1.6 x  $10^6$  cells cm<sup>-2</sup>). *Keywords : Diatoms, Estuaries, Adriatic Sea.* 

#### Introduction

Diatoms dominate benthic microalgae in temperate brackish waters [1]. Ecological conditions of the highly stratified Zrmanja Estuary, in the eastern part of the Adriatic Sea, have been poorly investigated [2]. The main goal of the presented research is to record the presence, abundance and colonization of attached diatoms on Plexiglas surfaces in the Zrmanja Estuary.

#### Methods

The colonisation of the periphytic community on Plexiglas plates was measured every three days during July 2000. Plates were inserted in a metal frame, anchored three meters off the bank, and 35 cm below the water surface. Substrates were vertically positioned and parallel to the water current. Samples were scraped off the plate surfaces with a scalpel and an adapted toothbrush, after rinsing with water. After acid cleaning, diatoms were identified under inverted microscope (magnifications 1000, 400 x) using standard manuals. Cells (200-300) were counted by inverted microscope [3]. Diatoms were presented by the frequency of appearance (f %) and abundance (a), expressed as number of cells per cm<sup>2</sup>. Biomarker pigments were analysed using high-performance liquid chromatography (HPLC).

#### Results and discussion

Thermohaline stratification and low water inflow (avg.  $1.43 \text{ m}^3 \text{sec}^{-1}$ ) provided favourable conditions for periphyton colonisation during the summer. The surface salinity varied between 8 and 14, and temperature between 19 and 24 °C. The colonisation period could be differentiated into three phases: the lag phase (lasting 13 days), growth phase (13-25 days) and decline phase (after 25 days).



Fig. 1. Distribution of diatom abundance and concentrations of pigments chlorophyll *a* and fucoxanthin, in the upper reach of the Zrmanja Estuary, during July, 2000.

Chemotaxonomic analyses provided evidence of maximum periphyton biomass (chlorophyll *a* 1630-1674 ng cm<sup>-2</sup>) during the second phase (19-25 days), and dominance of fucoxanthin among other accessory periphyton pigments (figure 1). Diatom assemblage was composed of 69 taxa, with highest species diversity in the genera *Navicula* (13 taxa), *Nitzschia* 

(12 taxa) and Achnanthes (6 taxa). The records of maximum diatom abundance ( $1.8 \times 10^7$  cells cm<sup>-2</sup>) corresponded with maximum pigment fucoxanthin concentration ( $1371.4 \text{ ng cm}^{-2}$ ), which were detected at the end of second phase (figure 1).

The dominant diatoms (table 1) were Amphora coffeaeformis var. coffeaeformis (C.A. Agardh) Kützing, Licmophora gracillis (Ehrenberg) Grunow, Navicula veneta Kützing, Nitzschia longissima (Brébisson) Ralfs (Nitzschia closterium (Ehrenberg) and Synedra tabulata (C.A. Agardh) Kützing (frequency of appearance >72% n=18 and abundance >10<sup>6</sup> cells  $cm^{-2}$ ) (table 1). Among fifteen pioneer species, Navicula sp. (356 cells  $cm^{-2}$ ) and N. gregaria Donkin (127 cells  $cm^{-2}$ ) dominated in the first 10 days of succession. The species N. veneta and L. gracillis also dominated as initial colonizers that were mainly found throughout the entire period of colonisation (table 1). The diatoms Synedra tabulata, L. gracillis and Nitzschia longissima ( N. closterium) were found as both attached and planktonic taxa living in the surrounding water column. The domination of diatom A. coffeaeformis var. coffeaeformis throughout entire colonisation period (table 1) relates to its characteristics as a holoeurihaline and cosmopolitan taxon that prefers summer growing conditions [4]. The diatoms Melosira moniliformis (O.F. Müller) Agardh and Falacia sp. were found to be dominant species in the end of the second growth phase.

Tab. 1. Dominant diatoms during colonisation on Plexiglas plates (Zrmanja Estuary, July 2000).

| taxa / day                               | 4   | 7   | 10   | 13      | 16      | 19      | 22       | 25       | 28      | sum a    | f (%) |
|------------------------------------------|-----|-----|------|---------|---------|---------|----------|----------|---------|----------|-------|
| I iomonhova avasillis                    | 26  | 105 | 761  | 160410  | 126800  | \$2(22  | 276424   | 284032   | 200202  | 1512065  | 0.4   |
| Synedra tabulata                         | 18  | 195 | 626  | 218740  | 10139   | 105244  | 138212   | 213024   | 154696  | 1097858  | 94    |
| Haslea spicula *                         | 13  | 39  | 127  | 15221   | 30416   | 7810    | 138212   | 102708   | 154696  | 555077   | 72    |
| Navicula veneta                          | 173 | 78  |      |         | 253600  | 52622   | 691060   | 639072   | 1701656 | 3662724  | 72    |
| Amphora coffeaeformis var. coffeaeformis | 13  | 78  | 8633 | 2012412 | 1648400 | 3578296 | 15617956 | 13633536 | 6265188 | 55598208 | 100   |
| Nitzschia longissima or N. closterium    | - 1 | 39  | 127  | 289205  | 126800  | 3905    | 2626028  | 2875824  | 464088  | 6694891  | 80    |
| Melosira moniliformis **                 |     |     | 3    | 43748   |         |         | 1382120  | 1540620  |         | 2966491  | 22    |
| Falacia sp.**                            | 13  |     | 127  |         | 10139   | 7544    | 691060   | 994112   | 154696  | 2022328  | 56    |

(underlined values > 65% of total abundance (a) in cells cm<sup>-2</sup>; \* only frequent (f), \*\*only abundant )

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# PAH DEGRADATION EFFECTS OF SOME BACTERIA

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# Abstract

*Escherichia coli, Bacillus subtilis, Pseudomonas aeruginosa, Vibrio fluvialis, Serratia marcescens, Klebsiella pneumoniae* were isolated from seawater and refinery soil. The highest PAH (polycyclic aromatic hydrocarbons) degradation effect was observed in the mixed cultures of refinery isolates. PAH degradation effects had more impact on *V. fluvialis* and *K. pneumoniae* than on other sea water isolates. *Keywords : Bacteria, Black Sea, Petroleum.* 

#### Introduction

Marine environments offer abundant resources for research and development yet, the potential of this domain as the basis for new biotechnologies remains largely unexplored. Since hydrocarbons are natural products widely distributed in nature, it is not surprising that bacteria able to degrade hydrocarbons can easily be isolated by standard enrichment culture procedures. By varying parameters, such as temperature, pH, hydrocarbon concentration, and basal medium, a wide variety of different hydrocarbondegrading and emulsifying bacteria can be obtained from aquatic or terrestrial environments [1, 2]. Determination, isolation and characterization of microorganisms which participate in the biodegradation of polycyclic aromatic hydrocarbons (PAHs) have great significance in the decontamination of the environment in shorter periods. Decontamination of PAHs, which cause environmental pollution and affect biological equilibrium dramatically, has also great significance for environmental and applied microbiology. In this study, the PAH degradation effects of some bacteria isolated from soil and seawater were investigated.

#### Material and Methods

The membrane filtration (Millipore) techniques were used to isolation of bacteria from sea water. M-Endo and m-FC were used for viable counts. Nutrient broth, Endo Agar, Bacillus Medium, Nutrient Agar were used for isolation of soil bacteria. Dubious colonies were identified using Nutrient Agar, SS Agar, Blood Agar, serologic and biochemical tests (SIM, API 20E) and identified strains were used for the degradation test. Minimum inhibitory concentration (MIC) values were obtained with a mineral salt medium. Identified strains [2, 3] were inoculated in to the medium which were supplemented with 1% crude oil and incubated on a laboratory shaker at 150 rpm and 25°C. Bacterial counts were carried out at 24 hour intervals and PAH degradation effects were observed by measuring the thickness of petroleum layers over one month [4].

#### Results and Discussion

The strains isolated from the soil within the Batman oil refinery and the Istanbul Strait and MIC values determined are summarized in Table 1.

Tab. 1. Isolated strains of the soil within Batman oil refinery and Istanbul Strait.

| Samples                         | Isolates                                                   | MIC Values (%)         |
|---------------------------------|------------------------------------------------------------|------------------------|
| Soil within<br>the oil refinery | B. subtilis<br>P. aeruginosa<br>E. coli                    | 100<br>50<br>100       |
| Istanbul Strait                 | E. coli<br>V. fluvialis<br>K. pneumoniae<br>S. marcescens, | 50<br>100<br>50<br>100 |

It was observed that *P. aeruginosa* and mixed cultures of all isolates from the soil within the Batman oil refinery efficiently use crude oil. Among the refinery isolates, *E. coli* caused an increase in the thickness of the petroleum layer and did not utilize the crude oil. *V. fluvialis, S. marcescens, K. pneumoniae* were determined to be the seawater isolates and were most effective in decreasing the surface area of the crude oil. These strains are stocked for further studies related to bioremediation.

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# DETERMINATION OF LIMITING NUTRIENT FOR PHYTOPLANKTON GROWTH IN THE OMBLA ESTUARY

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# Abstract

The method of determining the limiting nutrient for phytoplankton growth in estuarine waters, at any salinity, was applied for the Ombla estuary. The results indicate that P is a limited nutrient at any salinity along the longitudinal axis of the estuary, except at higher salinities (salinity values  $\geq$  38.4), when there is a transition from P to N limitation. *Keywords : Estuaries, Phytoplankton, Salinity.* 

### Introduction

The spring of the karstic 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 in depth, while the lower reach is up to 25 m depths. The discharge measurements of the Ombla River show that the average outflow equals  $26 \text{ m}^3 \text{s}^{-1}$  (discharge varies between 2.3 and 112 m $^3 \text{s}^{-1}$ ). The scope of this paper is to determine which nutrient might be responsible for the limitation of phytoplankton growth along the longitudinal section of the Ombla estuary, at any salinity.

#### Results and discussion

Samples for the analysis of hydrographic, chemical and biological parameters were collected bi-weekly (1999/2000) at three stations (Ombla 1, Ombla 2, Ombla 3) along the estuary. Temperatures rose from March to end-May and were more or less constant until September. In October, the water column began to cool, especially in the surface layer. A sharp halocline persisted throughout the year and delimited the low salinity surface layer, as well as the saline bottom layer. Salinity in the surface layer throughout the estuary oscillated from 9.68 - 37.54. The salinity in the bottom layer was quasi constant throughout the year, with most values around 38 and a range from 33.3 - 38.88. Forty per cent of the samples had salinity values ≥38.4. Oxygen saturation indicated good aeration, with most saturation values at around 1. The concentration of all nutrients decreased throughout the estuary for most of the year. Maximal nutrient values, excluding ammonia, were found in the surface layer. The nutrient concentrations in the surface layer oscillated far more than in the bottom layer, especially total inorganic nitrogen TIN=(NO<sub>3</sub>+NO<sub>2</sub>+NH<sub>4</sub>) and SiO4. TIN and PO4 are the main forms of N and P that are readily bio-available for phytoplankton growth and these have a Redfield atomic ratio of N:P=16:1. In the Ombla estuary the Redfield ratio values were appropriate for phytoplankton growth from April to August. The Redfield ratio increased throughout the estuary, almost due to decreased PO4 concentrations (<0.01  $\mu$ mol dm<sup>-3</sup>). The method of determining the limiting nutrient for phytoplankton growth in estuarine waters, at any salinity, is based on nutrient ratios in the water, using overlaid graphs for nutrients vs salinity [1]. This method was applied for the Ombla estuary, using TIN vs salinity and  $PO_4$  vs salinity. The results (Fig.1) indicate that P is limited nutrient at any salinity along the longitudinal axis of estuary, except at higher salinities (salinity values Âş38.4), when there is a transition from P to N limitation (the trendlines for N and P intersect at salinity  $\geq$ 38.4). Two peaks of microphytoplankton (cells longer than 20  $\mu$ m, MI-CRO) were noted throughout the year. The first peak of MICRO occurred during end-May. The population was composed mostly of dinoflagellates (>89%), mainly the species Prorocentrum triestinum (max. 1.3 x 10<sup>5</sup> cells  $1^{-1}$ ), whose intensive development has been noted before in this estuary during May, [2]. A second peak appeared at end-August. Most of the MI-CRO 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 [3].

The phytoplankton abundance decreased along the estuary, as well as throughout the water column [4]. Phytoplankton abundance was greater at lower salinity and maximal 2.8 x  $10^5$  cells L<sup>-1</sup> was found at a salinity 29.21. P is a limiting nutrient throughout the Ombla estuary, and N may become a limiting nutrient at salinity values  $\geq$ 38.4. A lower phytoplankton abundance at higher salinities is probably caused by N limitation in this estuary.



Fig. 1. Overlaid nutrients vs salinity graph for the Ombla estuary.

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# IMPROVEMENTS IN THE DIVERSITY OF SPECIES CAUSED BY A WASTE WATER TREATMENT FACILITY AS EVIDENCED BY DISCRIMINATION OF PHYTOPLANKTON POPULATIONS USING DISCRIMINATE ANALYSIS

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## Abstract

In this study, the variations in the diversity of phytoplanktonic species (Shannon-Wiener) were investigated vertically and quantitatively in three stations located in the inner, middle and outer bay of Izmir over the years 1998 to 2001. Statistically significant positive increases in the diversity of species have occurred after the commencement of the wastewater treatment activities. *Keywords : Phytoplankton, Pollution, Aegean Sea.* 

#### Introduction

The Izmir Bay has been under constant pressure of ever-increasing household and industrial contamination since 1970's. Having been put in operation in 2000, the Cigli Wastewater Treatment Facility, with its nitrogen and phosphorus units, managed to achieve an apparent upgrading in the Izmir Bay within a year. This study aims at identifying phytoplankton species, their quantitative distributions and the variances in the diversity of species along a time vector of 1998 to 2001.

#### Materials and Methods

This study seasonally examines the population structure of the group in the Izmir Bay at 3 predetermined stations. The samples were taken from depths of 0.5 m, 5.0 m, 10.0 m and 15.0 m (Figure 1).



Fig. 1. Sampling stations

In order to determine the diversity of phytoplankton, the Shannon-Wiener diversity indexes were calculated. Variations within a year and between years were first tested using the Student's t-test. If any such variations were detected by the Student's t-test, a discriminate analysis was carried out to obtain discriminant functions at micro-algae class levels for different years.

#### Results and Discussion

Koray [1], in his studies on the Izmir Bay, reports that in case the selected organism group is phytoplankton, using the diversity index value to indicate a level in the eutrophication process may lead to erroneous results and that such indexes may only be used for the purposes of comparison in relation to time and region. Using diatoms as an indicator of eutrophication level will produce more accurate results than if dinoflagellate or total phytoplankton is used. Similarly in our study, variations in the diversity of diatom species were found to be more consistent than those in the diversity of dinoflagellate species. While the maximum value of the diatom population was 3.445 bits in 1998, it went up to 3.734 bits just after the treatment unit had been put in operation in 2000 and further to 3.782 bits in 2001. The results of the Student's t-test conducted to clarify the annual differences at the sampling stations. According to these results, the dinoflagellate populations did not display any annual differences, whereas the diatoms clearly showed a difference in their species composition from 1998 to 2000. This difference continued in 2001.

The results of the Student's t-test run following the  $log_{10}$  transformation of the cell concentrations integrated into cm<sup>2</sup> surface along the vertical water column seem to exhibit a successful distinction. However, they were, in any case, tested by discriminate analyses as well.

Diatom populations appear to differ from each other on an annual basis at a level of p=0.00353. Figure 2 summarises the distribution diagram of these two components. As can be seen on the diagram, an increasingly evident distinction exists, moving from 1998 towards 2001 (Figure 2).



Fig. 2. Distribution diagram of the first two components

Having been put in operation, the Wastewater Treatment Facility of the Izmir Bay enhanced a positive increase in the diversity of species in phytoplankton populations especially in diatom populations.

In this study, the micro-plankton data pertaining to pre- and post-treatment facility periods in the Izmir Bay were, for the first time, successfully discriminated from each other by using discriminate analyses. The use of discriminate analyses to determine eutrophication is a relatively new area of research. By making use of discriminate analysis, Tsirtsis and Karydis [2] tried to determine the eutrophication of the Aegean Sea.This proves that the ecologic balance limits in the bay has not yet been surpassed. Therefore, the Izmir Bay may, with a high probability, re-establish itself in the first decade of the  $21^{st}$  century.

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# PHOTOBACTERIUM PHOSPHOREUM: UNIQUE REPRESENTATIVE OF THE LUMINOUS MICROBIAL COMMUNITY IN THE SOUTH-EASTERN IONIAN SEA?

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# Abstract

Luminous bacteria were isolated from Mediterranean water samples taken from the surface to 3.300 m depth during oceanographic cruises in the Southern Ionian Sea and the Sicily Channel. Bacterial plate counts in SWC medium were carried out in 380 water samples from 16 Stations of this area of the Mediterranean Sea. Results ranged from 0 to 20 CFU/100ml. Generally, two peaks in abundance were detected: one in the upper 300 m of the water column, which mainly concerns the Sicily Channel; and a second between 500 and 1200 m, in the South-Eastern Ionian Sea. The physiological and molecular analysis show that all the isolates were *Photobacterium phosphoreum* differently from those found by others in different locations.

Keywords : Bacteria, Ionian Sea, Sicilian Channel, Biodiversity.

Luminous bacteria have been extensively studied and are well described phylogenetically and ecologically. Compared to the broad distribution and high abundance in the marine environment, only one luminous species has been isolated from fresh water and another has been isolated from soil. Luminous bacteria have been observed living in many ecological niches including planktonic, saprophytic, symbiotic, and parasitic niches. Some species inhabit more than one niche. Despite several studies describing the distribution and abundance of luminous bacteria, details regarding population dynamics, ecological function, and especially niche relationships remain poorly understood ([1]). *Photobacterium phosphoreum* has been well described relative to their light organ symbioses with several families of marine fish inhabiting cold and deep ocean waters. Free-living *P. phosphoreum* has been isolated by direct plating of seawater. Aside from the free-living forms and symbioses formed with marine fish, *P. phosphoreum* has been described as living saprophytically and parasitically.

Isolation of luminous bacteria from 16 stations in the South-Eastern Ionian Sea and in the Sicily Channel was carried out, throughout the years 2004-2006 during two different oceanographic cruises.

Water samples were filtered through Millipore filters of 0.45  $\mu$ m mean pore size, and filters were placed on SWC Agar and incubated in the dark at room temperature (ca. 20°C). Within 48 h after incubation, the presence of luminescence from colonies was checked visually in a dark room. The bioluminescent colony were purified and stored at -80 °C with 40% glycerol until analysis.

From ca. 200 luminous colonies randomly selected from the various plates, 89 grown on replicates were analysed for further morphophysiological and taxonomic analysis. The isolates were characterized using the routine tests and by BIOLOG GN microplates and API 20 NE for Gram negative bacterial strains.

Viable counts on SWC varied from 0 to 20 luminous CFU/100ml and the population of bioluminescent bacteria constitued 0,007 (november 2004) to 0,011% (october 2006) of the total, viable, aerobic heterotrophic bacteria enumerated by the plate counts.

Luminous CFU were most abundant in two layers: between the surface and 300 m of the water column (mainly in the Sicily Channel) and with lower values respect the second layer between 500 and 1200 m, wich is present in the whole South-Eastern Ionian Sea.

Molecular analysis was performed with bacterial DNA extraction, 16S rDNA amplification and sequencing. The PCR amplification of 16S rRNA gene was done using the bacterial universal primers 27f and 1492r. The PCR products were digested with enzymes AluI and RsaI to develop an amplified ribosomal DNA restriction analysis (ARDRA) methods.

The physiological characterization of the isolated strains shows that there was only a species of bioluminescent bacteria, of the 89 isolates, *Photobacterium phosphoreum* (figure 1).

The marine bioluminescent bacteria ARDRA analysis of the 16S rRNAgene, developed with two restriction enzymes, allowed discrimination of 3 clusters species of bioluminescent bacteria that during sequencing always gave the same result of the phenotypical analysis (figure 2).

The results of this research, in relation to previously studies, not suggest a seasonal variation of the luminous microbial community distribution in this area. The spatial distribution of luminous bacterial shows two peaks: one in the upper 300 m of the water column, which mainly interests the Sicily Channel; and a second between 500 and 1200 m, which is present in the Eastern area (Ionian Sea).

The species distribution observed in this study is different from data re-

ported for the Mediterranean Sea and for the Atlantic Ocean([2], [3]). *Photobacterium phosphoreum* is prevalent in many different locations but is not the unique luminous bacterial species found, in our survey.



Fig. 1. Phylogenetic tree of luminous bacteria isolates in the two oceanographic cruises MEDBIO (2004 and 2006).



Fig. 2. Restriction patterns of the 16S rRNA gene (ARDRA method) amplicon from marine bioluminescent strains PCR-amplified 16S rRNA gene was digested with AluI and RsaI.

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# IMPACT OF RAINFALL ON BEACH WATER QUALITY

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## Abstract

The microbiological quality of sea water at the mouth of seven small rivers of a Greek island was investigated over a twelve month period. After rain incidents the bacterial indicator concentrations, which were normally below European Union Standards, were elevated above the limits. The finding suggests that extra precautions should be taken after storm events by managers of recreational coastal areas in the vicinity of rivers or dry gullets, in order to avoid public health problems associated with swimming in polluted seawater. *Keywords : Coastal Waters, Monitoring, Sewage Pollution.* 

In countries like Greece, with a shortage of extended coastal sand deposits, mouths of small rivers and dry gullets offer sandy beaches suitable for bathing and recreation. The microbial quality of bathing water is routinely investigated in European Union countries by bimonthly sampling from May to October, according to legislation [1]. Sampling is not required after storm events. On the other hand storm water is known to cause deterioration of the microbial quality of coastal waters, by carrying into the sea micro organisms collected from running over land in the river basin [2,3,4]. The aim of this study was to investigate the effect of sporadic rain events on the microbiological quality of coastal waters normally complying with EU requirements.

Seven sampling stations, located at the mouths of small rivers and dry gullets on the eastern coast of the island of Lesvos, Greece, were sampled at monthly intervals for a twelve month period. Samples were carried to the laboratory in ice boxes and processed within four hours of collection. Microbiological tests were performed according to Standard Methods and included cultures for total coliforms (TC), faecal coliforms (FC) and enterococci (Ent). The levels of the three faecal pollution indicators (TC,FC,Ent) in the seawater, in all seven stations, were assessed in dry weather to be below the limits set by the EU legislation regarding the quality of bathing waters. These levels were exceeded when sampling was initiated after a storm event. The amount of precipitation (measured in mm/24h preceding sampling) associated with elevated indicator concentrations.

Tab. 1. Faecal indicator concentrations detected in coastal waters at the mouths of seven small rivers and dry gullets after precipitation events.

| Rain /24h |          | TC/100ml<br>median  | FC/100ml<br>median     | Ent/100ml<br>median |
|-----------|----------|---------------------|------------------------|---------------------|
| 36.5 mm   | (April)  | $2.4 \times 10^{3}$ | $5.6 \times 10^2$      | $>10 \text{ x}10^4$ |
| 2.0 mm    | (May)    | 9.0 x10             | 4.3 x10                | 1.4 x10             |
| 1.3 mm (D | ecember) | $>10 \text{ x}10^4$ | $1.0 \ \mathrm{x10^2}$ | $1.9 \ x 10^2$      |
| 0.7 mm (N | ovember) | 9.5 x 10            | 1.1 x10                | 2.0 x10             |
| 0.1 mm    | (March)  | 1.4 x10             | 5.8 x10                | 5.7 x10             |

Rain is not uncommon in the Mediterranean countries during the bathing season. Even the strict sampling demands of the European Union Directive concerning the quality of bathing waters [1], do not require sampling after incidents of rain. The results of our study indicate that in the Mediterranean region, too, as in North America and Australia [2,3,4], rain causes severe deterioration of recreational water quality in the vicinity of mouths of even small rivers (point sources). This is a fact that should not be ignored by those managing coastal recreational areas.

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lationships between indicators, pathogens and water quality in an estuarine system. *Water Research*, 30, 2045-2054.
# FIRST CONFIRMED RECORDS OF THE BROWN RING DISEASE (BRD) IN THE CLAM (*RUDITAPES DECUSSATUS*) FROM TUNISIAN WATERS (CENTRAL MEDITERRANEAN)

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## Abstract

In this paper, the authors present the first confirmed records of the brown ring disease in wild populations of *Ruditapes decussatus* collected in 15 sampling sites from marine and brackish Tunisian waters. Prevalence rates ranged from 0% to 20%. By contrast, a prevalence rate of 40% was recorded for one sampling site located in southern Tunisia. The prevalence rates assessed were not related to mortality in clams populations investigated. Moreover, no strain of *V. tapetis* has been isolated.

Keywords : Bivalves, Bacteria, Diseases, Coastal Waters, Western Mediterranean.

#### Introduction

The brown ring disease (BRD) was reported in clam species such as *Ruditapes philipinarum* and *Ruditapes decussatus* collected in France, England, Spain, Italy, Eire and beyond until Southern Korea [2-3, 5].

The BRD disturbs shell calcification process, reduces growth rate and induces shell deformation, concomitant to occurrence of a brown organic deposit on inner surface of shell, located between pallial line and shell margin [5]. This infection was frequently due to clam infestation by the bacterial species *Vibrio tapetis* or Vibrio P1 [1, 4].

In the present study, we report and comment the first BRD records observed in adult wild populations of *R. decussatus* collected in both marine and brackish Tunisian waters.

#### Materials and Methods

Sampling and processing:

Wild clams were collected from 15 different areas in the Tunisian inshore during December 2000. Further survey was realized for clams harvested monthly from four northern sites (northern Lake of Tunis, Canal of navigation and lagoon of Bizerte) for the period of January to October 2001. Determination of the brown ring disease (BRD) prevalence:

Diagnosis of brown ring was realized depending on the external observations of shells (brownish organic deposit that adheres to the internal surface of the valves).

## Bacterial numeration:

For all the sites, we proceeded to counting total mesophyllic charge and total *Vibrionaceaes* charge present in clams by the method of plate counting agar (PCA), using Zobell agar (ZA) and Zobell mannitol agar (ZMA). Phenotypic characterization of pathogenic bacterial isolates:

The bacterial isolates, were selected on Zobell Mannitol Agar medium and TCBS agar and identified by standard morphological, physiological and biochemical tests including : Gram staining, motility and sporulation feature, sensitivity test to vibriostatic agent O129, oxydase test, growth temperature and using the Api systems (Api 20E, Api 20NE and Api 50CHE) and Biolog system (based on ninety six different metabolic tests). Else, the strain *V. tapetis* (CECT 4600 from IUEM - Brest collection) was used in the identification tools of ours isolates.

#### Results and discussion

The prevalence rates obtained for the BRD investigations in wild clams populations taken, were lower than 10% in almost areas. Nevertheless, a prevalence of 40% was noted for one southern site (O. Chabaa).

The monthly survey of BRD prevalence rates in four northern stations (northern lake of Tunis, channel of navigation, Faroua and Menzel Jemil), showed that BRD infection was more frequent in the summer than in the winter for almost stations investigated (Fig.1). All the clams investigated presented high bacterial charges that varied from  $1.10^5$  ufc/mg to  $8.10^5$  ufc/mg (for heterotrophic and mesophyllic bacteria). The phenotypic characterization (based on more than 24 different tests), allowed us to identify thirty five bacterial strains originated from BRD clams. All the isolates were Gram negative, motile non sporulating curved rods that were oxidase positive, sensitive to vibriostatic agent O129 and for almost didn't metabolize sucrose and mannitol. All these isolates were obtained for temperature incubation lower than  $25^{\circ}$ C. According to results obtained

at first by the Api system profiles, five Vibrio species were identified: *V. alginolyticus* (3 strains), *V. proteolyticus* (1 strain), V. *harveyi* (1 strain), *V. vulnificus* (1 strain), *V. carchanium* (1 strain). Nevertheless, we failed to type twenty six bacterial strains by Api system and to specify the BRD bacterial agent (V.tapetis).

Although the report of the BRD in the two species of clams in northern Mediterranean countries, in Tunisia, data about bacterial disease in shellfish were lacking. Preliminary results obtained here, showed presence of this infection at very low rates. Else, prevalence rates obtained were more important in the spring period than in winter nor in summer. As this infection was observed mainly in the northern European countries (French Atlantic coast, Norway and Scotland), it could be classified as a cold water disease.

Although the *Vibrio tapetis* was incriminated in studies of tracking for the illness, it shouldn't be considered as the only condition of development of the brown ring at the bivalves [1, 5]. The failure to isolate a *Vibrio tapetis* of the infested samples prospected. This was probably due to that a recovery state. Further studies incriminated biochemical method to be not sufficient to identify this bacterial species [4, 5]. It will be useful to employ antigenic and molecular methods jointly to biochemical methods.



Fig. 1. BRD prelevance rates recorded in the four northern sites.

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# ÉTUDE DES CHAÎNES ALIMENTAIRES LE LONG D'UN GRADIENT CROISSANT DE SALINITÉ: LA SALINE DE SFAX, TUNISIE

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## Résumé

L'étude de la dynamique spatiale et temporelle des communautés planctoniques (bactéries hétérotrophes, picoplancton autotrophe, flagellés, ciliés, phytoplancton et zooplancton) le long d'un gradient croissant de salinité montrent que: (i) la richesse spécifique diminuent avec le gradient de salinité, (ii) avec l'augmentation de la salinité, on a une réduction des eucaryotes au profit d'une augmentation des procaryotes (iii) les groupes taxonomiques capables de s'adapter aux conditions de sursalure sont peu nombreux (iv) les bassins de la saline constituent un système où la chaîne alimentaire est progressivement simplifiée le long de la chaîne de concentration des halites. *Mots clès : Food Webs, Salinity, Plankton.* 

#### Introduction

L'importance qualitative, quantitative et fonctionnelle de la voie microbienne doit, aujourd'hui, être précisée, notamment dans les écosystèmes extrêmes tels que les marais salants. Seuls certains microorganismes sont capables de peupler les salines, quelle soient naturelles ou artificielles [1]. Les microorganismes du réseau alimentaire microbien ont fait l'objet de très peu d'étude [2, 3]. Dans la saline de Sfax, les études ont porté sur le phytoplancton [4, 5], le zooplancton [4, 6] et les protozoaires ciliés [7].



Fig. 1. Schéma hypothétique du réseau trophique le long du gradient de salinité dans différents bassins de la saline de Sfax.

## Matériels et méthodes

La saline de Sfax écosystème artificielle, est formée de bassins salicoles contigus de salinité croissante, allant de l'eau de mer aux bassins de cristallisation de sel. Une étude du réseau trophique a été réalisée de Janvier à Décembre 2003 au niveau de six bassins de salinité croissante : A1 (Salinité moyenne  $\pm$  écart type = 43.9  $\pm$  2.6 p.s.u), A16 (78.7  $\pm$  8.8 p.s.u), C2-1 (89.8  $\pm$  11.7 p.s.u), M2 (189.0  $\pm$  13.8 p.s.u), B1 (302.5  $\pm$  20.5 p.s.u) et TS (424.5  $\pm$  35.6 p.s.u). L'énumération du pico et du nanoplancton a été effectuée avec un microscope à épi fluorescence. Un échantillon de 200 ml d'eau brute est fixé au lugol et observé au mi-

croscope inversé pour le dénombrement des ciliés et des microalgues. L'identification et le comptage des organismes du zooplancton a été réalisée à l'aide de la loupe binoculaire.

#### Résultats et discussions

Les différents bassins de la saline constituent un système où la chaîne alimentaire est progressivement simplifiée le long de la chaîne de concentration des halites (fig. 1). Nous pourrons tirer les enseignements suivants : (i) dans la gamme de salinités <50 p.s.u, les communautés sont similaires aux communautés marines côtières et elles présentent une taille relativement faible. (ii) Entre 50 et 150 p.s.u, se développe une importante biomasse phytoplanctonique constituée essentiellement par des diatomées et des dinoflagellés. Les bactéries hétérotrophes sont très importantes, leur abondance étant de l'ordre de  $10^7$  cellules ml<sup>-1</sup>, les protozoaires flagellés et ciliés sont présents en grande quantité. Au niveau de cette gamme de salinité, la pression de prédation par le zooplancton (copépodes essentiellement) est sans doute très élevée. (iii) Entre 150 et 250 p.s.u, on est dans le domaine salin proprement dit, où les organismes sont représentés par des espèces hyperhalophiles : le crustacé phyllopode Artemia salina, la chlorophycée Dunaliella salina, le cilié Fabrea salina et les Archaea. Les ciliés et flagellés présentent généralement des abondances plus faibles que dans les bassins en amont mais la biomasse des ciliés peut être très importante en raison de la grande taille de F. salina. (iv) Au delà de 300 p.s.u, les bactéries hétérotrophes et surtout les Archeae sont très abondantes. A ce niveau, seule Dunaliella salina est présente et constitue ainsi le seul organisme eucaryote dans ces bassins. En effet, les autres algues, les protistes hétérotrophes et les métazoaires sont absents dans ces bassins. Ces observations sont comparables à celles rapportées par Pedrós-Alió et al. [2] qui ont montré une diminution de l'abondance et du nombre de groupe d'eucaryotes au profit d'une augmentation des procaryotes.

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## BROUTAGE DU PHYTOPLANCTON ET DES PROTISTES CILIES DANS LA SALINE DE SFAX, TUNISIE

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## Résumé

La mesure de l'impact du broutage (d) du zooplancton crustacé sur le phytoplancton et les protistes ciliés ainsi que la croissance de ces derniers ( $\mu$ ) ont été estimées par la méthode de fractionnement pendant 2003. La prédation exercée par le zooplancton sur le phytoplancton et les ciliés de petite taille, met en évidence le rôle des ces organismes dans le transfert de la matière et de l'énergie dans les systèmes aquatiques.

Mots clès : Zooplankton, Phytoplankton, Growth.

## Introduction

Le zooplancton crustacé joue le rôle de lien trophique dans les écosystèmes côtiers marins et d'eau douce. Son impact sur la dynamique des communautés phytoplanctoniques et protistes ciliés est peu connu et rarement étudié [1]. Très peu d'étude sont réalisées sur les interactions trophiques, les taux de croissance et le broutage dans les salines [2, 3]. Au cours de cette étude nous allons essayer d'estimer *in situ* les taux de croissance et de broutage par la méthode de fractionnement.

## Matériel et Méthodes

Une étude sur trois bassins de salinité croissante de la saline de Sfax, A1 (43 p.s.u), A16 (74 p.s.u) et C2-1 (100 p.s.u) consiste à la mesure des densités du phytoplancton et des ciliés incubés pendant 24h, en présence et en absence du zooplancton. Deux aliquotes de 100 ml d'eau de chaque bouteille sont prélevés à t=0 et t=24h, et fixé au lugol et conservé à 4°C. L'identification et le dénombrement des algues et des protistes ciliés sont réalisés en microscopie inversée selon la méthode Uthermöhl [4]. Le taux de croissance ( $\mu$ ,  $j^{-1}$ ) avec et sans zooplancton est calculé suivant l'équation :  $\mu = (\ln N_t - \ln N_0) / t$  Avec  $\mu$  le taux de croissance,  $N_0$  et  $N_t$ est les densités initiale et finale, et t la durée d'incubation. Le taux de mortalité (d,  $j^{-1}$ ) est la différence entre le taux de croissance sans et avec zooplancton. Les expériences sont réalisées en double, le taux de mortalité est la moyenne des résultats dans les deux bouteilles.



Fig. 1. Taux de croissance du phytoplancton et des ciliés en absence du zooplancton

#### Résultats et discussion

Le taux de croissance dans les bouteilles fluctue entre 0,009 et 0,054 j<sup>-1</sup> pour le phytoplancton et entre 0,008 et 0,045 j<sup>-1</sup> pour les protistes ciliés (Fig. 1). Le taux de mortalité dû au broutage par le zooplancton varie entre 0,002 et 0,019 j<sup>-1</sup> pour le phytoplancton et entre 0,001 et 0,020 j<sup>-1</sup> pour les protistes ciliés (Fig. 2). Ces taux de mortalité sont corrélés positivement avec le taux de croissance (r=0,94, p<0,05). L'impact du broutage du zooplancton sur le phytoplancton et les protistes ciliés par la méthode de fractionnement a été appliqué par de nombreux auteurs [5]. Toutefois, cette méthode représente plusieurs limites (i) la séparation des proies et de leurs prédateurs ne peut pas être assurée d'une façon stricte [6], (ii) l'estimation des taux de croissance faible à cause des cellules endommagés [7], (iii) provoque un enrichissement en matière organique dissoute [8], (iv) ne permet pas de mesurer le broutage espèce par espèce, (v) elle nécessite des manipulations des communautés et un temps

d'incubation long (24h) ce qui perturbe probablement les nombreux processus de rétroaction au sein de la communauté microbienne [8], (vi) le zooplancton est incapable d'avoir un comportement de broutage normal [1]. La différence dans les méthodes de mesure du taux de croissance et du broutage rend difficile la comparaison de nos résultats avec ceux obtenus dans la littérature.



Fig. 2. Taux de mortalité du phytoplancton et des ciliés en absence du zooplancton

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# DETERMINATION OF HEAVY METAL SUSCEPTIBILITIES OF *VIBRIO HARVEYI* STRAINS BY USING 2,3,5-TRIPHENYLTETRAZOLIUM CHLORIDE (TTC)

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## Abstract

In the present work, minimum inhibitory concentration of 11 heavy metals (Zn, Cu, Pb, Cd, Co, Mn, Ni, Ag, Hg, Cr and As) against *Vibrio harveyi* TEM05 and TEMS1 were determined via the dehydrogenase activity using 96-well microplates. Different concentrations of 11 heavy metals from 0.78  $\mu$ g/ml to 102.400  $\mu$ g/ml were studied. The growth indicator 2,3,5- tri phenyltetrazolium chloride (TTC) was utilized to indicate bacterial growth/growth inhibition. Results showed that TEMS1 had the highest MIC values for As and Pb (102.400  $\mu$ g/ml) and *V. harveyi* TEM05 had the highest MIC values for Pb (>102.400  $\mu$ g/ml). Therefore, these luminous bacteria are very resistant against As and Pb. Besides, according to the results of MIC susceptibility tests, heavy metals the most effective against both isolates are Cu, Cd and Hg (25  $\mu$ g/ml).

Keywords : Aegean Sea, Bacteria, Coastal Waters, Metals.

## Introduction

Heavy metals generally exert an inhibitory action on microorganisms by blocking essential functional groups, displacing essential metal ions and modifying the active conformations of biological molecules. However, at relatively low concentrations some metals are essential for microorganisms (e.g. Co, Cu, Zn, Ni) since they provide vital co-factor for metalloproteins and enzymes [1]. Heavy metals are common marine pollutants derived from industrial and sewage treatment discharges and anti-fouling paints [2]. Luminous bacteria are the most abundant and widely distributed light emitting organisms and are found in marine, freshwater and terrestrial environments. These bacteria are all Gram-negative, motile rods and can function as facultative anaerobes. To date less than 1%of the known species have been studied in detail and most information concerns the marine bacteria of three genera: Photobacterium, Vibrio and Shewanella. Bioluminescent bacteria emit light when they are in an optimal environment [3]. For the first time, Vibrio harveyi TEMO5 and TEMS1 were isolated from the gut of Holothuria tubulosa and coastal seawater of Izmir Bay (Turkey), respectively. The susceptibility of these isolates to heavy metals was determined using the growth indicator 2,3,5triphenyltetrazolium chloride (TTC) and the metalsÂăzinc (Zn), copper (Cu), lead (Pb), cadmium (Cd), cobalt (Co), manganese (Mn), nickel (Ni), silver (Ag), mercury (Hg), chromium (Cr) and arsenic (As).

## Material and Methods

#### Microorganisms

*Vibrio harveyi* TEMO5 and TEMS1 was isolated from the gut of *Holothuria tubulosa* and coastal seawater of Izmir Bay, Turkey. The strains were identified by morphological and biochemical characteristics and by 16S rDNA sequencing. *V. harveyi* TEMO5 and TEMS1 has been deposited in the GenBank database under accession number DQ842241 and DQ842240, respectively [4]. All experiments were performed on Nutrient Broth Media (NB) supplemented with 2% (w/v) NaCl.

## Determination of minimum inhibitory concentration (MIC)

All *V. harveyi* isolates were grown in 20 ml of NB (with 2% NaCl) with shaking at 150 rpm for 17 h (20°C). Minimum inhibitory concentrations of eleven heavy metals against *V. harveyi* TEMO5 and TEMS1 were determined using the growth indicator TTC. Different concentrations of heavy metals from 0.78  $\mu$ g/ml to 102.400  $\mu$ g/ml were studied. To dilute heavy metals, appropriate amounts of stock solutions were added to steril NB with 2% NaCl in microplate wells. To each well, 125  $\mu$ l of bacterial suspension with a turbidity equivalent to 0.5 Mcfarland standard was added and then 125  $\mu$ l of different concentrations of heavy metals were transferred into a microplate well. The microplates were incubated at 20°C overnight. 20  $\mu$ l of steril TTC was put in each well and then the microplates were incubated at 20°C again. After overnight incubation, the minimum inhibitory concentration (MIC) of heavy metals against the isolates was determined.

## Results and Discussion

The tetrazolium salt TTC can be used as an artificial electron acceptor to detect dehydrogenase activity and thus metabolically active bacteria. The detection of activity is based on the reduction of the water-soluble and col-

orless tetrazolium salts to colored crystals of the water-insoluble formazan products. TTC is reduced to a red insoluble formazan [5]. Therefore, the wells with red color were evaluated as positive and the highest concentration of a specific heavy metal without color was considered MIC. The heavy metals which are the most effective against both isolates are Cu, Cd and Hg (25  $\mu$ g/ml). *V. harveyi* TEMS1 has the highest MIC value for Pb and As (102.400  $\mu$ g/ml). For *V. harveyi* TEMO5, MIC of Pb and As was achieved >102.400  $\mu$ g/ml and 102.400  $\mu$ g/ml, respectively.

Our data showed that *V. harveyi* TEMO5 and TEMS1 is very resistant against Pb and As and Pb, respectively. Otherwise the strains are very sensitive against Cu, Cd and Hg. MIC values of Mn, Ni, Zn, Pb and Cr against *V. harveyi* TEMO5 were different from that of *V. harveyi* TEMS1. Thus, there are isolate-specific differences in the metal sensitivity.ÅäRahman et al. (2004) determined antimicrobial susceptibilities of gram-negative fermentative bacteria by using redox indicator TTC in a microplate [6]. But this kind of study with bioluminescent bacteria, *V. harveyi*, is performed for the first time.ÅäWith data obtained from this study, our strains can be employed to determine heavy metal contents of seawater or other material as indicator organisms.

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## PHYTOPLANKTON COMPOSITION IN THE AREA OF A FISH FARM: PIGMENT ANALYSIS

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## Abstract

Aquaculture activity has a serious impact on the environment, e.g. the enrichment of the water column in dissolved organic and inorganic material. This may subsequently affect populations of phytoplankton differently. In this study we report on short-term changes in the water column in relation to fish feeding and differences along the transect from the centre of a fish farm towards open waters. We took samples at different sites around the fish cage. Using HPLC (High performance liquid chromatography) pigment analysis we determined the phytoplankton community structure. Comparing the pigment fingerprints in the fish farm area before and after feeding we observed only minor differences. The main phytoplankton group were diatoms. We noticed differences in the profile from the centre of the fish cage outward.

Keywords : Adriatic Sea, Aquaculture, Eutrophication, Phytoplankton, Pigments.

#### Introduction

Aquaculture activity has a serious impact on the environment. One of the main environmental concerns associated with fish farming is the direct discharge of suspended solids and dissolved nutrients into coastal waters and thus the enrichment of the water column by dissolved organic and inorganic material. This may subsequently affect populations of phytoplankton differently [1]. In Slovenia we have cage fish farms of sea bass (*Dicentrarchus labrax*) and sea bream (*Sparus auratus*). The fish farm is situated in the inner part of the semi-enclosed Bay of Piran (Gulf of Trieste, Adriatic Sea). The depth beneath the fish cages is about 13 m. As a part of the EU founded project ECASA we want to identify quantitative and qualitative indicators of the effects of aquaculture on the environment and vice versa. In this study we report on short-term changes in the water column in relation to fish feeding and differences along the transect from the centre of the fish farm towards open waters.

#### Methods

Seawater samples were taken from 5 m depth at 6 different points of the compass around and in the centre of the fish cage (00CC), approximately 1 hour before feeding (A) and three hours after feeding (B). The first ring of sampling sites was 6 m from the centre (00N1, 0EN1, 0ES1, 00S1, 0WS1, 0WN1), and the second was 20 m away (00N2, 0EN2, 0ES2, 00S2, 0WS2, 0WN2). In addition, we sampled at sites on the profile from the centre of fish cage outwards: 00CC, 6 m (00N1), 20 m (00N2), 1166 m (ZBMA) and 6825 m (ZC0B). Using HPLC (High performance liquid chromatography) pigment analysis we determined the phytoplankton community structure. Photosynthetic pigments have proved to be useful biomarkers of the abundance, composition and physiological status of the phytoplankton biomass in the marine environment although they cannot be considered to be fully specific diagnostic markers of individual phylogenetic groups of phytoplankton.

#### Results

Comparing the pigment fingerprints in the fish farm area before and after feeding we observed only minor differences in pigment concentrations and the phytoplankton groups contribution to the total biomass. The main phytoplankton group were diatoms (66.3 - 77.9 %) followed by Primnesiophytes (13.7 - 21.2 %). The phytoplankton biomass in the centre of fish cage expressed in chlorophyll *a* concentration was 1.06 m  $\mu$ g 1<sup>-1</sup> before the feeding and 1.57  $\mu$ g 1<sup>-1</sup> 3 hours after the feeding. In the area 6 m from the centre the concentration was 1.03±0.09  $\mu$ g 1<sup>-1</sup>, and 20 m away 1.24±0.12  $\mu$ g 1<sup>-1</sup>. But we noticed differences in the profile from the centre of the fish cage outward, most of all in the decrease in the chlorophyll *a* degradation products was measured 6 m (00N1) from the centre of the fish cage, 20 m from the centre (00N2) was a little bit lower and the decline in the direction outward from the fish cage (ZBMA, ZC0B) was nicely expressed (Fig. 1).

The main part of the concentration of chlorophyll *a* degradation products was due to concentrations of chlorophyllide *a* and pheophorbide  $a_1$ . A similar trend was also observed for pheophorbide  $a_2$  but here the concentrations were very low. Chlorophyll *a* degradation products are good indicators of the physiological state of phytoplankton and show that fish farming influences the phytoplankton population in a negative way. Three hours after feeding we observed changes in nutrient concentrations. An increase of PO<sub>4</sub><sup>3-</sup> (from  $0.08\pm0.03$  mol  $l^{-1}$  to  $0.14\pm0.04$  mol  $l^{-1}$ ),

 $\rm NH_4^+$  (from 0.58±0.08 mol  $\rm l^{-1}$  to 0.72±0.15 mol  $\rm l^{-1}$ ) and  $\rm P_{tot}$  (from 0.29±0.03 mol  $\rm l^{-1}$  to 0.35±0.01 mol  $\rm l^{-1}$ ) concentrations was measured, while the concentration of SiO<sub>4</sub><sup>4-</sup> decreased (from 5.55±3.02 mol  $\rm l^{-1}$  to 2.29±1.81 mol  $\rm l^{-1}$ ).



Fig. 1. The distribution of chlorophyll a degradation products concentration along the transect from the centre of the fish farm towards open waters.

#### Discussion and Conclusions

We noticed the influence of fish farming on the environment first of all from higher concentrations of chlorophyll *a* degradation products in the fish farm area. Measured values of two indicators of the trophic state,  $F_p$ ratio [2] and the trophic index TRIX [3], were higher in the fish farm area compared to the control site [4] showing again an influence of the fish farm on the environment. This was more significant during the period of a homogeneous water column [4]. Three hours are not enough to detect changes in the phytoplankton community due to the input of organic and inorganic matter. And, in addition, this is an open system with normal diurnal migrations of phytoplankton, and current influence that are possible causes of changes in phytoplankton community composition.

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# SEASONAL PATTERNS OF PHYTOPLANKTON COMMUNITIES IN THE ALBORAN SEA

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## Abstract

The changes of the phytoplankton communities in an upwelling area of the Alborán Sea (Western Mediterranean Sea) during an annual cycle and its relation to physical and meteorological forcing have been explored. The spring peak of chlorophyll a was associated to the increased abundance of diatoms and small flagellated cells while pico-phytoplankton cells accounted for a sharp increase of chlorophyll a in fall. The Shannon index for the micro-plankton increased from spring to summer and declined afterwards. The seasonal changes in the community taxonomic structure were linked to the annual hydrological cycle.

Keywords : Alboran Sea, Phytoplankton.

## Introduction

The northwestern area of Alboran sea is characterized by a high seasonal variability in its hydrological structure due to deep mixing of the water column in winter and a strong stratification in summer. Nevertheless, the presence of superficial cores of colder and saltier water than the surface Atlantic is common, which toprovides evidence of the almost permanent influence of a geostrophic front where deep Mediterranean water is upwelled [1]. This upwelling is fuelled by the Atlantic jet coming in throughout the Strait of Gibraltar, although several other mechanisms also contribute to it, mainly the westerlies which intensify the upwelling.

Many previous studies indicate that the chlorophyll a concentration in the northwestern Alboran Sea is higher than in other Mediterranean regions, which has been assumed to be correlated to high microplanktonic abundances. Concordantly, an annual spring peak of chlorophyll and micro-phytoplankton cell abundance associated to more favourable upwelling conditions during this period has been described [2, 3]. However, a seasonal pattern in micro- and nano-phytoplankton taxonomic composition has been not described. Moreover, during the period 2000-2002, a reduction in the microplankton abundance was noticed, although a decline in chlorophyll a was not detected. This suggests that the pico- and nanoplankton contribution to the phytoplanktonic biomass may be important, at least during some periods.

## Materials and methods

Three shelf bread stations were sampled during four surveys (July 2005, October 2005, January 2006, May 2006). Samples were collected from surface to 100 m water depth (0, 10, 20, 50, 100 m) and preserved in glutaraldehyde (for cytometric studies) and lugol (microscopy). In addition, different amounts of sample were filtered through 0.7-, 2- and 20- $\mu$ m filters for spectrophotometric determination of chlorophyll a. Moreover, CTD profiles were taken at each station.

The taxonomic composition of the largest fraction of the phytoplankton (2-200  $\mu$ m) was determined with an inverted microscope using Utermöhl technique. The smaller fraction (<2  $\mu$ m) was estimated by flow cytometry. Wind data and satellite images were also analysed.

#### Results

The hydrological structure of the Alboran sea during the four surveys was strongly influenced by the meteorological conditions, from a strong stratification in summer to a complete destratification in winter induced by winds. In spring and fall, the upwelling was intensified, as deduced from satellite images and wind data. Two peaks of chlorophyll a concentration were obtained (in spring and fall) although the phytoplankton composition was quite different. During the spring bloom, the abundance of diatoms of the genera *Leptocylindrus*, *Rhizosolenia and Pseudonitzchia* was elevated (Figure 2). In contrast, the fall bloom was mainly caused by an increase of the pico- and nanoplankton spring peak coincided with the lowest abundance of pico- and nanoplankton spring peak coincided with the lowest abundance of pico- and nanoplankton while the fall peak was characterized by a very low microplankton abundance.

The Shannon index was calculated for the four surveys on the basis of the relative abundance of the identified microplanktonic groups. The results indicate an decrease in diversity from summer (when the highest value was reached) to spring, indicating that the spring bloom is due to the growth of a few genera (H=2.756).



Fig. 1. Seasonal concentration of pico- and nanoplankton (cells/ml).



Fig. 2. Seasonal concentration of microplankton (cells/ml).

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# DISTRIBUTION AND ACTIVITIES OF PROKARYOTES IN THE WATER COLUMN OF THE TYRRHENIAN SEA

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## Abstract

Tyrrhenian Sea is a poorly studied part of the Mediterranean Sea. During the CIESM-SUB1 multidisciplinary cruise in April 2006, we studied hydrostatic pressure effect on the prokaryotic activities and the structure of communities. Results show an important aminopeptidase and phosphatase activities in the deep sea. Community structure has been studied using two approaches: CARD-FISH and cloning/sequencing. The main result shows an increase of *Archaea* population according to the depth. *Euryarchaeota* (group II *Archaea*) dominates deep-sea waters of Thyrrhenian Sea. Preliminary results of cloning/sequencing have shown that gamma-Proteobacteria (*Bacteria*) are dominant in deep sea among Bacteria.

Keywords : Bacteria, Biodiversity, Deep Sea Ecology, Deep Sea Processes, Tyrrhenian Sea.

The CIESM-SUB1 cruise is the first survey of a long term project aimed to study, through a multidisciplinary approach, the main diversity patterns of a poorly investigated area of the Mediterranean Sea, namely the Southern Tyrrhenian area up to the Sardinia-Sicily Channels. Results shown thereafter are focused on the understanding of hydrostatic pressure effects on the prokaryotic activities and the structure of communities.

The sampling area is located off the Gulf of Napoli up to the Sardinia-Sicily channel and sampling was done on board the R/V Universitatis. Three water masses [1] can be well identified by Theta-S diagram as:

- Surface Water (SW), originated from Atlantic waters

- Levantine Intermediate Water (LIW), originated from the eastern basin older than the deep water masses

- Western Mediterranean Deep Water (WMDW) originated from the surface waters of the Gulf of Lion.

Samples were collected at 5 stations at 3 depths (20, 500, 3000m) with Niskin bottles. In parallel, deep-sea water samples were collected via high-pressure bottles (HPBs) to maintain deep-sea samples at the in situ conditions (pressure, temperature ; for more details see [2]).



Fig. 1. Distribution of Bacteria, Crenarchaea, Euryarchaea at 20m, 500m and 3000m depths of the Thyrrhenian Sea in April 2006 as percent CARD-FISH<sup>+</sup> of DAPI counts. Bars represent mean of 5 stations (+/- standards errors).

Aminopeptidase and phosphatase activity showed maximum rates in the surface water and minimum rates in the LIW, while the WMDW was characterized by high rates. These rates were in the same range than those measured in the Ionian Sea [3]. However, both aminopeptidase and phosphatase rates in the deep-sea waters were in the same range than those in the surface waters. Measurements obtained at in situ pressure conditions were higher than those obtained under atmospheric pressure. This suggests that a substantial part of the prokaryotic community is adapted to high pressure conditions.

The CARD-FISH data shows that archaeal numbers (sum of Crenarchaea and Euryarchaea, figure 1) increased with depth as previously demon-

strated for the Pacific Ocean [4] and the North Atlantic [5]. However, in the Tyrrhenian Sea, the dominant archaeal group was the Euryarchaea rather than the Crenarchaea [4- 6] suggesting a peculiar structure of the prokaryotic community of the Tyrrhenian Sea.

Preliminary data on the impact of hydrostatic pressure indicate a selective response of some members of the prokaryotic community, however, data analysis is still in progress.

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# DIEL AND SEASONAL VARIATIONS IN ABUNDANCE, ACTIVITY AND COMMUNITY STRUCTURE OF PARTICLE-ATTACHED AND FREE-LIVING BACTERIA IN THE NW MEDITERRANEAN SEA (0-100M)

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## Abstract

A multidisciplinary approach was used to investigate the response of the attached versus free-living bacteria during dial or seasonal changes within the water column at the NW Mediterranean JGOFS-DYFAMED station. Community structure and activity of both compartments answered very rapidly to night/day changes during spring phytoplanctonic bloom and were clearly influenced by depth stratification in summer. These results, coupled with other biotic and abiotic parameters, suggested that bacterial successions could affect or reflect the bacterial response to changes in the quality or quantity of organic material in the water column. *Keywords : Bacteria, Biodiversity, Fecal Pellets, Food Webs.* 

A major topic in aquatic microbial ecology concerns the fate of particulate organic matter (POM) and the pathways by which is produced, transferred within the food web, transported downward as sinking POM through the water column, and decomposed and mineralized by microbes. It is well established that pelagic bacteria play an active role in the transformation of particulate (POC) to dissolved organic carbon (DOC) via a wide variety of enzymatic pathways [1]. Even if the relative contribution of particle-attached versus free-living bacteria in the total bacterial abundance and activity is relatively well known, the influence of bacterial diversity on the functions of both communities remains poorly documented.

The most important finding of this study was that the activity of attached bacteria showed pronounced diel variations in the upper mixed water column with higher activities at night. Under mesotrophic conditions, the contribution of attached bacteria to total bacterial activity increased from less than 10% at day time to 83% at night time (Figure 1).



Fig. 1. Diel variations of particle-attached versus free-living bacterial activity, and contribution of the attached bacteria to the total bacterial activity under mesotrophic conditions (spring) at the JGOFS-DYFAMED station (NW Mediterranean).

At high chlorophyll *a* concentration, the highest cell-specific activities and contribution to total bacterial activity were due to free-living bacteria at day and to attached bacteria at night. Under summer oligotrophic conditions, free-living bacteria dominated and contributed to the most important part of the bacterial activity at both day and night whereas attached bacteria were much less abundant but presented the highest cellspecific activities. These diel and seasonal variations in activities were concomitant to changes in bacterial community structure, mainly in the upper layer. The number of attached CE-SSCP [2] ribotypes was fairly constant suggesting that particles are colonized by a relatively limited number of ubiquitous ribotypes. Most of these ribotypes were also freeliving ribotypes suggesting that attached bacteria probably originate from colonization of newly formed particles by free-living bacteria in the upper layer.

These results reinforce the biogeochemical role of attached bacteria in the

cycling of particulate organic carbon in the NW Mediterranean Sea and the importance of diel variability in these processes.

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# SPECIFICITIES AND INTERANNUAL VARIABILITY OF THE SURFACE PLANKTON ECOSYSTEM OF THE BAY OF CALVI (CORSICA)

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## Abstract

In the oligotrophic Bay of Calvi, Corsica (Ligurian Sea, Northwestern Mediterranean), the seasonal dynamics of surface plankton communities is studied for three decades, with the aim of assessing seasonal patterns, plankton assemblages and interannual trends. A major interannual variability is observed and seems to be controlled by hydro-climatic changes, rather than by anthropogenic perturbations. This confirms that the Bay of Calvi offers a unique site where ecosystem responses to climate change can be studied. *Keywords : Plankton, Ligurian Sea, Food Webs, Biodiversity, Global Change.* 

In the oligotrophic Bay of Calvi, Corsica (Ligurian Sea, Northwestern Mediterranean), the seasonal dynamics of surface plankton communities is studied for three decades.

As a distinctive feature of the Bay of Calvi, a plurimodal plankton bloom occurs generally between January and April, with large interannual variability. Later in the season, the plankton biomass remains very low from May to December.

A major interannual variability of plankton organisms, assemblages and food webs is observed, and seems to be controlled by hydro-climatic changes rather than by anthropogenic perturbations [1, 2]. A seasonal succession of characteristic plankton assemblages is observed: 1) late winter and early spring assemblages with diatoms, radiolarians, tintinnids and euphausids; 2) spring assemblages with small diatoms and large copepods; 3) late spring and summer communities dominated by phytoflagellates and cyanobacteria, ciliates, small copepods, salps and appendicularians; 4) late summer communities often characterized by mixotrophic organisms.

As a general rule, the organisms size decreases from late winter to autumn, while the diversity increases over the same period. This succession corresponds to the ecosystem functional response to decreased nutrient availability.

Another specific characteristic of the Bay of Calvi is that the winter spring bloom does not occur each year, which is largely attributable to the nutrient limitation characteristic for mild winter. When occurring, the bloom is dominated by large Diatoms and macrozooplankton. Smaller phytoplankton and microzooplankton exhibit less interannual variability.

The main factors controlling the composition of the surface plankton of the Bay of Calvi are strong oligotrophy, winter climate variability, wind stress, the interactions with the *Posidonia* seagrass [3] and the vicinity of the Liguro-Procençal Front.

Because of its oligotrophic status and its sensitivity to climate forcing, the plankton ecosystem of the Bay of Calvi is at the limit between a state characteristic of temperate and tropical ecosystem functioning. Through modifications in patterns of plankton biomass and biological assemblages, small changes in the physical environment propagate throughout the plankton ecosystem and control the entire food web dynamics. As a consequence, the diversity of the upper trophic levels of the pelagic ecosystem is not affected directly by temperature changes, but is indirectly sensitive to the physical and climate changes. These environmental changes affect also the microbial plankton food web as a source of food (e.g. qualitative and quantitative interactions, match / mismatch).

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# PATTERNS OF PHYTOPLANKTON COMMUNITY STRUCTURE AND RELATED ENVIRONMENTAL PARAMETERS IN GREEK COASTAL WATERS

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## Abstract

Monitoring was carried out along the coastal waters of Aegean Sea during the period March - October 2002 and 2003. The environmental (temperature, salinity, chl a, nutrients) and ecological (phytoplankton species composition, diversity, taxa dominance, community dissimilarities) parameters from five Gulfs of the Aegean Sea are analyzed. *Keywords : Phytoplankton, Coastal Waters, Aegean Sea*.

This study presents data on environmental (temperature, salinity, chl a, nutrients) and ecological (phytoplankton species composition, diversity, taxa dominance, community dissimilarities) from five Gulfs (Saronikos, Evoikos, Pagassitikos, Thermaikos, Kavala) of the Aegean Sea, E. Mediterranean, collected during March-October 2002 and 2003. The levels of environmental parameters in all Gulfs ranged as follows: temperature 20.1-21.2 °C and salinity 35.5-38.1 psu. The highest (0.71 µM) phosphate concentration was found in Thermaikos Gulf, the lowest (0.21  $\mu$ M) concentration in Kavala's Gulf and it varied from 0.24  $\mu$ M to 0.35  $\mu$ M in the other Gulfs. On the other hand, the highest concentration (17.04  $\mu$ M) of total inorganic nitrogen (DIN) was found in Pagassitikos Gulf, the lowest concentration (3.32  $\mu$ M DIN) in Thermaikos Gulf and it varied from 6.47  $\mu$ M to 9.74  $\mu$ M DIN) in the other Gulfs. Silicate concentration was highest (23.12  $\mu$ M) in Pagassitikos Gulf whereas it varied from 1.29  $\mu$ M to 5.77  $\mu$ M in the other Gulfs. Total phytoplankton cell (range:  $1.1 \times 10^5 - 1.2 \times 10^6$  cells L<sup>-1</sup>) and chl a (range: 0.47-2.90 mg m<sup>-3</sup>) concentrations displayed a trend among Gulfs: Thermaikos, had the highest abundance of these parameters and followed by Saronikos, Pagassitikos, Evoikos and Kavala's Gulfs.

The Shannon-Wiener index species diversity did not show any significant fluctuations ranging from 1.9 bits/ind. (Gulf of Kavala) to 2.4 bits/ind. (Pagassitikos Gulf). In contrast, the Diatom/Dinoflagellate ratio differed among stations ranging from 7 to 56 and confirmed the predominance of diatoms over dinoflagellates at all Gulfs and so did the number of common species, ranging from 8 to 19, as well, as the number of rare species ranging from 73 to 245. The two predominant diatom species in each Gulf were centric (Skeletonema costatum, Chaetoceros socialis, Chaetoceros affine, Leptocylindrus minimus, Leptocylindrus danicus, Rhisosolenia alata, Rhizosolenia hebetata) and pennate (Nitzschia delicatissima, Thalassionema nitzschioides, Nitzschia closterium) forms. The former were more frequent and abundant comprising the  $30.6\%\mathchar`-54.5\%$  of the total algal community, than the latter (10.5%-25.6%). Analysis of communities dissimilarities [1] indicated considerable differences in assemblage composition between gulfs since the average dissimilarity coefficient of the pair-wise comparisons ranged from 45 to 70 [Table 1].

Tab. 1. SIMPER analysis breakdown of average dissimilarity between Gulf pairs into contributions from each indicator species.

| Gulf pairs                | Dissimilarity<br>coefficient | Important indicator species<br>(first in order) | Average<br>dissimilarity | Contribution<br>% |  |
|---------------------------|------------------------------|-------------------------------------------------|--------------------------|-------------------|--|
| Saronikos - Evoikos       | 58                           | Ochromonas oblonga                              | 5.35                     | 9.62              |  |
|                           |                              | Leptocylindrus minimus                          | 4.59                     | 8.26              |  |
| Saronikos - Pagassitikos  | 50                           | Phaeocystis sp.                                 | 4.11                     | 8.60              |  |
| 90.                       |                              | Alexandrium minutum                             | 3.27                     | 6.84              |  |
| Evoikos - Pagassitikos    | 60                           | Skeletonema costatum                            | 5.65                     | 9.92              |  |
|                           |                              | Ochromonas oblonga                              | 5.61                     | 9.64              |  |
| Saronikos - Thermaikos    | 45                           | Detonula confervacea                            | 3.48                     | 8.30              |  |
|                           |                              | Rhizosolenia hebetata                           | 3.14                     | 8.28              |  |
| Evoikos - Thermaikos      | 65                           | Ochromonas oblonga                              | 5.12                     | 8.17              |  |
| 111111 111 1111           |                              | Chaetoceros socialis                            | 4.94                     | 7.88              |  |
| Pagassitikos - Thermaikos | 55                           | Phaeocystis sp.                                 | 4.22                     | 8.19              |  |
|                           |                              | Detonula confervacea                            | 3.54                     | 6.88              |  |
| Saronikos - Kavala        | 64                           | Skeletonema costatum                            | 6.13                     | 10.07             |  |
|                           |                              | Rhizosolenia alata                              | 5.67                     | 9.32              |  |
| Evoikos - Kavala          | 60                           | Ochromonas oblonga                              | 6.16                     | 10.80             |  |
|                           |                              | Chaetoceros socialis                            | 5.24                     | 9.19              |  |
| Pagassitikos - Kavala     | 70                           | Skeletonema costatum                            | 7.89                     | 11.79             |  |
|                           |                              | Leptocylindrus danicus                          | 6.79                     | 10.14             |  |
| Thermaikos - Kavala       | 69                           | Skeletonema costatum                            | 5.29                     | 8.37              |  |
|                           |                              | Rhizosolenia alata                              | 5.55                     | 8.30              |  |

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# CARBON STEADY STATE MODEL OF THE PLANKTONIC FOOD WEB IN THE BIZERTE LAGOON

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## Abstract

A steady state model of the planktonic food web of the Bizerte Lagoon (Tunisia, western Mediterranean) was developed to characterize the structure and the functioning of its planktonic system. Carbon stocks of eight chosen compartments were determined and flows were assigned for each one from field data. Missing flows were, however, calculated by inverse analysis. The model showed a high phytoplankton and bacterial productions, which were actively channelled to mesozooplankton *via* severe grazing by microzooplankton. Moreover, results indicated that detritus played key role in the carbon cycling of the lagoon. Indeed, detritus were actively consumed by mesozooplankton and/or transformed to dissolved organic carbon (DOC) which was mostly consumed by bacteria. *Keywords : Plankton, Food Webs, Inverse Methods, Lagoons.* 

## Introduction

Since inverse method constitutes a powerful tool to estimate ecosystem flows, it has been used to build complete models of carbon flows in a wide range of aquatic environments [1-2]. These models provide an internally consistent description of trophic interactions among various functional groups of the ecosystem. The Bizerte Lagoon is under a high anthropogenic pressure, but until now the global functioning of the planktonic community wasn't investigated. The aim of the study was to build up a model of the planktonic food web in the lagoon.

#### Material and methods

Study was carried out on July 2004 at one station of the lagoon, which is under urban pollution. Water sampling was performed at three depths. Samples were used for determination of dissolved organic carbon (doc) and particular organic carbon (poc) concentrations [3], and carbon stocks of bacteria (bac), phytoplankton (ph1, ph2, ph3) and microzooplankton (mic). Vertical tow was performed to determinate carbon biomass of mesozooplankton (mes). Production rates of phytoplankton and bacteria and microzooplankton consumption rates on them were estimated from dilution method [4]. Vertical fluxes of carbon particles were measured with sediment traps [5]. Missing flows were calculated by inverse approach [1], which was also used to construct the complete steady state carbon flows. To characterize efficiently the food web structure, network analysis were applied to the resulting flows.

## Results and discussion

Inverse solution for the planktonic food web flows is represented in the figure 1.



Fig. 1. Inverse solution for planktonic food web flows in the Bizerte Lagoon during summer 2004.

Each carbon flow is represented by an arrow that width is proportional to the calculated value. The main carbon input was supported by the primary production (1495 mg C m<sup>-2</sup> d<sup>-1</sup>). >10  $\mu$ m phytoplankton (ph3) con-

tributed largely (93%) to this carbon input. Allochthonous carbon input accounted for 106 mg C  $m^{-2}$   $d^{-1}.$ 

Total respiration represented 60% (947 mg C m<sup>-2</sup> d<sup>-1</sup>) of the total carbon input. Algal respiration did not exceed 5% of their primary production, which corresponded to the minimum given by the constraint on the respiration. Heterotrophic bacteria and zooplankton were the major contributors to the respired carbon loss (485 and 381 mg C m<sup>-2</sup> d<sup>-1</sup>, respectively). The remaining carbon outputs from the system were driven by the sinking fluxes (561 mg C m<sup>-2</sup> d<sup>-1</sup>, 35% of carbon outputs) and the consumption of mesozooplankton by the highest trophic levels (93 mg  $C m^{-2} d^{-1}$ , 5% of carbon outputs). Grazing by microzooplankton (705 mg C m  $^{-2}$  d  $^{-1})$  removed 21% and 49% of the production of 2  $\cdot 10~\mu m$ phytoplankton (ph2) and ph3, respectively. Mesozooplankton grazed only on ph3 and contributed of 5% of their production loss. doc exudation by algae (329 mg C m<sup>-2</sup> d<sup>-1</sup>) accounted of 22% of primary production. The most important flows were those where bacteria was implicated. Indeed. >80% of the DOC uptake by bacteria originated from the exudation of the living compartments. The bacterial path was important in Bizerte Lagoon, with major pathways going from living compartments to detritus (det), then to doc and finally to bacteria. These latter were in turn consumed by microzooplankton. Microzooplankton grazing on bacteria (485 mg C m<sup>-2</sup> d<sup>-1</sup>) represented 50% of bacterial production. Bacterivory and herbivory accounted for 40 and 60% of microzooplankton diet, respectively. However, herbivory contributed of only 20% of the mesozooplankton diet. Microzooplankton provided the remainder carbon demand of mesoconsumers. The carbon flow that has a cyclic pathway through the system is determined by Finn Cycling Index which value was 26. The main emergent property of the system is a good recycling activity with a balance between herbivory against bacterivory.

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# FLUCTUATIONS DES POPULATIONS PHYTOPLANCTONIQUES LORS D'UN CYCLE DE MARÉE DANS LA ZONE INTERTIDALE DES CÔTES NORD DE SFAX (SUD-EST DE LA TUNISIE)

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## Résumé

La zone intertidale des cotes nord de Sfax reflète aisément le paysage bionomique de l'ensemble du littoral du golfe de Gabès à savoir, un substrat sablo vaseux, les herbiers de phanérogames et un phénomène de marée semi diurne engendrant des estrans très étendues. Ces cotes abritent une population malacologique très importante faisant du golfe le premier pole d'exploitation des bivalves du pays. La surveillance du phytoplancton toxique est un impératif pour pouvoir commercialiser cette richesse. L'identification des périodes d'échantillonnage lors des périodes de balancements de la marée et la compréhension des fluctuations des microalgues étaient nécessaires pour mener à bien ce suivi.

Mots clès : Biodiversity, Phytoplankton, Tides.

#### Introduction

La zone intertidale balayée pendant une période donnée par des courants spécifiques, abrite une faune et une flore dont la richesse et la variété sont sans doute bien spécifiques de par leur pouvoir d'adaptation et de conditionnement au stress. On a toujours aussi considéré que le phénomène de marée contribuait à l'enrichissement du littoral en phytoplancton du moins par une re-oxygénation du milieu, la stratification de la colonne d'eau et la mise à la disposition de ces organismes de plus de nutriments.

Le présent travail se propose la caractérisation des populations phytoplanctoniques sur la zone intertidale des cotes Nord de Sfax et essentiellement l'identification des fluctuations du phytoplancton en fonction du marnage.

## Matériel et Méthodes

Notre site d'échantillonnage se situe à 6km au nord de la ville de Sfax au niveau d'une passerelle ayant une avancée de 400m en mer. L'échantillonnage s'est déroulé à basse et à haute mer, au cours des dix jours de vive eau et ceci lors des quatre différentes saisons.

Nous nous sommes, intéressés à l'identification de la diversité du phytoplancton en fonction de la remontée de l'eau suite à des prélèvements par bouteille de 11 de contenance. Les lectures et les dénombrements phytoplanctoniques ont été effectués sous microscope à phase inverse selon la méthode de sédimentation d'Uthermohl. Une attention particulière a été aussi portée aux épiphytes suite à un lavage des algues et phanérogames rencontrées dans cette zone.

## Résultats et discussion

La diversité spécifique phytoplanctonique de ce milieu est invariable à marée basse comme à marée haute. Les mouvements de ce courant n'enrichissent point la communauté phytoplanctonique et il n'y a pas d'apports externes surtout venant du large. Le phénomène de résonance identifié pour la marée dans la région du golfe de Gabès semble se répercuter aussi à l'échelle biologique [1]

D'une façon générale, les diatomées dominent en diversité et ceci en toutes les saisons et à tous les niveaux. Mais quantitativement nous avons remarqué que les dinoflagellés s'imposent davantage surtout au printemps et en été, lors des premiers jours de la marée et au milieu du cycle. Les fortes densités observées au début et au milieu du cycle sont certainement conditionnées par l'excystement des kystes piégés dans le sédiment ou encore au niveau des macroalgues suite au remuement généré par le mouvement du flot et par la suite à une meilleure adaptation des espèces à ces perturbations.

Pour définir un calendrier d'échantillonnage dans le cadre du réseau de surveillance des espèces toxiques, il serait judicieux par conséquent de choisir ces deux périodes afin de statuer sur l'état de la zone.

L'enkystement des dinoflagellés sur ces cotes y est en effet très important et touche à une multitude d'espèces parmi elles on compte les espèces toxiques du genre *Alexandrium* et surtout *Karenia selliformis* espèce toxique emblématique du golfe. Ceci peut être du aux stress abiotiques que subissent ces espèces dans ce milieu.

## Conclusion

Les mouvements engendrés par la marée ne contribuent pas à la diversification des populations phytoplanctoniques dans la zone intertidale mais ce sont des stimulateurs des processus d'enkystement et d'excystement des cellules. Dans le cas de cellules toxiques, la zone, la période et l'heure d'échantillonnage sont des critères très importants à prendre en considération en cas de surveillance.

## Référence

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# ON THE DISTRIBUTION OF NUISANCE, POTENTIALLY AND OBLIGATORY TOXIC PHYTOPLANKTON SPECIES DURING THE RED-TIDE (IZMIR BAY, AEGEAN SEA)

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## Abstract

The bloom-forming phytoplankton species were studied in the heavily eutrophied inner part of Izmir Bay during the red-tide event observed in April 1998. During the period between 21- 24 April 98 when fish mass mortality was observed, the abundance of some nuisance and toxic species increased (*Pseudonitzchia seriata* group, *Alexandrium minutum*, *Gymnodinium* sp., *Prorocentrum micans*, *Dinophysis rotundata*, *Heterosigma cf. akashiwo Gymnodinium cf. mikimotoi* (*=Karenia mikimotoi*),*Prorocentrum minimum*, *Noctiluca scintillans*). The appearances of some of these species have been reported frequently since the early 1980ies. Particularly *Noctiluca scintillans* could have prominent effects on the water quality.

Keywords : Aegean Sea, Phytoplankton, Blooms, Eutrophication, Toxic Blooms.

Among the 5000 species of extant marine phytoplankton (Sournia et al., 1991), some 300 species can at times occur in such high numbers that they discolor the surface of the sea, resulting in so-called "red-tides", while only about 40 species have the capacity to produce potent toxins that can find their way through fish and shellfish to humans (Hallegraeff et al., 1995). Only about 1 % of 5000 species are toxin producer, though the impact of these few species can be profound. The amount of cell does not define Harmful Algal Blooms (HABs), as some species are so toxic that their presence, even in relatively low numbers, may be harmful, *i.e.*, the recommended concentration limits for species like *Dinophysis acuminata* and *Alexandrium spp.* are only 500 cells/l in Danish waters (Andersen, 1996).

Sampling was carried out in the inner Izmir bay in April 1998 at the start and peak of the bloom. Additional samples were taken from reddishbrown and orange patches on April 21-24 when mass fish mortality was observed. Phytoplankton samples (5 1) were taken from surface waters (0.3-0.5 m), fixed in lugol and counted using the single drop technique (Semina, 1978). Cells were photomicrographicied with an Olympus inverted microscope.

The first red-tide and mass fish mortalities events in Izmir Bay had been reported in the 1950ies (Numann, 1955) and the first record on toxic phtyoplankton species was *Alexandrium minutum* (8  $\times 10^6$  cells/l) in 1983 (Koray and Buyukısık, 1988) in the harbor region of the Inner Ba, during a red tide event.

During peak period of the bloom (17 April) the number of species with an abundance higher than 2000 cells/l was 23 in the reddish-brown patch while it was 33 in the orange patch. In both patches, there were 4 toxic and/or potential toxic species and their abundance was >10.000 cells/l in the latter. *Alexandrium minutum* reached a maximum abundance of 410.000 cells/l on 21 April, when the first observation on the mass fish mortality was reported. The main affected fish species were gray mullets (Mugilidae).

As an alternative red-tide causative, ciliates exhibited a significant correlation with nitrate (r=0,45 n=33, p<0,05). There is also a significant correlation between *Noctiluca scintillans* abundance and ammonium (0,61, n=14) as expected. *N. scintillans* had been observed generally in the inner and middle bay during the sampling period. Chl a and ammonium sharply increased whilst nitrate decreased during the sampling period in the inner bay.

On the bases of the data available in the last decade and the most recent observations (including August 2006), it is apparent that discoloration is still frequent, as the conditions causing eutrophication are still prevalent in spite of lower organic loads at present than in the past.

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# IMPORTANCE OF ALKALINE PHOSPHATASE IN THE NORTHERN ADRIATIC

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## Abstract

Northern Adriatic waters are poor in PO<sub>4</sub>, and DOP usually contributes more than 80% of the phosphorus pool. During 2004 APA was measured in these waters to establish if microbial communities use this enzyme to avoid phosphorus limitation. During the period of water column stratification APA in the upper 10 m was high (up 6.6  $\mu$ mol L<sup>-1</sup> h<sup>-1</sup>) and correlated with microbial biomass, indicating that microbes used alkaline phosphatase to avoid PO<sub>4</sub> limitation. During the period of water column mixing, APA was low everywhere (<0.2  $\mu$ mol L<sup>-1</sup> h<sup>-1</sup>) and was not correlated with microbial biomass.

Keywords : Adriatic Sea, Enzymes, Phosphorus.

## Introduction

In the productive northern Adriatic waters the N/P ratio is markedly unbalanced for microbial requirements, being about 60 during the 1970's [1], and further increased since the mid-1980's [2]. The strongly unbalanced N/P ratio and a low PO<sub>4</sub> concentration suggest that phosphorus is the limiting element for microbial growth. DOP concentration generally exceeds PO<sub>4</sub> concentration [3, 4], and may be an important source of phosphorus. To establish the role of alkaline phosphatase in supplying phosphorus from DOP in various ambient conditions, APA was measured in different seasons at a profile where conditions change from oligotrophic to eutrophic.

## Methods

Measurements were carried out at six stations at the Po River delta-Rovinj profile in the northern Adriatic during 7 cruises, from May to December 2004. Water samples were collected at 0, 5, 10, 20, and at the bottom. Alkaline phosphatase activity (APA) was measured in unfiltered water immediately after sample collection. Measurements were performed using methyllumbelliferyl-phosphate [5] in triplicate, and during incubation samples were kept in darkness at the *in situ* temperature. Nutrient analyses, dissolved organic phosphorus (DOP), chlorophyll *a* (chl *a*) and bacterial abundance (BA) were performed using methods widely used in oceanography.

#### Results and discussion

In the northern Adriatic APA showed marked seasonal changes (Fig. 1a). From May to September DOP strongly predominated the phosphorus pool (>90%) in surface waters and N/P ratio was markedly unbalanced (Fig 1b). A similar situation was found down to 10 m depth. In those waters APA was high (0.4-6.6  $\mu$ mol L<sup>-1</sup> h<sup>-1</sup>) and correlated with chl aand BA (p«0.005), indicating that microbes used this enzyme to avoid PO<sub>4</sub> limitation. The highest APA was found in May (Fig. 1a) during the spring freshet due to the strongly deficient PO<sub>4</sub> versus inorganic nitrogen supply from freshwater. In October mixing processes in the water column drastically reduced APA in the upper waters (<0.2  $\mu$ mol L<sup>-1</sup> h<sup>-1</sup>), as shown for the surface (Fig.1a). From October to December APA in the upper waters was not correlated with chl a and BA (p»0.005), even at the end October during the largest phytoplankton bloom found in the investigation period. This was probably due to a balanced nutrient supply from bottom waters where the N/P ratio was close to optimal for microbial growth during most part of the investigation period (Fig. 1d).

In the waters below 10 m APA was always several times lower, as shown for the bottom (Fig. 1c), concomitant with a less unbalanced N/P ratio (Fig. 1d). In these waters APA was not correlated to chl a and BA (p>0.005) suggesting that these communities were not PO<sub>4</sub> deficient.



Fig. 1. APA ( $\mu$ mol L<sup>-1</sup> h<sup>-1</sup>) and N/P ratio distribution in surface (a,c) and bottom (b,d) layer at the Po-Rovinj profile in the northern Adriatic during cruises in 2004.

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## MICROPHYTOPLANKTON IN A SHALLOW MARINE LAKE (EASTERN ADRIATIC, NE MEDITERRANEAN)

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## Abstract

The objective was to determine the structure and dynamics of microphytoplankton in the small shallow marine Lake Vlaška situated in the Middle Adriatic Sea. The microphytoplankton communities consisted mainly of diatoms throughout the year, while dinoflagellates caused outbursts of growth in autumn. The simultaneous dominance of more than one species is the main feature of the microphytoplankton assemblages in the lake. The reason for this can be found in the very frequent and rapid changes of the environmental conditions. *Keywords : Phytoplankton, Adriatic Sea.* 

The Neretva River estuary is a small, low tidal (25 cm average daily amplitude) estuary, situated on the eastern coast of the Middle Adriatic Sea. The marine Lake Vlaška is one of the smallest lakes ( $0.5 \text{ km}^2$ , 10 m max. depth) in the lower Neretva estuary. The lake has a highly stratified estuarine character with a very pronounced separation between the brackish and marine layers. Hypoxia (<40%) was present in the 6-10 m layer from July to December 1999.

An investigation of the phytoplankton in Lake Vlaška was carried out as a segment of an interdisciplinary research project from April 1999-April 2000. The objective was to determine the structure and dynamics of microphytoplankton (cells longer than 20  $\mu$ m) in order to study its importance in the water column. Samples for the analysis of phytoplankton abundance were fixed in 2% neutralized formaldehyde. Sub-samples (25-50 mL) were allowed to settle for 24-48 hours in the counting chambers. Microphytoplankton cells were counted using an inverted microscope Olympus IMT-2 equipped with phase contrast [1]. Microphytoplankton data were presented with reference to major groups: Bacillariophyta (Baci), Dinophyta (Dino), Chrysophyta and Prymnesiophyta (Chry). Results are expressed as cell density per liter, with each cell of filamentous or chain-forming taxa counted as a single cell.

#### Results

A total of 145 microphytoplankton taxa, 74 diatoms, 58 dinoflagellates, 8 coccolithophorids, 3 silicoflagellates, and 1 euglenophycean, chlorophycean and cyanophycean each were identified. The microphytoplankton communities consisted mainly of diatoms (an annual average of 74%), while dinoflagellates caused outbursts of growth in September 1999. The cyanophyte had a larger abundance (24-38% of microphytoplankton) from January to March 2000.

Microphytoplankton abundances oscillated over four orders of magnitude (Fig. 1). Three peaks of microphytoplankton were observed throughout the year. The first peak was in April 1999 ( $1.2 \times 10^6$  cells L<sup>-1</sup>), the second in August-September 1999 (8.0 and  $4.0 \times 10^6$  cells L<sup>-1</sup>), the second in August-September 1999 (8.0 and  $4.0 \times 10^6$  cells L<sup>-1</sup>), the second in August-September 1999 (8.0 and  $4.0 \times 10^6$  cells L<sup>-1</sup>), the second in August-September 1999 (8.0 and  $4.0 \times 10^6$  cells L<sup>-1</sup>), the first peak reflected the intensive development of the diatoms *Thalassiosira* sp., *Cerataulina pelagica, Chaetoceros compressus, Ch. curvisetus, Hemiaulus hauckii* and *Leptocylindrus danicus* that accounted for up to 78% of the microphytoplankton population (Fig. 2). The second peak was mostly (>87% of microphytoplankton abundance) made up of *Nitzschia longissima* (August 1999, 7.9 x  $10^6$  cells L<sup>-1</sup>). The third peak belonged to *Cyclotella* sp. and *Ceratium fusus* (94% of microphytoplankton). A minimum microphytoplankton abundance ( $4.4 \times 10^3$  cells L<sup>-1</sup>) was recorded in November 1999.

The surface layer showed fresh and brackish water (e.g. Dinobryon sertularia, Oscillatoria sp., Asterionella formosa, Fragilaria crotonensis and others), but they were present at background levels. The taxa from the deep Adriatic (Kofoidinium velleloides, Spatulodinium pseudonoctiluca, Podolampas palmipes and others) are frequently found together below 5 m depths. There were 30 rare taxa (<1% of the total number of samples): Rhabdosphaera tignifer, Oscillatoria sp., Pediastrum boryanum, P. clathratum, Cosmarium reniforme, Halosphaera viridis, Asterionella bleakeleyii, Bacillaria paxillifer, Synedra crystallina, S. superba, Chaetoceros rostratus, Ch. lorenzianus, Neocalyptrella robusta, Pleurosigma elongatum, Navicula cancellata, Entomoneis paludosa, Grammatophora marina, Ceratium horridum, C. setaceum, C. teres, C. arietinum, Gyrodinium opium, G. mitra, Oxytoxum parvum, O. laticeps, O. scolopax, O. sphaeroideum, Phalacroma rotundatum, Protoperidinium pyriforme and P. steinii.

#### Conclusions

The microphytoplankton community in the estuary is of marine origin, dominated by small diatoms (Thalassiosira, *Cyclotella*) in spring. In summer, some dinoflagellates increased in numbers, but larger diatoms (*Nitzschia, Pseudo-nitzschia*) were the most abundant cells. Dinoflagellates played a minor role throughout the year, but *Scrippsiella trochoidea* was abundant in autumn. These succession pattern were similar to those described by Margalef [2]. The simultaneous dominance of more than one species is the main feature of the microphytoplankton assemblages in Lake Vlaška. The reason for this is most likely the frequent and rapid changes of the environmental conditions in the estuary.



Fig. 1. Microphytoplankton abundance in the Lake Vlaška.



Fig. 2. Abundance of the microphytoplankton groups in the lake (diatoms-Baci, dinoflagellates-Dino, silicoflagellates and coccolithophorids-Chry).

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## DEGRADATION OF DISSOLVED ORGANIC MATTER: CHEMICAL CHANGES AND THE STRUCTURE OF THE MICROBIAL COMMUNITY

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## Abstract

Marine dissolved organic matter (DOM) represents a wide spectrum of biological reactivity. The aim of this study was to examine the bioavailability of high molecular weight DOM (>1000 Dalton) by measuring concurrent changes in chemical composition and microbial community structure. Sampling was carried out in the NW Mediterranean Sea at 0 m, 500 m and 1500 m and a series of incubations were subsequently carried out. The changes in chemical composition of DOM observed during incubations may reflect the nature of DOM at different depths, while flow cytometry and phylogenetic analysis revealed large variations in the abundance and structure of the microbial community. These results suggest potential links between community composition and DOM degradation.

Keywords : Organic Matter, Bacteria, Chemical Analysis.

Marine dissolved organic mater (DOM) displays a continuum of biological lability, from refractory material turning over on time scales of centuries to millennia to labile material turning over on time scales of minutes to days [3]. Despite a wide range for depth-integrated primary production (PP) in the world ocean [4], marine DOM concentrations are maintained in a remarkably narrow range in the upper 1000 m of the open ocean [2]. Given that DOM production can be a significant fraction of the total PP, this striking offset between the range in PP rates and dissolved organic carbon (DOC) concentrations indicates that there is a very tightlycontrolled feedback between production and sinks. Previous studies added important knowledge on the utilization of bulk DOM and monomers by prokaryotes (e.g. [2], [1], [6]), however controls on the biovailability of DOM components remain poorly understood. The aim of this study is to examine the biological reactivity of high molecular weight DOM (HMW: >1000 Dalton) by studying changes in its chemical composition during degradation, while at the same time examining the subsequent changes in the structure of the microbial community.

Sampling was carried out at site DYFAMED (NW Mediterranean) in December 2004. Seawater samples (200L each) were collected at 0 m, 500 m and 1500 m and processed through a tangential flow filtration system in order to provide a HMW DOM concentrate. Unfiltered samples from the same depths served as an inoculum of natural microbial populations. A 30-day long experiment, consisting of 3 replicate incubations per depth and one control per depth (0.2 micron-filtered seawater added to the DOM concentrate, rather than unfiltered inoculum) were carried out between April and May 2005. The following analyses were carried out on the time-series samples: DOC, amino acids, flow cytometry and Restriction Fragment Length Polymorphism (T-RFLP: phylogenetic analysis).

The experiment revealed variations between incubations, even when samples collected at the same location and depth were considered, highlighting the complex nature of the DOM degradation processes. For the surface samples, DOC concentration appeared to decrease by  $\sim 20\%$  in the first ten days of the incubation remaining largely stable for the remaining of the incubation time. The 500 m and 1500 m samples on the contrary showed no significant change in DOC concentrations throughout the incubation, potentially reflecting difference in the nature of DOM between surface and the deep ocean. Surface water controls also experienced degradation suggesting that the bulk of the organisms responsible for the changes observed were smaller than 0.2 micron or that microbial population were introduced after the start of the incubations.

Amino acid enantiomer analysis suggested that the bacterial contribution to the amino acid pool shows an initial increase during the incubation for surface water samples. In two out of the four 500 m incubations, peptidoglycan amino acid nitrogen (PG-AA-N) remained stable in the duration of the experiment, while the remaining showed a marked decrease from a PG-AA-N of ~12% to 6%. Three out of four 1500 m incubations also showed a significant decrease in PG-AA-N, while one remained stable.

Flow cytometry analysis showed a strong variability of bacterial and viral abundances ranging from  $1.9 \times 10^5$  to  $2.1 \times 10^6$  ml<sup>-1</sup> and  $4.2 \times 10^6$  to  $1.7 \times 10^8$  ml<sup>-1</sup>, respectively. A large increase in bacterial and viral numbers was observed in the first ten days of the incubations, as well as changes in the relative importance of different population sub-groups. Finally, preliminary T-RFLP results confirmed a large change in the structure of the microbial community throughout the incubation. This suggests tight links between DOM degradation and microbial community composition.

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# MICROSCOPIC EUKARYOTES ARE ALIVE AND WELL IN MARINE OIL-POLLUTED ENVIRONMENTS

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## Abstract

The dynamics of eukaryotic groups were studied in experimental oil-polluted marine microcosms (EC- COMMODE-VK-CT2002-00077). PCR amplification and sequencing of 18S rRNA gene combined with microscopic counts revealed that ubiquitous microscopic eukaryotes such as *Paraphysomonas foraminifera* were effectively grazing of hydrocarbonoclastic bacterial cells. *Keywords : Biodiversity, Food Webs, Plankton, Petroleum, Pollution.* 

The advent of molecular approaches brought a wealth of knowledge in the study of microbial diversity [1] and inoculated this field with more novel methodologies. The lack of eukaryote-focused studies in oil-pollution investigations is even more apparent, in contrast with the prokaryotes [4]. In order to investigate the dynamics of the dominant eukaryotic groups, we applied PCR amplification and sequencing of 18S rRNA genes in oil-polluted microcosms along with conventional cell counts (epifluorescence microscopy) in the framework of the EC-COMMODE project which aimed to increase our understanding of the dynamics of natural and anthropogenic remediation of crude oil-polluted systems. The 100 l capacity microcosms contained seawater from chronically polluted (P) and non-polluted (NP) oligotrophic sites of the Aegean Sea implemented with crude oil, crude oil + nutrients and crude oil + emulsifier. The analysis also included the relevant blank treatments (i.e. no oil or nutrients added). The microcosms were incubated at 21 °C for 10 days and sampled daily. In all cases, most of the heterotrophic flagellates (HNF) population (>90%) was killed after the addition of crude oil. A few resistant/opportunistic species exponentially grew after 96 hours on average, decimating the elevated bacterial concentrations. At the peak of the HNF abundance, DNA was extracted from 1-21 of water and was used for the construction of 18S rRNA gene libraries. For each treatment 20-52non-chimeric phylotypes were analyzed. GenBank numbers of the retrieved sequences are AY789780-AY789790 and DQ781322-DQ781336.



Fig. 1. NJ phylogenetic tree constructed with 1000 bootstrap replicates of 18S rRNA genes retrieved from oil-polluted marine microcosms (in bold).

Redundancy analysis and phylotype coverage was performed according to [5] by using the  $S_{Chao}$  and  $S_{ACE}$  indices. The retrieved phylotypes belonged to a wide range of taxa of Stramenopile, Alveolata, Choanoflagellida, Cryphomonadaceae, Katablepharidaceae, Cercozoa, Prasinophyceae and Cryptophyta (Fig. 1). The diversity of both N and P treatments was always higher to those containing crude oil ones. This was also indicated by the law phylotype coverage (21.6 -41.1%) in the former cases. The opposite occurred in the crude oil NP and P treatments, irrespective of the presence of nutrients or emulsifiers, where coverage reached 89.9% due to the dominance of certain phylotypes. A phylotype with 99% similarity to *Paraphysomonas foraminifera* dominated in all crude oil NP and P treatments. This phylotype appeared in the blank treatments as well,

suggesting that this species was selected against others after crude oil addition by being able to graze the hydrocarbonoclastic bacteria. Indeed, the *P. foraminifera* abundance peaked one or two days after the peak of the bacterial cells. This ubiquitous phagotrophic genus has a widespread distribution in the world oceans and reproduce rapidly in presence of photosynthetic, heterotrophic bacteria and nanoflagellates, which they decimate, suggest that they are voracious feeders on prey almost as big as themselves, ca.  $3.5 \times 2.5 \text{ mm}$  [2,3]. Other dominant phylotypes in the crude oil NP and P microcosms were the commonly occurring bacteriores *Pseudobodo tremulans* and the choanoflagelid *Monosiga brevicolis*, and a few novel phylotypes. Regarding bioremediation, our current findings suggest the occurrence of a microbial food web that includes intense bacterial grazing by protists and this aspect should be taken into account in the fate and activity of hydrocarbonocalstic bacteria in oil polluted marine systems.

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# SEASONAL MICROPHYTOPLANKTON VARIABILITY IN A EUTROPHIC AND OLIGOTROPHIC REGION IN THE NORTHERN ADRIATIC SEA (A PRELIMINARY STUDY)

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## Abstract

Seasonal pattern of microphytoplankton community based on the fifteen-year data set (1990-2004) was determined at the surface and bottom of the two sampling sites in the northern Adriatic Sea. Sites were chosen to represent the eutrophic and oligotrophic region in the northern Adriatic Sea, whereas the depths surface and bottom are intended to represent the extremes of the seawater column. *Keywords : Phytoplankton, Eutrophication, Adriatic Sea.* 

## Introduction

The northern Adriatic Sea is predominantly influenced by fluvial allochthonous input of the Italian rivers, especially Po River [1]. Freshwater inputs facilitate stratification of the seawater column, modifying main circulation and water masses exchange pattern between the northern and middle Adriatic Sea [1], whereas nutrient inputs [2] influence the microphytoplankton composition, succession and biomass [3, 4, 5].

## Material and Methods

Samples were collected on monthly basis from 1990 to 2004 at two sampling sites, SJ108 and SJ107, along a Rovinj (Croatia) - Po River Delta (Italy) transect. Microphytoplankton analysis was performed by a Zeiss inverted microscope using the Utermöhl settling technique [6]. As microphytoplankton were considered cells or colonies larger than 20 mm, in one dimension at least.

## Results and Discussion

Microphytoplankton blooms (Fig. 1.) occurring during the February to April period and again during the September - November are consequence of the regenerated nutrients distributed evenly throughout the region due to efficient circulation and vertical mixing [1]. From May to August circulation closes and seawater column stratifies, causing enhanced impact of nutrient rich freshwater inflows which consequently increase microphytoplankton abundance in eutrophic region.



Fig. 1. Seasonal cycle of microphytoplankton abundance at both depths of eutrophic (SJ108) and oligotrophic (SJ107) regions. Each monthly average was obtained from the entire data set during the study period.

In December and January, minimal freshwater inputs, efficient circulation and mixing lead to uniformity in the microphytoplankton abundance in the northern Adriatic Sea. Substantial discrepancy between the surface microphytoplankton abundances in the eutrophic region and bottom values in both regions as well as surface values in the oligotrophic region, for the majority of the year, explains the fact that under-surface layers of the water column in eutrophic region and complete oligotrophic region are of the same origin and under the same influence, that is, of the central Adriatic Sea waters [7].

Microphytoplankton community analysis indicated *Pseudo-nitzschia delicatissima* (*P del*) as the major dominant species during the majority of the year (Tab. 1). From January to April, *Skeletonema costatum* (*S cos*) was found to be the prominent bloom constituent in the eutrophic region. Minor importance of *Skeletonema costatum* in the oligotrophic region during shorter period (in February and March) confirms this diatom as a possible eutrophication indicator [8]. *Cerataulina pelagica* (*C pel*) is an important bloom species at the surface of both regions during warm period. From May until the end of the year, *Nitzschia longissima* f. *tenuirostris* (*N ten*) is frequent at the bottom of both regions. Dominance of *Asterionellopsis glacialis* (*A gla*) at the end of the year in the bottom layer of the eutrophic region, when seawater column is well mixed in both regions, emerges as an interesting topic, which is to be investigated further. Other species are occasionally dominant/ frequent, in either or both regions, however, none of them was recognized as a possible indicator species of either eutrophic or oligotrophic conditions. More detailed study of microphytoplankton species in relation with physical and chemical parameters could lead to detection of possible indicators, as well as to better understanding of the microphytoplankton ecology.

Tab. 1. Dominant and frequent microphytoplankton species at both depths of the eutrophic (SJ108) and oligotrophic (SJ107) region throughout the year.

|                   | Jan            | Feb            | Mar            | Apr            | May                     | Jun                     | Jul                     | Aug                     | Sep            | Oct                     | Nov                              | Dec            |
|-------------------|----------------|----------------|----------------|----------------|-------------------------|-------------------------|-------------------------|-------------------------|----------------|-------------------------|----------------------------------|----------------|
| SJ108,<br>surface | <u>S cos</u>   | S cos<br>P del | S cos<br>P del | S cos<br>P del | P del<br>C soc          | P del<br>C pel<br>N ten | P del<br>C pel          | P del                   | P del          | P del                   | C soc                            | N ten          |
|                   |                |                |                |                |                         |                         | C sp.                   |                         | C sp.          |                         | C sp.                            |                |
| SJ108,<br>bottom  | S cos<br>N ten | S cos<br>P del | S cos<br>P del | S cos<br>P del | P del<br>N ten          | P del<br>N ten          | P del<br>N ten          | P del<br>N ten          | P del<br>A gla | P del<br>N ten<br>A gla | C soc<br>C sp.                   | N ten<br>A gla |
| SJ107,<br>surface |                | S cos<br>P del | S cos<br>P del | P del          | P del<br>D fra<br>C ins | P del<br>C pel<br>C sp. | P del<br>C pel<br>C sp. | P del<br>C pel<br>D fra | P del          | P del<br>C sp.          | C sp.<br>C soc<br>N ten<br>L dan | C soc<br>N ten |
| SJ107,<br>bottom  | C sp.          |                | P del<br>S cos | P del          | C sp.<br>P del<br>N ten | C sp.<br>P del<br>N ten | C sp.<br>P del<br>N ten | P del<br>N ten          | P del<br>N ten | P del<br>N ten          | C sp.<br>N ten<br>C soc          | N ten          |

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# FIRST DATA ON MICROBIAL BIOMASS AND ACTIVITIES IN THE TYRRHENIAN SEA (MEDITERRANEAN SEA)

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## Abstract

First estimations of microbial biomass and activities in the water column of the Tyrrhenian basin in association with the main Mediterranean water masses, are reported. Exponential decrease with depth of biomass and activities was registered assessing the predominant weight of export production in the basin and the scarce advection of preformed organic matter within the water masses. Important seasonal changing patterns occurred for respiration and primary production more than for biomass. The evaluation of the carbon budget by microbial community showed PP/R ratios close to 1 in July, and a clear productive metabolism in December. *Keywords : Plankton, Biomass, Open Sea, Hydrology, Tyrrhenian Sea.* 

## Introduction

Microbial community (phototrophs and heterotrophs) has great potential for predicting the effect of climate change at the biological level because it is responsible for the assimilation of greenhouse gases at surface layers and it remineralized the produced organic matter to  $CO_2$  by respiration 1. Notwithstanding its importance in the biogeochemical processes, few data are available on microorganism biomass and activities for pelagic areas of the Mediterranean Sea.

## Materials and Methods

Two multidisciplinary surveys (CIESM-SUB1 and CIESM-SUB2) were performed with the aim of studying the role of microbial community in the C biogeochemistry. The studied data set covered hydrological parameters, microbial abundances and biomass (picoplankton, picophytoplankton, fractionated chlorophyll *a* and phytoplankton). Morphometric analysis, cell biovolumes and carbon content were determined. Moreover, Primary Production (PP) and Respiration (R) were studied with the aim of defining the community metabolism and C budget.

## Results and Discussions

A simple hydrological structure was identified: Modified Atlantic Water (MAW), Levantine Intermediate Water (LIW) and Transitional Deep Water (TDW). The most important hydrological differences were concentrated in the surface layer where the atmospheric forcing modify the thermohaline characteristics (summer-MAW and winter-MAW). Slight differences between the two seasonal periods were recorded for the picoplankton abundances, that resulted generally in the order of  $10^5$  cells ml<sup>-1</sup>. In July, abundances resulted similar between s-MAW and MAW and a decreasing pattern occurred with depth. In December, the highest counts in w-MAW and similar values in MAW and LIW were registered. TDW showed an abrupt decrease of cell abundances. Differently, noticeable cell size increases were observed with increasing depths, particularly in December. In July, high value of Cell Carbon Content (CCC) in s-MAW was detected, decreases in MAW and LIW and a subsequent increase in TDW. In December, an increasing trend with depth (also if with similar values in w-MAW and MAW) occurred. Distribution of biomass in the different water masses was comparable to abundances, with exception in December in TDW, where the biomass values increased owing to great cell volumes. As consequence, the locally achieved conversion factors varied in relation with water masses, depths and seasons (9-29 and 10-33 fg C cell $^{-1}$  in July and December, respectively).

Picophytoplankton abundances confirmed previous data from pelagic oligotrophic waters. Their presence below the photic zone, already observed in the deep Ionian sea, was totally lacking in the Tyrrhenian Sea. Phytoplankton abundances and carbon content appeared to be similar to those reported for other Mediterranean sites 2. The total microbial biomass was higher in summer than in winter (mean values 13 and 7  $\mu$ g C l<sup>-1</sup>, respectively) but the percentages of heterotrophs, phytoplankton and picophytoplankton were constant in both periods (about 62, 22 and 15 %, respectively). Primary production showed different trophic condition between the two seasons: low rates in summer (mean value 0.25  $\pm$  0.08 mg C m<sup>-3</sup> h<sup>-1</sup>) and high rates in winter (mean value 0.65  $\pm$  0.25 mg C m<sup>-3</sup> h<sup>-1</sup>) were measured. The pico-sized fraction contribution to total PP was high in both the seasons (50 % in July, 91 % in December).

ETS activity and respiratory rates greatly varied in the two seasonal periods. In July, two times higher values as well as wider distributions than in December were detected, particularly in the surface samples. A general decreasing trend with depth in both periods was observed with the lowest values in TDW.

The general decreases of biomass and activity with depth assessed the predominant weight of export production in the basin and the scarce importance of lateral advection in circulatory patterns.

The evaluation of the carbon budget driven through microbial community 3 showed PP/R ratios ranging between 0.78 and 3.52 in July, while a clear productive metabolism (PP/R ratios >6) in December occurred. In the studied area, the scenario seems prevailingly to turn towards a positive budget, indicating that in such surface area the microbial communities act as C sink.

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# SAISONNALITÉ ET VARIABILITÉ ANNUELLE DU PHYTOPLANCTON TOXIQUE DE LA CÔTE OUEST MÉDITERRANÉENNE MAROCAINE

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## Résumé

Le dépouillement des données de surveillance des efflorescences phytoplanctoniques du littoral ouest méditerranéen marocain de 1995 à 2002 a permis de mettre en évidence 330 espèces avec une dominance de diatomées et dinoflagellés. Quarante espèces ont fait l'objet d'une analyse ACP qui a permis de mettre en évidence l'abondance des premières espèces en hiver et printemps et des secondes en été. La richesse spécifique annuelle varie entre 43 à l'embouchure de l'oued Laou et 128 à M'diq. Le pourcentage des espèces toxiques est peu important. Cependant, des cas de contamination PSP dues à Gymnodinium catenatum ont été enregistrés; d'autres espèces toxiques ont été détectées. Des corrélations élevées ont été établies entre espèces toxiques et non toxiques.

Mots clès : Western Mediterranean, Diatoms, Dinoflagellates, Blooms, Toxins.

Une étude synthétique des données de surveillance pratiquée entre 1995 et 2002 sur la partie ouest de la cote méditerranéenne marocaine à travers un échantillonnage bimensuel au niveau de 7 localités (Fig. 1) a été réalisée. Les données, exprimées en nombre de cellules par filet, ont permis de calculer l'indice spécifique de Shannon H' et l'indice maximal H'max [1]. Un suivi de paramètres physicochimiques (T°, S psu) des eaux de surface et de fond a été effectués.

L'inventaire des espèces fait état de 330 espèces de phytoplancton dont les diatomées ( Chaetoceros, Rhizosolenia, Pseudo-nitzshia, Guinardia, Leptocylindrus) et les dinoflagellés (Ceratium, Protoperdinium, Dinophysis, Noctulica, Prorocentrum) constituent 96% de la flore totale. Quarante espèces sélectionnées selon leur fréquence d'apparition et leur abondance ont fait l'objet de traitement ACP. La majorité des diatomées est observée en période hivernale et printanière (1,3 104 Cel/l), 122 espèces réparties en 12 genres ont été inventoriées, la dominance est plus prononcée à Kabila qu'ailleurs. Les dinoflagellés prédominent en période estivale (4000 Cel/l), 189 espèces ont été recensées.

La répartition spatiale de la richesse spécifique totale montre un gradient croissant suivant le trajet fluvial à partir de l'embouchure de l'oued Laou vers le large (43 espèces) et de Martil, Kabila vers M'diq (128 espèces). L'évolution saisonnière de la diversité spécifique a permis de distinguer une période à population plurispécifique (septembre - avril) et une autre ayant une diversité minimale (mai - septembre). H' est inférieur à H'max, ce qui peut se traduire par un déséquilibre des écosystèmes.

Le pourcentage des espèces toxiques reste moins important par rapport à la flore totale (<20%). Cependant, des cas de contamination de type PSP dues à Gymnodinium catenatum ont été observés à plusieurs périodes de l'année (oued Laou - Kaâ Srass). D'autres espèces ont été identifiées : Alexandrium munitum, agent de la PSP détecté au printemps et en été, Dinophysis caudata agent de la DSP développant des blooms printaniers et Pseudo-nitzshia spp ayant une toxicité potentielle par l'ASP est rencontré à des concentrations plus élevées à Martil, M'diq et Kabila.

Des fortes corrélations entre espèces non toxiques et toxiques ont été établies (r>0,7): Lauderia spp et Prorocentrum micans avec Gymnodinium catenatum; Ceratium spp avec Dinophysis spp ; Navicula spp et Ceratium karsteni avec Alexandrium spp; Coscinodiscus spp et Leptocylindrus minimus avec Pseudo-nitzshia spp. La détection des espèces indicatrices permettrait de prédire les blooms à caractère toxique.

Dans toutes les localités, la température suit le même cycle. Des valeurs basses (13-15°C) en hiver coincident avec des densités modérées de diatomées alors que les dinoflagellés sont presque absents. Au printemps, 20°C sont atteints, la densité des diatomées augmente, celle des dinoflagellés évolue modérément. A partir de juin, les diatomées baissent au profit des dinoflagellés. La salinité a montré une stabilité permanente (35-36 psu) à l'exception des zones recevant des eaux fluviales (L3, L6 et Kabila). Les dinoflagellés sont favorisés par les salinités élevées à l'inverse des diatomées.

Ainsi, la richesse spécifique exprime bien les conditions climatiques. Mais l'efflorescence est liée aussi à d'autres paramètres (sels nutritifs, facteurs hydrodynamiques). Le bloom de Gymnodinium catenatum de l'automne pourrait être associé à l'apparition synchrone de cette espèce sur les cotes atlantiques marocaines et celles de la péninsule ibérique. Ainsi, son apparition en Atlantique après relaxation des upwellings en automne permet d'introduire cette espèce dans la région étudiée. Le tourbillon anticyclonique pourrait jouer un role primordial dans son extension en hiver et au printemps [2]. En outre, des foyers de kystes constituant un réservoir permanent pourraient exister : dès que les conditions hydroclimatiques deviennent favorables, il y a déclenchement du bloom. Dinophysis spp se caractérisant par une toxicité faible (200-500 Cel/l) suit une migration dans le sens Est-ouest suivant la dérive des courants de retour d'une partie des eaux atlantiques ayant traversé le détroit de Gibraltar. Alexandrium minutum est retrouvée depuis les cotes égyptiennes [3] et libanaises [4] jusqu'aux cotes marocaines et espagnoles. Des traces de l'acide domoique furent détectées dans Pecten maximus durant le bloom de 1997 à M'diq [5], les seuils de toxicité sont variables selon les espèces et les régions [6].



Fig. 1. Localisation des stations de prélèvements pour la surveillance des efflorescences phytoplanctoniques.

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# A NEW APPROACH TO PLANKTONIC MICROBES: THE MICROBIAL HUB

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## Abstract

When introduced in 1983, the "microbial loop" conceptual model assigned key roles to microbes in the planktonic food web. Here, we introduce the concept of "microbial hub" as an extension of the microbial loop, and develop this concept into an operational model, which provides a new, powerful tool for exploring marine pelagic community metabolism. *Keywords : Bacteria, Food Webs, Organic Matter, Plankton.* 

The conceptual model to which biological oceanographers presently refer when discussing planktonic microbes was proposed in 1983, under the name "microbial loop" [1]. In that model: dissolved organic matter released by autotrophic and heterotrophic plankton is utilised by heterotrophic bacteria; bacteria (both heterotrophic and autotrophic) are ingested primarily by heterotrophic flagellates, and these are in turn ingested by ciliates. In the microbial loop model, bacteria, flagellates and other microzooplankton have key roles, and they coexist or not with the herbivorous food web, where large phytoplankton are grazed by mesozooplankton. There is a fundamental food-web and biogeochemical difference between heterotrophic microbes, which include heterotrophic bacteria, and metazoa: microbes remineralise most of the organic carbon they ingest, whereas metazoa channel a relatively large fraction of the carbon they ingest to long-lived organisms and to sequestration. In the same vein, [2] showed that autotrophic and heterotrophic planktonic microbes, and large zooplankton are the three food-web control nodes of the main organic carbon fluxes in the upper ocean. Here, we implement the fundamental difference between heterotrophic microbes and metazoa in a model where we group all heterotrophic microbes in a "microbial hub". We propose that heterotrophic microbes represent a planktonic food-web microbial hub, into which organic carbon is channelled by various foodweb processes, and from which carbon is redirected towards both carbon dioxide (respiration) and larger heterotrophs.



Fig. 1. (a) Food-web model with 7 compartments, and (b) corresponding microbial-hub model, with 3 compartments. Symbols are defined in the text.

Figure 1 shows two versions of a food-web model, where boxes represent food-web compartments, and arrows are flows of carbon into and out of the compartments. The model in Fig. 1a has 7 compartments, many of which are simplifications of complex in situ processes. In the corresponding 3-compartment microbial-hub model (Fig. 1b), bacteria and microzoo-plankton are combined in the microbial hub, and heterotrophic organisms larger than microbes make up the metazoan compartment. The flows in Fig 1a are of various types, e.g. grazing, egestion, production, excretion, and respiration. Because the only additive property of the ecosystem is respiration (i.e. it sums up to 100% of primary production, without con-

sidering downward export and horizontal advection), the 5 flows in Fig. 1b are respiration. Heterotrophic microbes are central to the cycling of biogenic carbon within planktonic food webs for the following reasons. Bacteria (BACT) and microzooplankton (µZOO) assimilate dissolved primary production (PP) and ingest particulate PP, respectively. In addition, using the model in Fig. 1a, we calculated that the network of linkages channelled up to 35-45% of total PP (i.e., up to 45-55% of particulate PP into the dissolved organic carbon pool, assuming that 20% of total PP is dissolved), and thus towards bacteria. We also calculated that BACT and  $\mu$ ZOO remineralise most of the organic carbon they assimilate, with their combined respiration being at least 70% of total PP; the remainder of the organic carbon is transferred to mesozooplankton (MZOO) and larger animals (LARGE). The intense cycling organic carbon by the microbial hub (HUB) does not mean that MZOO do not have a significant role in carbon dynamics. Indeed, according to the food web under consideration, these organisms can consume directly most of particulate PP. In Fig. 1b, the pelagic food web is restructured around two poles: the HUB, introduced above, and a metazoan compartment (METAZ, comprising all heterotrophs larger than microbes). Structuring the pelagic food web around these two poles is consistent with the fundamental difference between heterotrophic microbes and metazoa. We applied the model in Fig. 1b to five planktonic food webs, from the extreme case where all particulate PP would be grazed directly by  $\mu$ ZOO to the other extreme where all particulate PP would be grazed directly by MZOO. We calculated that the HUB channels directly 20-100% of total PP toward community respiration. Hence, the HUB channels carbon from total PP toward community respiration even when all particulate PP is grazed by herbivores. When also found that temperature influences the partitioning of community metabolism between microbes and metazoa, i.e., as temperature increases, microbes directly respire more carbon and channel less carbon toward metazoan respiration.

Our review introduces and develops the concept of microbial hub as an extension of the microbial loop, and built this new concept into an operational model. We thus consolidated information on the functioning of the microbial heterotrophic components of the pelagic food web that had been published in the last decades. Crucial to our approach is the fundamental difference between heterotrophic microbes and metazoa, i.e., heterotrophic microbes respire a large fraction of the organic carbon they ingest, whereas metazoa move a large fraction of the carbon they ingest to long-lived organisms and to sequestration.

In conclusion, (1) the fundamental difference between heterotrophic microbes and metazoa leads to structuring the pelagic food web around two poles, i.e., the microbial hub, which comprises bacteria and microzooplankton, and metazoa, which consists of the heterotrophic organisms larger than microbes, (2) in the resulting microbial-hub model, a large fraction of the organic carbon originating from PP is channelled toward the microbial hub, from which organic carbon is redirected towards both hub respiration and metazoa, and (3) the microbial-hub model provides a new, powerful tool for exploring marine pelagic community metabolism.

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# PHYTOPLANKTON PHOTOSYNTHETIC RESPONSES IN A HIGHLY DYNAMIC FRONTAL AREA (NORTHERN ADRIATIC SEA)

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## Abstract

Photosynthetic parameters of phytoplankton assemblages in the frontal area off the Po river (Northern Adriatic Sea) were measured in different seasons. Changes in biomass concentrations and a high variability in phytoplankton photosynthetic capacity occurred on small spatial scales and were related to the notable differences in freshwater and nutrient discharge and in the complex circulation patterns of the Northern Adriatic.

Keywords : Adriatic Sea, Phytoplankton, Pigments, Primary Production.

#### Introduction

The northern Adriatic is among the most productive Mediterranean areas; the basin is one of those coastal ecosystems where seasonal and interannual variability of phytoplankton is mainly driven by the freshwater flow of major rivers(s) (e.g. [1], [2]). However, vast areas are essentially oligotrophic; phytoplankton biomass and primary production levels are relatively modest in the northern Adriatic as compared to other coastal embayments and estuaries with similar hydrological characteristics and/or nutrient inputs.

## Material and Methods

From 1996 to 1998 seven oceanographic campaigns were carried out covering all seasons in the area off the Po River delta. Data on phytoplankton physiology is lacking for the Northern Adriatic Sea and the main aim of our study was to measure photosynthetic parameters in highly variable conditions ranging from eutrophic to oligotrophic areas, including a not well-understood frontal zone between them. CTD recordings were performed and size-fractionated chlorophyll a (Chla) concentrations were measured. HPLC analyses were performed for diagnostic pigments and degradation products. PvsE experiments were conducted on samples collected over the study area and at different depths. We discuss photosynthetic parameters taking into account phytoplankton size classes and the capacity of phytoplankton assemblages to respond to physical variations on small spatial scales.

## Results and Discussion

The Po River strongly affects the thermohaline circulation in the area. Two different subsystems can be identified in a restricted area off the Po delta, separated by an ever-changing haline front. Recurrent algal blooms occur in the coastal area that is strongly influenced by the Po River, and low biomass characterizes the area outside the front. The different location of the frontal zone roughly coincided with the separation between diatom-dominated (fucoxanthin) and phytoflagellate-dominated (e.g. 19'-hexanoiloxyfucoxanthin) areas. PvsE experiments showed a clear relationship between the physiological response of phytoplankton populations and the changing hydrographic conditions caused by variations in the Po River flow.

At surface in the coastal area, directly influenced by the river plume, the photosynthetic capacity varied tenfold,  $P^B \max$  up to 20 mgC (mgChla)<sup>-1</sup>h<sup>-1</sup> was recorded, that is among the highest ever reported in marine systems, and comparable to values reported in land-locked ecosystems (e.g.  $P^B \max_{max} = 22$ , [3]). With the exception of such maximum value, the  $P^B \max_{max}$  reported here are similar to those found in temperate coastal waters. At the offshore stations,  $P^B \max_{max}$  between 2 and 9 mgC (mgChla)<sup>-1</sup>h<sup>-1</sup>, indicated that the phytoplankton assemblages of mainly small cells were well adapted to the low nutrient conditions of this area.

The variability in  $P^{B}_{max}$  was much less pronounced in the subsurface layer where environmental conditions were more stable. No correlation was found between salinity and  $P^{B}_{max}$ ; the light history is of major importance for phytoplankton photosynthetic performance.

Variations in PvsE parameters may be associated with differences in the size-structure and taxonomic composition of phytoplankton populations [4]. Our findings suggest some caution, however, as rapidly changing environmental conditions may not allow for the replacement of phytoplankton that are better adapted to the instantaneous conditions. In fact, high biomass and mainly large diatoms were occasionally associated with low photosynthetic performance suggesting accumulation at low hy-

drodynamic conditions. However, the Po delta area is characterized by discontinuous pulses of nutrient-enriched freshwater [5]. Thus any prediction of phytoplankton blooms and production in the Po delta area must be based on a physical model.

The relatively modest phytoplankton biomass reported in the eutrophic northern Adriatic may to some extent be due to the high but extremely unbalanced nutrient load being discharged into the area. Recurrent phytoplankton blooms are observed year-round in the Po river plume and accumulation of very high phytoplankton biomass occur inside the front. The phytoplankton turn-over rate may be very low due to the persistent vertical stratification of the water column and low grazing pressure as shown by the low phaeophorbid concentrations. At low Po River discharge the water circulation slows down in the plume area and nutrient limitation will occur imposing severe limits to the photosynthetic capacity of the phytoplankton.

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# BIODIVERSITY AND FATTY ACID PRODUCTION IN CYANOBACTERIA

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## Abstract

In this investigation we examined the genetic diversity of several filamentous clonal cultures of cyanobacteria, from different regions of the Antarctic (*Nostoc, Leptolyngbya, Plectonema*) and Mediterranean (*Nostoc*). The genetic diversity of different genera obtained by RAPD-PCR technique was correlated to certain physiological features of the cianobacteria such as their fatty acid production. UPGMA analysis revealed two different groups *Oscillatoriales, Plectonema* and *Leptolyngbya*, and *Nostocales*, comprising two Antarctic *Nostoc* strains and one *Nostoc* Mediterranean strain. Such a study, which confirms the endemism of *Nostoc* genus in Antarctic and Mediterranean, shows phylogenetic distribution in relation to geographical position. The physiological features of the strains show a high degree of specificity with regard to their content of fatty acids. Differences were noted in production of the two groups. Such information is relevant to many questions, both basic and applied, in monitoring and assessing environmental quality in relation to the production of bioactive metabolites in response to stress.

Keywords : Cyanobacteria, Biodiversity, Physiology.

In this investigation, we examined filamentous clonal cultures of cyanobacteria, from different locations of the Antarctic and Mediterranean. Cyanobacteria (tab.1) were collected in the Antarctic region during the 2004 summer cruise and subsequently grown in axenic laboratory conditions prior to analysis at optimum laboratory conditions (Light intensity 5  $\mu$ E m<sup>2</sup>s<sup>-1</sup> PAR Photosynthetic Active Radiation; T=20 °C). Morphological and biomass analysis (Tab.1) were checked before genetic studies. DNA extraction was carried out (MagnaRack, Invitrogen SpA, Italy). Biodiversity was detected by PCR. The amplification products were separated by gel electrophoresis (agarose 1.4%) and photographed under U.V. light after ethidium bromide staining. Eight primers were used: BY11 (5'-ATCCACTGCA-3'); BY12 (5'-GGTCGCAGGC-3'); BY15 (5'-CTCACCGTCC-3'); DN4 (5'-GTCGTGCTAT-3'); DN5 (5'-CCGACGGCAA,-3'); DN6 (5'-TGGACCGGTG-3'); UB24 (5'-GGGTGAACCG-3'); UB28 (5'-GCTGGGCCGA-3'). Cluster analysis (UPGMA) of the similarity index was carried out using NT-SYS software. To analyse fatty acid, the samples were methilated. Fatty Acid Methyl Esters (FAME) were detected by gas chromatography using C19:0 as internal standard.

| Strain                           | Sampling site                     | Biomass (cell/mL)<br>7,5 x 10 <sup>5</sup> |  |  |
|----------------------------------|-----------------------------------|--------------------------------------------|--|--|
| Nostoc<br>(KP1a S01)             | Kar Plateau<br>76°54'S 162°32'E   |                                            |  |  |
| Nostoc<br>(EPN 16b S01)          | Edmonson point Nord               | 17,5 x 10 <sup>5</sup>                     |  |  |
| Nostoc<br>(Mediterranean)        | Mediterranean                     | 5 x 10 <sup>6</sup>                        |  |  |
| Leptolyngbya<br>(CK 338b S01)    | Cape King<br>73°53'S 166°40'E     | 360-490 x 10⁵                              |  |  |
| Leptolyngbya<br>(TN 1b S04)      | Teall Nunatak<br>74°50'S 162°34'E | 51-76 x 10⁵                                |  |  |
| <i>Plectonema</i><br>(KP 1a S04) | Kar Plateau<br>76°54'S 162°32'E   | 78-116 x 10 <sup>5</sup>                   |  |  |

Tab. 1. Data on the seven populations of cyanobacteria.

## Discussion of results

UPGMA phenogram (Fig.1) revealed the pattern of genetic distance, showing two different groups comprising the order of Nostocales and Oscillatoriales. This analysis confirms the endemism of Nostoc genus in the Antarctic and Mediterranean regions, revealing its phylogenetic distribution in relation to geographical position. Data relating to the matrix of similarity [1] revealed an average similarity of 15,37 % between the six populations of cyanobacteria analized; the average value of similarity of 27,04 % appears for *Nostoc* Mediterranean and two *Nostoc* Antarctic. Matrix correlation (r) obtained by Mantel test gave a value of 0.95, revealing a good statistical result. Genomic fingerprinting, revealed by PCR technique, gave several molecular fragments of varying sizes, ranging from 0.1 to 8.0 Kb. The distribution of molecular fragments for each

species analysed indicates that the majority of the molecular fragments are in the range of 251-1000 Kb, especially in the Nostoc genus. The genetic variability we encountered was correlated to the fatty acid production of the different strains. The physiological features of the strains showed a high degree of specificity regarding their content of fatty acids. We observed that the largest percentage of fatty acid produced by all the strains was the 16:0 (palmitic) and 18: 2 n6 c (linoleic); whilst the 17:0 ante (IUPAC) was produced in large amounts by the Leptolyngbya instead of Nostoc. The 18:3 n3 (linolenic) showed an opposite trend with the highest percentage of production by Antarctic Nostoc rather than Leptolyngbya genera. Plectonema showed an intermediate concentration in percentage of production regarding this fatty acid. This analysis revealed that the amount of some fatty acids is sometimes correlated to the genus, as seen in linoleic and alpha-linolenic acids that were abundant in Nostoc species [2]. The RAPD-PCR amplification revealed that Nostoc genera produced the greatest number and weight of molecular fragments. Molecular analysis together with morphological and physiological study, is confirmed to be a valid tool in determining a first screening of the different cyanobacteria, evidencing an ample range of molecular weight between 0.1 to 8.0 Kb. These results evidence the high capacity of these organisms to consolidate their key-role. Cyanobacteria adapt physiologically to different environments, producing secondary biologically active molecules which are useful for human health [3].



Fig. 1. UPGMA phenogram constructed from matrix of RAPD-based genetic distances of populations.

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## ON THE APPLICATION OF PHYTOPLANKTON BODY- SIZE STRUCTURE AS ECOLOGICAL QUALITY DESCRIPTOR OF TRANSITIONAL WATERS (VARNA LAGOON-BLACK SEA)

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## Abstract

The present paper is an attempt to test applicability of individual body size biomass distribution spectra of phytoplankton communities as alternative quality descriptor for assessment of Varna lagoon transitional waters ecological status, analyzed against taxon-based phytoplankton quality attributes.

Keywords : Bio-indicators, Eutrophication, Lagoons, Phytoplankton.

While the WFD sets the basics of ecosystem ecological quality assessment and monitoring the identification of consistent ecological quality descriptors and metrics remains still a scientific challenge. Recently the relation among individual, population, community, ecosystem and body size was synthesized in a metabolic theory of ecology [1]. The concept employ body size to explain home range size, nutrient cycling, numerical abundance distribution, biomass production and speciation and, as a community feature, it is expected to vary with disturbance gradients, according to energetic and ecological constraints [2].

The Varna Lake - Varna Bay system is influenced by domestic and chemical industrial waste water emissions and intensive shipping, preconditioning a clearly pronounced nutrient gradient and related impacts on the biota [3].

The analysis was based on data collected during seasonal field surveys (Dec'04, May and Aug'05) at 5 station along the system: Varna bay (VB), Varna Canal (C) and Varna Lake (VL). The taxonomic composition and body size were determined under OLIMPUS-BS41 inverted microscope and a VIASystem at 200x magnification. The construction of Normalized Biomass Size Spectra (NBSS) of phytoplankton counts was according to [4]. Parallel sub-samples of chl. a fractionation ( $0.45\mu m$ ,  $20\mu m$  and  $2\mu m$ ) were measured.

The following phytoplankton attributes have been analyzed: taxonomic composition, abundance, biomass, dominant species, taxon-based indices (species richness, diversity, evenness) and NBSS descriptors - width and slope. In addition to  $T^{\circ}$ , S, O<sub>2</sub>, and nutrient measurements the Throphic State Index (TRIX) was calculated as an integrated measure of euthrophication

A steady gradient of eutrophication along the VL-VB axis persisted during all seasons - TRIX in VB maintained around 5 (moderately euthrophic), in the Canals - between 5 -7 (euthrophic/hyper-etrophic) and in VL above 7 (hyper-euthrophic). Chl. *a* was in average about 5 times higher in VL as compared to VB (25.2 -  $6.56 \mu g/l$  in spring and  $16.23 - 3.38 \mu g/l$  in summer). The nano- size fraction dominated in spring the entire system, while in the summer in the C-VL sites, overriding that in the Bay >20 fold (0.44-11.15 mg/m<sup>3</sup>).

The phytoplankton communities manifested high variability in the taxonomic spread, dominant species, abundance and biomass, species richness and diversity that in general followed the environmental gradient of nutrients. Bacillariophyceae and Dinophyceae were the dominant taxa in the abundance and biomass during winter-spring while in summer Haptophyceae took over in the abundance especially in the Canal (82.77%). Enhanced diatoms proliferation from VB to VL repsented the bulk of the biomass irrespective of the season (in % of the total in winter: 33-98-98%, spring: 33-22-81% and summer 34-69-62%) the total biomass in VL exceeding 3-5 times the biomass measured in the Bay (winter- 352-1002-2141 mg/m<sup>3</sup> and spring -1450-3930- 4068). The heterogeneity was featured also by the dominant species diversity along the gradient - Heterocapsa triquetara in VB and Rhizosolenia fragilissima in VL (winter), Cyclotella caspia (VB), Heterocapsa triquetra (C) in spring and Nitzschia delicatissima (VB), Phaeocystis pouchetii (C) and Gloeocapsa sp. (VL) in summer, related mainly to the seasonal variability of nutrients, their ratios and grazing pressure in the system. The spatial and temporal body size distribution of phytoplankton communities react to the disturbance pressure (nutrient enrichment) in a way consistent to the response of the taxon-based phytoplankton quality elements, the width decreasing along the euthrophication gradient, typical for ecosystems under stress. In contrast to the relatively high seasonal variability of most of the phytoplankton descriptors analyzed in the study, the width manifested a unimodal pattern irrespective of the season - Fig.1.



Fig. 1. Seasonal variability of phytoplankton quality descriptors: A) taxonomic structure by biomass  $[mg/m^3]$ ; B) body-size spectra width and slope.

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# MICROBIOLOGICAL AND CHEMICAL ANALYSIS OF OIL DEGRADATION IN TWO GREEK MARINE ECOSYSTEMS

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## Abstract

The structure of the bacterial community prior and after crude oil contamination in two different marine ecosystems, a chronically exposed to petroleum pollution and a low polluted, was investigated using experimental microcosms. Seawater samples for 16S rRNA gene diversity and chemical analysis were taken at critical time points. More than 30% of the phylotypes retrieved from contaminated microcosms showed highest similarity to members of the Alteromonadaceae family. Chemical analysis revealed that biodegradation of n-alkanes and low MW unsubstituted PAHs was almost complete whereas higher MW- PAH were degraded to a much lower extent. *Keywords : Bacteria, Chemical Analysis, Petroleum*.

## Introduction

Hydrocarbonoclastic bacteria (HCBs) usually exist in very low abundance in marine environments but oil-pollution may stimulate their growth and cause changes in the bacterial community structure of the contaminated area [1]. Prior studies have shown extended oil-pollution in some coastal areas of Attiki (Saronikos Gulf) [2]. The aim of this study was to describe and compare the structure of the bacterial community prior and after oil contamination in two different marine ecosystems: the chronically exposed to petroleum pollution Elefsina Bay (Saronikos Gulf, Greece) and the low polluted Anavyssos Bay (Saronikos Gulf, Greece). Material and MethodsFour 100-1 microcosms were used. One microcosm from each site served as a control (uncontaminated) whereas a second was contaminated with a reference mixture of different crude oil. Seawater samples were taken when bacterial abundance was highest for the determination of the community structure and chemical analysis of the degrading oil. Mixed community DNA was extracted and used as template in PCR amplifications with 16S rRNA specific primers. PCR products were cloned, sequenced and the sequences were used as templates in database (Gen-Bank) searches to identify the closest relatives. Phylogenetic analysis was performed according to standard procedures.

## Results and Discussion

The majority of the sequences retrieved from both contaminated and uncontaminated samples showed a higher homology to members within the phyla of alpha- and gamma- Proteobacteria and Bacteroides/Flavobacteria. Phylotypes exhibiting higher similarity to members of the Rhodobacteraceae family and Flavobacterium genus, both positively associated with hydrocarbon degradation [3], appeared more frequently in samples originating from Elefsina Bay; the latter may reflect its chronic oil polluted state. In contrast, the uncontaminated microcosm of Anavyssos Bay contained the most abundant bacterium on the planet, Pelagibacter ubique. More than 30% of the phylotypes retrieved from contaminated microcosms showed highest similarity to members of the Alteromonadaceae family. Although this group has not been as yet strongly associated with oil degradation, members of it have been reported as "non-professional" HCBs [4]. The most significant biodegradation was observed for n-alkanes (n-C<sub>14</sub>-n-C<sub>35</sub>) and low MW unsubstituted PAHs, as these compounds were almost completely removed in both microcosms. Higher MW- PAH were degraded to a much lower extent and only in Elefsina microcosm, while in all cases significantly lower biodegradation of substituted compounds was obtained in comparison with the parent ones. This is an expected event since the substitutes obstruct bacterial attack. The rate of oil degradation in the contaminated Elefsina microcosm appeared to be greater than that of Anavyssos Bay.

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# MONTHLY AND REGIONAL VARIABILITY OF THE PHYTOPLANKTON ABSORPTION IN THE CILICIAN BASIN

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## Abstract

Cilician Basin is located at the North Eastern end of the Mediterranean Sea. Basin is known as oligotrophic area, however some part of the area is getting large amount of river input and relatively long shelf areas. The particle absorption measurements have done both on river plumes and offshore areas in different seasons in year 2005. Besides, monthly samples have collected from the METU-IMS time series station (36:26.463N 34:21.606E). The monthly variability and the regional variability of the phytoplankton absorption curves have extracted from the total absorption measurements (1,2,3). Results shown, that the shape of the curves and magnitude of the peaks are changing spatially and seasonally.

Keywords : Phytoplankton, Eastern Mediterranean, Pigments.

## Methodology

Particle samples have collected by filtering sea water over GF/F filters getting with 5 lt Niskin bottles. Separation of the pigmented and nonpigmented (detritus) fraction of the total particulate matter done by extracting the filters with methanol (HPLC grade). Measurements have done, Helios Single beam 2 nm resolution spectrophotometer (1,2,3).

Regional Differentiations (Offshore Mediterranean and Coastal Mediterranean

Mediterranean offshore waters and Mediterranean costal (Usually estuarine region) water samples have compared. Most of the measured phytoplankton absorption measurements are utilized among 78 samples. As a result 61 samples for offshore, and 17 samples for coastal are used. Comparison of these regions has done by averaging the all data collected from the concerned basin and normalized the averaged values to the highest absorption (at 440 nm). The comparison of these curves is showing that the chl a concentration is higher in the coastal then the offshore waters. Signature of the chl a is the absorption peak at the 675 nm (1). However, beside this well known feature, the shape of the curves are much more important. Actually both curves are similar to each other, whereas small variations are indicating the differences between the regions. Phytoplankton groups are the reason of these variations. Offshore waters of the Mediterranean are different from the coastal region by the first peak around 415 nm and nearly straight line between 550-650 nm, and a small shoulder around 490 nm. Coastal Mediterranean has clear peak at 440 nm and a shoulder occurring between 600 and 650 nm (Figure 1).



Fig. 1. Comparison of the mean normalized absorption coefficients of the regions.

## Seasonal Variability of the Phytoplankton Absorption.

The seasonal variability is not really observed. However, there are similarities within the six months periods. Between April and September, and between October to March, the absorption curves have shown similar shapes. According to these results, instead of a seasonal variability, like classical autumn, winter, spring or summer blooms, only one period should be observed. These results are also in good agreement with the HPLC chlorophyll a measurements done at the same station parallel to the particle absorption measurements (Figure 2).



Fig. 2. Monthly normalized phytoplankton absorption curves.

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# BACTERIAL PRODUCTION AND RESPIRATION IN THE SEA-SURFACE MICROLAYER OF THE WESTERN MEDITERRANEAN SEA AND THE SUBTROPICAL ATLANTIC OCEAN

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## Abstract

We measured bacterial production and respiration along with physico-chemical parameters in the sea-surface microlayer (SML) and the underlying water (ULW) of the western Mediterranean Sea and the subtropical Atlantic gyre. Dissolved organic nitrogen and amino acids were significantly enriched in the SML as compared to the ULW, however, bacterial production was consistently low. The low bacterial production and the low bacterial growth efficiency in the SML coincided with high contributions of dissolved free amino acids to the total dissolved amino acid pool in the SML. This indicates that nitrogen rich dissolved organic matter is accumulating in the SML due to retarded DFAA availability or bacterial uptake.

Keywords : Western Mediterranean, Secondary Production.

The sea-surface microlayer is the boundary layer between the atmosphere and the oceans covering 70% of the earth's surface. Despite the longlasting interest in the physico-chemical properties of the SML, studies on microbial metabolism in the SML are scarce, particularly for open oceans. To gain more knowledge on the biological dynamics of the open ocean SML we studied a stable anti-cyclonic eddy system in the western Mediterranean Sea (WMED), and a transect from the Mauritanian upwelling into the subtropical North Atlantic gyre (SATL).

In the WMED and the SATL, the SML was significantly enriched in dissolved organic carbon (DOC), dissolved organic nitrogen (DON) and inorganic nutrients with enrichment factors (EF = SML/ULW) ranging from 1.2 up to 12. In the SML at both study sites the contribution of dissolved free amino acids (DFAA) to the total hydrolyzable amino acid pool (THAA) was remarkably high, averaging  $61 \pm 14\%$  and  $47 \pm 10\%$  in the WMED and the SATL, respectively. In contrast, the contribution of DFAA to the THAA pool was significantly lower in the ULW and 12-37%.

Bacterial production in the SML of the WMED was not significantly different from that in the ULW (Fig. 1a). Enrichment factors for bacterial production in the SML of the WMED ranged from 0.1-3 and were therefore highly variable. In the SATL, bacterial production in the SML was generally low (Fig. 1b) with enrichment factors 0.13. In the WMED, bacterial respiration was highly variable between the different stations (Fig.1c). On average, bacterial respiration in the SML and ULW was similar although considerable differences in the respiration rates between SML and ULW were detected at individual stations. Comparing average bacterial respiration rates between the two study sites for the SML and ULW separately, no significant difference was found. In the SML of the SATL, bacterial respiration was high in the upwelling region (9.5  $\pm$  0.9  $\mu$ mol O<sub>2</sub> L<sup>-1</sup> d<sup>-1</sup>) and decreasing towards the oligotrophic gyre ( 3.6  $\pm$ 2.0  $\mu$ mol O<sub>2</sub> L<sup>-1</sup> d<sup>-1</sup>; Fig. 1d). In contrast, bacterial respiration in the ULW was consistently low along the transect (0.8  $\pm$  0.8  $\mu$ mol O<sub>2</sub> L<sup>-1</sup>  $d^{-1}$ ). Thus, contrary to bacterial production, bacterial respiration was significantly higher in the SML than in the ULW over the entire transect with enrichment factors ranging from 1.6-66.



Fig. 1. Bacterial production and respiration measured in the surface microlayer (SML) and the underlying water (ULW) at the different stations in the western Mediterranean eddy (a, c) and the subtropical Atlantic (b, d).

Generally, labile DOM accumulates if the production of this DOM pool is higher than its consumption. DFAA usually cover a considerable fraction of the bacterial nitrogen demand [2]. The enrichment of DFAA in the SML suggests that bacteria in the SML are apparently inhibited in their uptake of DFAA which might also explain the low bacterial growth efficiency (BGE=BP/BR+BP) ranging from 0.2-2%. Our data on the unusually high contribution of DFAA to the THAA pool indicate a decoupling of DFAA release and uptake. Inorganic nitrogen, DON and amino acids were highly enriched in the SML and the variability of nitrogen in the SML is independent of that in the ULW, suggesting either production of DON in the SML independent from those in the ULW [3] or selective scavenging of N-rich DOM on, e.g., rising air bubbles [1].

We found that the SML in the open ocean is a highly variable environment with generally low bacterial biomass production and high respiration. Bacterial production was not related to bacterial respiration and bacterial growth efficiency was mainly determined by respiration. Despite the significant enrichments in dissolved nitrogen in the SML, with concentrations generally higher than commonly reported for oligotrophic systems, the low bacterial production in combination with high bacterial respiration suggests that the DOM pool of the SML, and particularly the amino acid pool is not readily available for bacteria inhabiting this ocean atmosphere interface.

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# THE DINOFLAGELLATE-DIATOM RATIO IN THE SOUTHERN BLACK SEA OFF SINOP IN THE YEARS 1999-2000

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## Abstract

In the present study, the seasonal composition and the qualitative and quantitative distributions of phytoplankton have been studied at two stations in the southern Black Sea during January-May 1999 and March 2000-October 2000. A total of 76 genera including 149 species and varieties were identified of which 46% were dinoflagellates and 34% were diatoms. The abundances of the genera *Emiliana* (in January-May 1999), *Pseudosolenia* and *Ceratium* (in March-October 2000) were higher than that of the other genera in almost every sampling period. Increased dinoflagellate to diatom ratio reflects more fertile conditions in the southern Black Sea. *Keywords : Dinoflagellates, Diatoms, Phytoplankton, Black Sea*.

#### Introduction

Phytoplankton abundance and biomass has increased in relation to a net increase in nutrient concentrations. The species composition has changed with a relative increase in species number, abundance and biomass of dinoflagellates compared to the diatoms and there has been a trend towards small-sized phytoplankton groups in the western Black Sea [1]. When the taxonomic structure (by biomass) of phytoplankton communities were compared for the years 1980's and 1990's, a decrease in the dominance of diatom species were observed [2]. However, the share of diatoms increased in winter and autumn. The taxonomic diversity was high in summer and autumn. The seasonal and the long term changes in phytoplankton community structure could be attributed to the shift of the nutrient ratios (N:P, Si:N and Si:P) [2]. Unfortunately, there is no data to compare our dinoflagelate to diatom ratios in the southern Black Sea.

## Material and Methods

The monthly samples were collected from the two stations (Fig.1) near the Sinop Peninsula in the Black Sea by the R.V. "Arastirma I" within the framework of TUBITAK (The Scientific and Technical Research Council of Turkey) project during January-May 1999 and March-October 2000. A total of 123 samples were collected in two stations from different layers of the water column (0, 10, 20, 30, 40, 50 and 75 m). A hand bucket and a Niskin Bottle were used for the sampling of surface and lower depths, respectively. Sedimentation method was used for counting and identification of the species. Samples were fixed with buffered formaldehyde to reach a final concentration of 2.5% and stored in 1 l of dark bottles for 2 or 3 weeks. Thin hoses were plunged into the bottles and the supernatant was evacuated down to a volume of 100 ml.



Fig. 1. Sampling stations.

## Results and Discussion

In January-May 1999 and March-October 2000, a total of 149 species were identified from both stations. Representatives of all phytoplankton groups were obtained during the whole study period (Tab. 1). In terms of

the species composition, dinoflagellates were the dominant group with a proportion of 50%, diatoms ranked second while silicoflagellates were the third group. In terms of the species number, diatoms were more abundant in spring (March, April) than the other periods. However, dinoflagellates were more abundant in summer (May and June) and autumn.

Tab. 1. Species composition of the total phytoplankton groups during January-May 1999 and March-October 2000.

|                   | Station A |      | Station B |      | TOTAL |      | %    |      |
|-------------------|-----------|------|-----------|------|-------|------|------|------|
| Species           | 1999      | 2000 | 1999      | 2000 | 1999  | 2000 | 1999 | 2000 |
| Dinoflagellates   | 58        | 32   | 46        | 22   | 64    | 35   | 50   | 50   |
| Diatoms           | 37        | 24   | 28        | 19   | 45    | 27   | 35   | 39   |
| Silicoflagellates | 3         | 3    | 5         | 2    | 5     | 3    | 4    | 5    |
| Euglenoids        | 1         | 2    | 1         | 2    | 1     | 2    | 1    | 3    |
| Cyanophytes       | 1         | 1    | 1         | 1    | 2     | 1    | 2    | 1    |
| Coccolithophores  | 5 7       | 1    | 5         | 1    | 6     | 1    | 5    | 1    |
| Chlorophytes      | 1         | 1    | 1         | 1    | 1     | 1    | 1    | 1    |
| Criptomonads      | 5         | ÷.   | 1         | 2    | 5     | -    | 4    |      |
| Total             |           |      |           |      | 129   | 70   | 100  | 100  |

Maximum and minimum species numbers were recorded in January 1999 (74 taxon) and October 2000 (29 taxon), respectively. The decline in diatoms was followed by an increase in dinoflagellates which began in late spring (May), reached a maximum in June and gradually decreased towards October. Dinoflagellate blooms were observed in summer. Diatoms were dominant in spring with a bloom in mid spring. The dinoflagellate to diatom ratio in terms of species number differs with season and region. In the summer and in the eutrophic regions, species number of dinoflagellates was relatively higher than in other seasons and regions. For example, while the percentage of dinoflagellates to the total species number was as low as 21 % in April 1989 [3] it increased to 51% in April 1999. Even respective ratios from summer also appeared to increase to 50 % in the year 2000, from 46 % in August 1995- July 1996 [4]. These findings indicate more fertile conditions in the Black Sea and is in accordance with the rise in fish landings.

## Acknowledgments

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# OCCURRENCE OF THE POTENTIALLY TOXIC DIATOM *PSEUDO-NITZSCHIA* IN BIZERTE LAGOON (WESTERN MEDITERRANEAN)

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## Abstract

Abundance of the potentially toxic diatoms *Pseudo-nitzschia*, temperature, salinity and dissolved nutrients were reported for the Bizerte Lagoon (Northern Tunisian coast, Western Mediterranean) from March 2004 to March 2005. Distribution of *Pseudo-nitzschia delicatissima* complex species showed a stronger seasonality and was more correlated with summer conditions than *Pseudo-nitzschia seriata* complex species, which in turn exhibited a narrow spatio-temporal distribution and appeared independent from major environmental constraints. *Keywords : Diatoms, Lagoons, Western Mediterranean*.

## Introduction

The first renewed ASP (Amnesic Shellfish Poisonning) event occurred in November 1987 in Canada. This deadly event led to the identification of the neurotoxin DA (domoic acid) as a harmful algal toxin. The causative species is a pennate diatom belonging to the genus *Pseudo-nitzschia* Peragallo [1]. This diatom is widely distributed and occurs well throughout the Mediterranean regions [2]. There are few data about their biology and ecology in the Tunisian coastal waters despite that occurrence of *Pseudo-nitzschia* spp. was well noted in several lagoons [3]. The aim of this study is to give information about incidence of *Pseudo-nitzschia* spp. in the Bizerte Lagoon, an important area of mussel production.

### Material and methods

Sampling was carried out monthly from March 2004 to March 2005 at four stations in the Bizerte Lagoon. Water temperature and salinity were recorded *in situ* using a microprocessor conductivity meter (LF 196). Water samples were collected at 2m depth. Subsamples were taken for nitrate, nitrite, phosphate and silicate analyses [4]. Sub-samples for identification and enumeration of phytoplankton were analysed following the Utermöhl method [5]. and *Pseudo-nitzschia* species were separated into *Pseudo-nitzschia* delicatissima or *P. seriata* groups depending on their valve width [6]. The distribution patterns of these potentially toxic species were statistically analyzed by Spearman's correlations in order to address relationships between their dynamics and the environmental variables.



Fig. 1. Annual trends of *Pseudo-nitzschia delicatissima* and *Pseudo-nitzschia seriata* groups in the four sampling stations.

## Results and discussion

Temporal distributions showed that *P. delicatissima* complex species were present during all the sampling period. Cell densities ranged between 0.034 and 3 x  $10^5$  cells  $1^{-1}$ , with the highest values in July at all the prospected stations (Fig. 1). *P. seriata* group had a narrower spatiotemporal distribution than *P. delicatissima* group. Cell densities of *P. seriata* ranged between 0.03 and 0.44 x  $10^5$  cells  $1^{-1}$ . The *P. delicatissima* group species are therefore the most frequent and abundant particularly interesting in term of their periodicity and intensity. Our results parallels those found in the Mediterranean basin, indeed the *P. delicatissima* 

group species represented a potential component of the Italian and French coasts waters [7]. Abundances of *P. delicatissima* group were positively correlated with temperature and salinity (Table 1). They were so more associated with summer water conditions. Conversely, blooms of *P. calliantha*, frequent component of the *P. delicatissima* group in the Italian coast waters, were rather associated to winter water environment [2]. A Significant positive correlation was also found between *P. delicatissima* group species number and silicate concentrations. These species tends so to be dominant in waters of non limiting concentrations of silicate. In contrast, no significant relationship was found between abundances of the *P. seriata* group and any of the environmental factors. This group appears therefore independent from major environmental constraints.

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# STUDY OF THE NITRATE REDUCTASE ACTIVITY IN THE ELEFSIS GULF

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## Abstract

Nitrate reductase activity was measured along the water column during summer and fall by determination of nitrite produced in nitrate rich denitrifying bacteria extracts. It was found that below the thermocline, there was an oxygen depletion, and a second nitrite maximum associated with the activity of the enzyme respiratory or "anaerobic" nitrate reductase (NR). In the upper part of the water column, nitrate reductase activity was absent. The destruction of the seasonal thermocline, was followed by termination of the nitrate reductase activity. *Keywords : Anoxia, Phytoplankton, Enzymes, Models, Oxygen.* 

In marine systems, the N-cycle plays a significant role controlling the biological productivity [1]. Many microorganisms are able, via membrane transporters, to take up and assimilate dissolved inorganic nitrogen. Nitrate assimilation refers to biological conversion of nitrate to ammonium, a two step eight-electron reduction process using two enzymes. Under oxygen limiting conditions, denitrifying bacteria reduce nitrate to nitrite by assimilatory nitrate reductase and then to ammonium by assimilatory nitrite reductase [2]. Respiratory or "anaerobic" nitrate reductase (NR) is an enzyme present in various marine phytoplanktonic species that grow in nitrate rich environments while when there is either ammonium enrichment or grow on nitrite, urea or amino acid, low enzyme levels are found [3].

The measurement of nitrate reductase activity is an indicator of plankton metabolism. In the present study, nitrate reductase activity was measured during summer and autumn, at various depths along the water column of the deepest area of Elefsis gulf, a rather closed gulf in Saronicos, receiving various anthropogenic pollutants. The sampling site was selected as anoxic conditions occur seasonally near the sea-floor due to stratification. For this purpose, nitrite content, produced by nitrate rich denitrifying bacteria extracts, was determined [3-6].

It was found that during the summer, when the seasonal thermocline was well established and the water column stratified, the deeper water column was depleted in oxygen and hydrogen sulphide was present. At the same time, a secondary nitrite maximum was found, associated with nitrate depletion, showing a close relation between nitrogen species distribution and denitrification procedure. Also, nitrate reductase activity corresponded to higher values as nitrate respiration, via the enzyme NR, which is the first step of denitrification mechanism.

Nitrate reductase activity was increased in nitrate enrichment while decreased in ammonium enrichment. in the upper seawater layer, where high dissolved oxygen content was measured, nitrate reductase activity approached zero values.

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# FATE OF PHYTOPLANKTON PRODUCTION IN A RESTRICTED MEDITERRANEAN LAGOON

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## Abstract

The fate of phytoplankton production was assessed in summer 2005 in the Bizerte Lagoon. Four stations were sampled for particulate organic carbon (POC), biomass, composition, growth rate and production of phytoplankton, microzooplankton grazing and vertical sinking of organic carbon. POC concentrations and algal biomasses exhibited significant spatial and vertical heterogeneity. The phytoplankton production (511- 851 mg C m<sup>-2</sup> d<sup>-1</sup>) was mainly grazed by microzooplankton (63 - 83%) and then channelled to the higher consumers, while sinking flow corresponded to 31- 36% of the carbon produced which was exported to the benthic food web. *Keywords : Lagoons, Phytoplankton, Carbon.* 

## Introduction

Bizerte Lagoon, which supports intensive fishery activities and several aquaculture farms, is experiencing increasing anthropogenic of pollutants loading from expanding urban, agricultural and industrial development along its shores. This affected the productivity which in turn may lead to the dystrophy of planktonic and/or benthic communities. Hence, in order to assess the actual trophic status of the lagoon, it is urgent to understand and determine the carbon cycle within the lagoon. The focus of this study was to investigate the phytoplankton production and its export to the higher planktonic levels, *via* microzooplankton grazing, and to the benthic food web, through sedimentation.

## Material and Methods

The sampling was carried out in summer 2005 at four stations (MA, MB, MJ and R), which are impacted by different human activities. Each station was sampled at three depths (2, 4/5 and 7.5/8.5 m) for particulate organic carbon (POC), abundance, composition, growth rate and production of phytoplankton (<2 µm, 2-10 µm, >10 µm) and microzooplankton grazing. In the four stations, the sedimentation of organic carbon was assessed using particular interceptor traps, which were installed at 9 m depth. POC was analysed on pre-combusted GF/F (21 mm) filters with a Perkin-Elmer 2400 CHN elemental analyzer. Picophytoplankton (<2  $\mu$ m) was counted using epifluorescence microscope (x100 Fluotar objective). Identification and enumeration of 2-10  $\mu$ m and >10  $\mu$ m algae were determined under the inverted microscope (100 x objective) on 50-100 ml settled volumes. Phytoplankton abundances were converted to carbon biomass by measuring the biovolumes of species and converting them to cell carbon using conversion factors from literature. Phytoplankton production rate was estimated by the <sup>14</sup>C method. Rates of algal growth and microzooplankton grazing were determined using the dilution protocol [2]. A two-ways ANOVA analysis was performed to test spatial and vertical heterogeneity on different estimated variables.

## Results and discussion

Particular organic carbon (POC) exhibited no significant difference among stations (P>0.05) but showed vertical heterogeneity (218-400 mg C m<sup>-</sup> P<0.05). At station MA, POC concentrations increased with depth, while they decreased in the other stations. The carbon biomasses for different size fractions of phytoplankton exhibited significant spatial variations (P<0.001). The >10  $\mu$ m phytoplankton had higher biomass at station MA, with value increased from 2 m (225.6 mg C m  $^{-3})$  to 7.5 m (308 mg C m<sup>-3</sup>). In contrast, in the other stations, >10  $\mu$ m algal biomass (111.5-231 mg Cm<sup>-3</sup>) decreased with depth. The >10  $\mu$ m, which constituted the main fraction of total phytoplankton carbon, were mainly represented by diatoms. These algae were dominated by several species of Cerataulina, Chaetoceros, Navicula, Rhizosolenia and Nitzschia. The biomasses of picophytoplankton (4.5-18.9 mg C m  $^{-3})$  and 2-10  $\mu m$  phytoplankton (3.7-10.5 mg C m<sup>-3</sup>) showed vertical heterogeneity in all stations, higher concentrations being in stations MJ and MB, respectively. In most stations, total phytoplankton carbon contributed 49-80% of POC. This indicates that autotrophs were the main components of the planktonic system, since heterotrophs and detritus represent 20-50% of the POC. In stations MJ and R the production rate was maximal at 2 m and decreased with depth. Obviously, the vertical distribution of algal production is related to the vertical profile of light in the water column [3]. Algal biomasses in both stations were almost similar, but production rate was higher at station R (36-84 mg C m<sup>-3</sup> d<sup>-1</sup>) than that measured at station MJ (48-132 mg C m<sup>-3</sup> d<sup>-1</sup>). This may be due to the higher growth rate estimated at station R (0.42 d<sup>-1</sup>) than that at station MJ (0.26 d<sup>-1</sup>). The picophytoplankton contributed the main fraction (75-82%) of the production. The 2-10  $\mu$ m and >10  $\mu$ m phytoplankton represented 11-20 and 6% of produced carbon, respectively. The areal production rates, calculated by vertically integrating the values from the three sampling depths, were 511 and 851 mg C m<sup>-2</sup> d<sup>-1</sup> at stations MJ and R respectively. These rates were higher than those found in Open Ocean but similar to those measured in nearshore environments [4, 5].

Rates of microzooplankton gazing varied significantly (P<0.01) among stations, the higher rate (0.27 d<sup>-1</sup>) was at station MB and the lower (0.15 d<sup>-1</sup>) at station MJ. Grazing coefficients corresponded to consumption rates of 42-102.5 mg C m<sup>-3</sup> d<sup>-1</sup>. In station MJ and R, the levels of grazing were equivalent to daily losses of 63-83% of the phytoplankton production. The vertical flow of organic carbon exhibited spatial heterogeneity (P<0.01), higher and lower values was observed at station MA (561 mg C m<sup>-2</sup> d<sup>-1</sup>) and MJ (187 mg C m<sup>-2</sup> d<sup>-1</sup>), respectively. In station MJ and R, the sinking rates corresponded to 31-36% of the carbon produced which was exported to the benthic food wed. This stresses that the main flow of organic carbon was through microzooplankton grazing that play a key role in the carbon transfer to the higher pelagic consumers.

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## SEASONAL DYNAMICS OF FRACTIONATED PHYTOPLANKTON PIGMENTS IN A COASTAL ENVIRONMENT (TYRRHENIAN SEA)

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## Abstract

The temporal variations in pigment spectra of two phytoplankton size classes ( $<5\mu$ m and  $>5\mu$ m) were investigated at a coastal site in the Tyrrhenian Sea over an annual cycle. The  $<5\mu$ m fraction accounted on average for 50% of the total phytoplankton biomass and small eukaryotes were the dominant component.

Keywords : Phytoplankton, Pigments, Coastal Waters, Tyrrhenian Sea.

#### Introduction

The cell size influences the role of phytoplankton in biogeochemical cycles and the characteristics of community structure via size-dependent interactions [1]. Signature pigments are very useful in outlining the main algal groups including the small and fragile forms, generally underestimated with classical approaches [2]. This study is focused on the seasonal dynamics of ultraphytoplankton ( $<5\mu$ m) both in terms of abundance and composition, in coastal environments. The results are discussed in relation to abiotic (e.g. nutrients) factors.

## Material and methods

The sampling site is located at 40°48.5'N and 14°15'E, in proximity of the 80m isobath. Sampling was carried out weekly between July 2004 and July 2005. CTD profiles (S, T, oxygen, fluorescence) were performed utilizing a SBE 911plus. Samples for nutrients determinations were collected along the water column. For the determination of pigment spectra (HPLC-[3]) water samples were collected at four depths (0, -10, -20 and -40m) and filtered sequentially on polycarbonate membrane (porosity of 5 $\mu$ m) and on glass-fibre filters (GF/F) for the fraction >5 and <5 $\mu$ m respectively.

## Results

Total phytoplankton biomass (average TChl  $a = 0.83 \pm 1.15 \text{ mg m}^{-3}$ ) indicated the generally mesotrophic conditions of the area, while the negative correlation between biomass and salinity highlighted the importance of land run-off for the phytoplankton blooms. TChl a peaks were mainly due to an increase in the >5 $\mu$ m fraction (slope =0.80; r = 0.98, P<0.01, n=200), while the percentage contribution of  $<5\mu$ m decreased. As to the vertical distribution, the contribution of ultraphytoplankton was higher in the 20-40m layer. The eukaryotes accounted, on average, for  $84.1 \pm 11.0\%$ of the ultraphytoplankton biomass and their contribution increased at higher nitrate concentrations. The ultraphytoplankton fraction showed a higher diversity than the  $>5\mu$ m fraction in terms of the pigment composition. Fucoxanthin and 19'hexanoiloxifucoxantin values indicated that small diatoms and prymnesiophytes were the most important groups in the  $<5\mu$ m fraction, especially during the blooms. However, the occurrence of alloxanthin highlighted the contribution of small cryptophytes during the autumnal peak (40% of the ultraphytoplankton biomass at surface). Prasinoxanthin concentrations indicated that Prasinophyceae accounted for 25% of the ultraphytoplankton TChl a during the early spring bloom (March). The prokaryotes, cyanobacteria (zeaxanthin $_{syn}$ ) and prochlorophytes (divinyl-chlorophyll a) presented an opposite distribution along the water column in summer: the prochlorophytes were almost completely absent in the surface layer, while cyanobacteria accounted for  $22.2\pm10.3\%$ of ultraphytoplankton biomass (Fig.1). In addition, prochlorophytes were never recorded at high TChl *a* concentrations (>1 mg m<sup>-3</sup>).

## Conclusions

Despite the conspicuous blooms of larger cells, the ultraphytoplankton (above all the small eukaryotes) plays a pivotal role in the phytoplankton community of coastal areas. We may hypothesize that these small eukaryotes are more competitive in exploiting the episodic arrivals of new nutrients as compared to prokaryotes. Further, the higher pigment diversity of the ultraphytoplankton may be related to a complex and stable community within the microbial loop.



Fig. 1. Contribution of the main algal groups to the ultraphytoplankton TChl a at surface (a) and at - 40m (b), during the sampling period.

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# CHARACTERIZATION OF HETEROTROPHIC BACTERIA ISOLATED

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## Abstract

Research were carried out to evaluate the viable microbial communities structure in a two restricted areas of the Mediterranean Sea (Southern Tyrrhenian Sea and the northern side of Sicily Channel) in July 2005. Bacterial plate counts in Marine Agar medium were carried out in 202 water samples from 14 Stations of these poorly studied areas of the Mediterranean Sea and 61 bacterial strains were investigated. Isolates were tested by API 20NE system, BIOLOG GP microplates and by classical identification pathways and classified by molecular approach also.

Keywords : Bacteria, Tyrrhenian Sea, Sicilian Channel, Biodiversity.

In the framework of a multi-year investigation on distribution of the microbial communities in Mediterranean surface, intermediate and deep sea waters to compare bacteriological parameters with different water bodies [1-2] we had the opportunity to carry out researches on bacteria strains isolates from water samples taken during CIESM-SUB1 cruise (Fig. 1).



Fig. 1. Sampling area.

This multi-disciplinary oceanographic campaign, started on July 21th 2005 on board the R/V Universitatis, explored the deep waters of littleknown areas in the southern Tyrrhenian Sea and the northern Sicily Channel to analyze physical and biological changes induced by the inflow of warmer, saltier waters from the eastern sub-basin.

At each station (St. 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 13, 15, 20 and 21) were collected sea water samples from surface down to 3596 m, according to the physical and chemical survey, by means of Niskin bottles fitted on CTD-Rosette sampling system.

Water samples were immediately sewed, by spread-plate technique, on Marine Agar plates and incubated at 20°C during 8 days; heterotrophic bacteria pure cultures on Marine Agar plates were obtained from colonies random selected, that were characterised in lab using morpho-physiological and taxonomic approaches.

The isolates were characterized using the following tests: gram staining, cell morphology, oxidase, catalase, motility, lipolytic activity on Tween 80, susceptibility to the vibriostatic O/129 ( $150\mu$ g), growth on TCBS medium via the classic methods. The biochemical characterization was carried out using API 20 NE for Gram negative bacterial strains and BI-OLOG GP microplates.

Viable colonies on Marine Agar showed highest values  $(4.9 \times 10^3 \text{ CFU/ml})$  at 800-1200m layers. From 200 isolated strains, 61 grown on replicates were analysed. From obtained results 87,3% of isolates were gramnegative, 58,1% were rod-shaped, 95,8% were oxidase positive, 63,2% were catalase positive and 64,6% motile.

For molecular analysis [3], bacterial DNA was extracted and 16S rDNA amplified for sequencing to achieve phylogenetic affiliations. Taxonomic results showed presence of 68,9% of gamma- *Proteobacteria* (42,9% *Alteromonas*, 26,2% *Halomonas*, 9,5% *Pseudoalteromonas*, 9% *sea wa*-

ter bacterium), 16,4 % of alfa-Proteobacteria (70% Erythrobacter,10% Methylarcula, 20% others), 8,2% of Firmicutes (60% Bacillus, 20% Oceanobacillus, 20% others), 4,9% of Actinobacteria (66,7% Micrococcus, 33,3% Cellulosimicrobium) and 1,6% of Bacteroidetes (100% Salegentibacter) (Fig. 2).



Fig. 2. Phylogenetic tree of isolates.

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## THE EFFECT OF TWO DIFFERENT CULTURE MEDIA AND FIVE DIFFERENT SALINITIES ON GROWTH OF TETRASELMIS SUECICA

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## Abstract

*Tetraselmis suecica* was cultured at five different salinities, 15 psu, 20 psu, 25 psu, 30 psu and 35 psu and two culture media during one week. The highest growth (648 x  $10^4$  cell.ml<sup>-1</sup>) was determined at 25 psu and Walne medium in 6<sup>th</sup> day. However in Super medium cell density was reached 310 x  $10^4$  cell.ml<sup>-1</sup> in 20 psu in 6<sup>th</sup> day. At the end of the experiments final cell densities were significantly different between experimental groups (p<0.05).

Keywords : Phytoplankton, Growth, Aquaculture.

## Introduction

Microalgae are required for larvae nutrition during a brief period, either for direct consumption, in the case of molluscs and penaeid shrimp, or indirectly, as feed for the live prey fed to small larvae fish [1]. Microalgae types vary, but the most common are single-celled algae such as Tetraselmis, Chlorella, and Isochrysis. Tetraselmis is a marine green flagellate widely used in aquaculture facilities as feed for bivalve molluscs, penaeid shrimp larvae and rotifers [2]. *Tetraselmis suecica* has good nutritional properties [3-4]. The aim of this study was to determine optimal salinity and most suitable culture medium for successful *T. suecica* culture.

## Material and methods

*T. suecica* was obtained from algal culture collection of Fisheries Faculty, Ege University. Each experiment (1 1 flask) was designed in five different salinities (15 psu, 20 psu, 25 psu, 30 psu and 35 psu) and two culture mediums Walne [5] and Super Medium (ammonium sulphate, Super Phosphate, EDTA, Ure). Sea water was filtered and sterilized by autoclave. Initial cell densities in each flask were approximately  $30.6 \pm 1.27 \times 10^4$  cell ml<sup>-1</sup>. The cultures were kept under constant illumination and aeration at  $20\pm 2^{\circ}$ C during one week. Two replicates were set for each culture condition. Cell density was counted daily, using a Neubauer in an optic microscope. Differences between salinities and culture mediums were compared with One way ANOVA by using SPSS 11.0.

#### Result and Discussion

Figure 1 shows that the growth of *T. suecica* in Walne medium. The highest cell density was determined  $648 \times 10^4$  cell ml<sup>-1</sup> at 25 psu salinity in  $6^{th}$  day. However in Super medium maximum cell was obtained 310 x  $10^4$  cell ml<sup>-1</sup> at 20 psu salinity (Fig. 2).



Fig. 1. The growth of T. suecica in Walne culture medium.



Fig. 2. The growth of T.s uecica in Super medium.

Growth showed a decline after 6 days in two culture media and all salinities except 35 psu. Statistical analyses showed no significant differences between experimental groups at daily growth (p>0.05). But final cell densities between two culture mediums showed significantly differences (p<0.05). Similarly it has been reported that good *T. suecica* growth occurred between 25-35 psu [6]. As a result of this study, we can suggest that 25psu salinity and Walne medium is better for obtaining high cell density of *T. suecica*.

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# DIEL CYCLES IN SINGLE CELL ACTIVITY OF PROKARYOTES IN THE WESTERN MEDITERRANEAN

## SEA

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## Abstract

The abundance and activity parameters of prokaryotic communities were studied over four diel cycles in an anticyclonic eddy in the Western Mediterranean Sea. The prokaryotes from the different depths expressed diel variability in all the studied parameters. The prokaryotic community from the deep chlorophyll maximum (DCM) fluctuated in cell size, with larger cells appearing from the morning until noon, followed by the increase in the relative contribution and single-cell-activity of small cells. The percentage of prokaryotic cells taking up leucine showed no significant trend during the day and the single-cell uptake was higher in the early morning and around noon, however, distinct activity patterns were recorded for specific prokaryotic groups.

Keywords : Bacteria, Western Mediterranean, Open Sea.

#### Introduction

Diel cycles in prokaryotic abundance and production have been reported for several marine environments (e.g. [1]), with peaks in activity in the early morning or in the evening. These diel dynamics in prokaryotic heterotrophic activity are governed by phytoplankton production providing labile dissolved organic matter (DOM) to bacterioplankton and by ultraviolet radiation. While phytoplankton-derived DOM stimulates bacterioplankton activity, UV radiation inhibits it [2, 3].

The main objective of this study was to determine whether these diel cycles, if present, were expressed in the same way by the different prokaryotic groups at a single-cell level or whether there are interspecific differences in the activity pattern.

#### Material and Methods

An anticyclonic eddy located in the Western Mediterranean Sea was followed from 23 Sep to 6 Oct 2003 using a drifting buoy. Diel cycles of different prokaryotic parameters (abundance, production, actively respiring cells, abundance of cells with damaged membrane, MICRO-CARD-FISH) were determined by taking samples from six depths (near-surface: 5, 10, 20, 30 m), deep chlorophyll maximum (DCM, at about 50 m depth) and at the bottom of the euphotic layer at around 100 m depth approximately every 4 h over diel cycles. Using microautoradiography, the silver grain area associated with the prokaryotic cells taking up leucine has been used as an indicator of single cell activity [4, 5] at the DCM during one diel cycle.

## Results and Discussion

The abundance and phylogenetic composition of some major groups of bacteria (as determined by fluorescence in situ hybridization, FISH) was fairly stable during the diel cycles, with lowest abundance at 100 m depth (mean 2.5 x  $10^5$  cells ml<sup>-1</sup>) and highest abundance in the DCM with an average of 7.4 x  $10^5$  cells ml<sup>-1</sup> and increasing abundance from 5 m depth to 30 m depths (Table 1). The percentage of cells with a high nucleic acid content followed a similar trend (Table 1).

Although the different prokaryotic parameters varied during the day, no clear prokaryotic diel cycles were found at any of the studied depths. The percentage of cells of the prokaryotic community of the DCM taking up leucine showed no significant differences during the 4th diel cycle, while the silver grain area of the DAPI-stained cells taking up leucine were highest in the early morning and at noon. Bacteria dominated the community (48 %) followed by Euryarchaea (17 %) and Crenarchaea (7 %). The SAR11 clade and Cytophaga-Flavobacter group represented 25 % and 16 %, respectively, of the prokaryotic community, while the Roseobacter cluster represented only 4 % and SAR86 was hardly detected. Single-cell activity of Bacteria showed no clear trend during the day, but members of the Cytophaga-Flavobacter cluster exhibited high cell activities during early morning and afternoon. Archaeal groups exhibited higher cell activities in the early morning and at noon (Crenarchaea) or afternoon (Euryarchaea). The prokaryotic community size structure showed three main peaks, at size classes of 0.12-0.14, 0.16-0.18 and 0.20-0.22  $\mu \mathrm{m}$  equivalent spherical diameter (ESD) and was quite stable from early morning until noon. From the early morning towards noon, some larger cells appeared, followed by an increase in the relative abundance of the 0.12-0.14  $\mu$ m ESD size class during the afternoon, decreasing again towards the next morning. This pattern would be in accordance with an increase in cell size during the day and division during the afternoon. The dynamics of single-cell activity per size class was more variable. Higher single-cell activities were found at noon and early morning, and in the larger size classes. Excluding the larger sizes, an increase in single-cell activity was found from the smaller sizes towards the 0.26-0.28  $\mu$ m ESD during the morning, afterwards the higher cell activities were found in smaller size classes coinciding with the increase in the abundance of these small size classes.

In summary, diel dynamics of the abundance and activity of the prokaryotic community were variable in the open Mediterranean Sea. The percentage of cells inhabiting the DCM and taking up leucine was stable during the day, but the single-cell activity was higher in the early morning and noon. Different prokaryotic groups showed different diel dynamics in single-cell activity.

Tab. 1. Average ( $\pm$  SD) of prokaryotic abundance and activity over the different depths. \* The % of cells taking up leucine corresponds to one time point (6:00 am).

|       | 10 <sup>5</sup> Cells<br>ml <sup>-1</sup> | % HNA    | % CTC+  | % Sytox  | nmol Leu I' d' | amol Leu cell'1d'1 | % cells<br>taking up<br>Leucine* |
|-------|-------------------------------------------|----------|---------|----------|----------------|--------------------|----------------------------------|
| 100 m | 2.5±0.9                                   | 43.8±2.2 | 6.9±7.9 | 12.7±5.7 | 0.15±0.08      | 0.66±0.41          | 40.16                            |
| DCM   | 7.4±1.6                                   | 51.0±3.7 | 8.7±7.0 | 12.6±5.4 | 1.47±0.50      | 2.12±0.94          | 47.40                            |
| 30 m  | 6.1±1.4                                   | 48.8±3.3 |         | 8.3±3.1  | 0.83±0.23      | 1.44±0.51          |                                  |
| 20 m  | 5.1±1.3                                   | 44.1±2.6 |         | 7.9±3.1  | 1.02±0.14      | 2.21±0.83          |                                  |
| 10 m  | 4.7±1.3                                   | 43.8±3.0 |         | 8.0±2.6  | 0.85±0.17      | 1.98±0.73          |                                  |
| 5 m   | 4.4±1.2                                   | 43.5±2.2 | 5.3±5.3 | 8.0±2.6  | 0.84±0.21      | 2.08±0.86          | 54.42                            |

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# DYNAMICS OF A HAB DEVELOPED AFTER AN EPISODIC RAINFALL EVENT IN A COASTAL AREA

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## Abstract

The mechanism of HAB formation and evolution in relationship to anthropogenic nutrient loading remains poorly understood despite their increasing occurrence in coastal waters around the globe. In the present study, the causes and mechanisms of the development of a HAB of the potential ASP toxin producer *Pseudonitzschia calliantha* and the confirmed PSP toxin producer *Alexandrium minutum* was studied. The event occurred in the Gulf of Kalloni in the Aegean Sea after a major rainfall event in winter. The spatial and temporal dynamics of the two HAB species were analyzed and associated to physicochemical parameters, supporting the view that a cause and effect relationship seems to exist between the HAB event and anthropogenic activities in the watershed. The indirect negative impacts of these activities on fisheries and local economy are also discussed.

Keywords : Toxic Blooms, Coastal Waters, Aegean Sea.

Nutrient inputs from terrestrial runoff have been strongly associated to the development of phytoplankton blooms as well as harmful algal blooms (HABs) in coastal waters [1]. Recurrent HAB events in the coastal zone can have serious impacts on public health and local economy. The need for meticulous monitoring of productive coastal areas is necessary in order to understand the causes and mechanisms of different HAB species development and distribution.

The Gulf of Kalloni is a semi-enclosed, highly productive, shallow water body, located at the south-western part of Lesvos Island (Greece) in the Aegean, with a surface area of 110 km<sup>2</sup>. Fish and bivalves (mussels, scallops and clams) are being harvested and exported at the national and international market. According to the EU legislation, water and shellfish quality are being monitored on a regular basis since 2001 [2]. Agricultural activity in the watershed includes olive tree, cereal and vegetable cultivation. The main contributor of nitrogen salts is runoff from the agricultural land (59%), while for phosphorous salts are domestic sewage (59%), fertilizers (19%) and residual wastes of olive press industries (19%) [3].

In order to investigate the effect of terrestrial runoff from the surrounding watershed on the phytoplankton community composition and dynamics, a network of eight stations (5-12) was set up along a gradient formed by the river plume of Tsiknias, the most important freshwater input of the area. Two of them (stations 5 and 7) along with two control stations (1 & 2) in the open sea were sampled on a monthly basis from August 2004 to July 2005, in order to collect baseline information, whereas additional samples were collected from the gradient stations (5 to 12) during the rainfall period. Physical parameters, Chl  $\alpha$  and nutrients were measured at 1 and 5 m depths. Phytoplankton species were identified, counted and measured following the Utermöhl method [4]. Phytoplankton biovolume was also calculated.

During February, a period of fertilizer application in the watershed, a major episodic rainfall event caused maximal river discharge in the gulf. At the same time nutrient (NO<sub>3</sub>, NO<sub>2</sub>, SiO<sub>2</sub>, PO<sub>4</sub>) concentrations were significantly higher than the usual background concentrations (ANOVA, P<0.05) (Fig. 1). Throughout the gulf area, the input of freshwater formed a surface layer of lower density, characterized by significantly higher nutrient concentrations and lower salinity and temperature than the bottom layer (P<0.05). This abrupt nutrient loading and the resulting stratification stimulated the development of a bloom of the potentially toxic diatom P. calliantha (max cell number of  $10.6 \times 10^6$  cells  $l^{-1}$ ) as well as the toxic dinoflagellate A. minutum (max cell number of  $1.5 \times 10^5$  cells  $1^{-1}$ ). The spatial distribution of A. minutum seemed to be related to the nutrient concentrations, since densities of this species were significantly higher in the surface layer (P<0.05) and close to the river mouth. However, the distribution of P. calliantha was more homogeneous. Both cell densities and nutrient concentrations were scarce at the outer part of the gulf. Nutrients as well as phytoplankton cell number retreated to background concentrations almost two weeks after the episodic event.



Fig. 1. Annual cycle of rainfall height and average nitrate concentrations along the river plume (stations 5-8).

The present study confirms earlier observations on the presence of the toxic dinoflagellate *Alexandrium minutum* [5] and the potentially toxic diatom *Pseudonitzschia calliantha* [6] in coastal areas with high nutrient loading. The mechanism of this recurrent bloom is attributed mainly to strong rainfall events occurring in winter (January or February), a period of fertilizer application in the watershed. The understanding of the mechanism of bloom formation not only supports the establishment of cause and effect relationships between HABs and anthropogenic activities in the coastal zone, but can additionally act as an early warning system protecting public health and local economies based on fisheries.

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# PREDICTION OF NANOPLANKTON CHANGE IN IZMIR BAY (AEGEAN SEA-TURKEY) WITH TIME BY NEURAL NETWORKS

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# Abstract

In this study, neural network analysis was used to construct prediction models of nanoplankton population change with nutrients and other environmentally important parameters. The results indicated that, with a data set of 52 weeks, it is possible to predict nanoplankton change.

Keywords : Aegean Sea, Coastal Waters, Eutrophication, Phytoplankton.

# Introduction

Coastal areas are subject to diverse anthropogenic influence including industrial development, domestic wastes, maritime transport and agricultural activities. Neural networks, a statistical tool for data analysis, can be used to extract the relations between variables depending on the predictive variables used by means of a mechanism called training or learning. After a training process, Neural Networks are able to give estimations by using the relationship developed during the learning phase. The aim of this research was to predict of temporal changes of nanoplankton variation and physico-chemical environmental parameters using Neural Networks.

# Materials and Methods

*Experimental:* In this study, physico-chemical environmental parameters, nutrients and some general biological parameters were measured weekly during an one year period. All these parameters were measured at different depths of 3 selected sampling stations which are located in middle and inner part of Izmir Bay.

*Neural networks:* Artificial Neural Networks (ANNs) are information processing algorithms that are inspired by the way biological nervous systems work, such as learning from past experience, making generalizations from similar situations and producing decisions out of incomplete knowledge of the states [1]. Neural networks are generally used in two main application areas, function approximation and pattern classification [2]. A feed-forward ANN, trained with the back-propagation algorithm, was implemented using the software package Neuroshell 2 (Ward Systems Group Inc., 2000).

*Data division and pre-processing:* 468 data was collected from selected stations, however, 18 points from PON and 18 points from nanoplankton data were missing. Missing data points replaced with the values from best matching weight vector for corresponding variable after training process using Self Organizing Map (SOM). Self Organizing Map (SOM) is an unsupervised neural network method which has properties of both vector quantization and vector projection algorithms. The obtained data were smoothened by Simple Moving Average (5 weeks) technique.

The 464 available data sets were divided into three groups, of which the 63 were used for testing, a set of 53 for evaluation and the remaining 348 data were used for training. The training set was used for adjusting the connection weights, whereas the testing set was used for the determination of network geometry and model parameters. Finally, the validation set was used for testing the optimality and generalization ability of the model developed [3]. The data were normalized between 0.0 and 1.0 before the NN analysis, corresponding to the limits of the transfer function, in order to improve training characteristics.

*Network:* The best results were obtained with a network consisting of two hidden layers, with having 14 and 4 neurons, respectively. Hyperbolic tangent transfer function used at hidden layers. Every  $4^{th}$  data for testing and evaluation set extracted from the data.

# Results and Discussion

During training, a number of different descriptive correlation values, namely the R Squared and Minimum Average Error (MAE) were observed for both training and testing sets. Using these values, monitoring of the local and the global minimum values for correlation values could be possible. Therefore, training was continued until overtraining was observed. Correlation values were calculated for evaluation data set after training.

The best network geometry was chosen according to highest correlation and lowest MAE error value of the testing/evaluation sets. Overall results are given in Table 1.

Tab. 1. Overall results. \* percent of data within specific error range.

|                   | Training |       | Testing |       | Evaluat | tion  |
|-------------------|----------|-------|---------|-------|---------|-------|
|                   | DO       | NP    | DO      | NP    | DO      | NP    |
| Corr. Coeff. R    | 0.975    | 0.946 | 0.959   | 0.891 | 0.962   | 0.916 |
| MAE               | 0.23     | 73375 | 0.29    | 95672 | 0.29    | 86363 |
| % within 5*       | 82.76    | 25.00 | 69.84   | 12.70 | 69.81   | 22.64 |
| % within 5 to 10  | 14.37    | 19.54 | 26.98   | 20.64 | 30.19   | 20.76 |
| % within 10 to 20 | 2.87     | 22.99 | 3.18    | 19.05 | 0       | 24.53 |
| % within 20 to 30 | 0        | 15.23 | 0       | 23.81 | 0       | 15.09 |
| % over 30         | 0        | 17.24 | 0       | 23.81 | 0       | 16.98 |

The prediction models demonstrated good abilities to model the training data. The denormalized actual and simulated DO and nanoplankton values are presented in Figure 1. As seen, the actual and predicted values were in good agreement. The performance of neural networks can be seen from training and evaluation data sets. As can be seen, the proposed network exhibited a good performance overall.



Fig. 1. Comparison between actual and predicted values of the NN model.

#### Conclusions

ANNs were applied to the obtained data. These analyses were carried out so that less analyses in laboratory conditions are needed in future to see the effect of nutrients on the nanoplankton population.

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# CONTRIBUTION AU SUIVI QUALITATIF ET QUANTITATIF DU PHYTOPLANCTON ET DES CILIEÉS PLANCTONIQUES À L' EST D' ALGER.

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# Résumé

Dans l'ensemble de nos récoltes nous avons inventorié 192 espèces réparties entre les différents groupes phytoplanctoniques suivants : Les Diatomées, Dinoflagellés, Coccolithophoridés, Cryptophycées et les silicoflagellés. La liste floristique obtenue indique que les Diatomées détiennent le premier rang avec 96 taxons, le deuxième rang revient aux Dinoflagellés avec 62 espèces. La richesse quantitative des ciliées est répartie entre deux espèces : *Strombidinium wullfi* et *Mesodinium rubrum* du phylum des Ciliophora. Les résultats obtenus par une MANOVA, montrent que la station et le mois (descripteurs qualitatifs) n'ont pas un effet significatif sur l'abondance et la richesse spécifique (descripteurs dépendants) ; L'interaction de ces deux facteurs n'est pas significative (p = 0.767). *Mots clès : Algerian Basin, Diatoms, Dinoflagellates*.

La biodiversité méditerranéenne est menacée par l'intrusion d'espèces non indigènes. Parmi les espèces introduites (par exemple par les eaux de ballast de navires), le phytoplancton occupe une place de choix ; notre laboratoire effectue un suivi mensuel du phytoplancton ainsi que des protozoaires planctoniques, dans le but d'établir un inventaire floristique et un suivi de la biodiversité côtière.

#### Matériels et méthodes

Les prélèvements ont été réalisés l'année 2004 sur deux stations localisées à Tamentfoust (Est d'Alger) : l'une située dans une zone protégée et l'autre exposée aux vents. Les récoltes d'eau destinées à l'étude microscopique du phytoplancton et des ciliés ont été faites à l'aide de bouteilles de type Van Dorn, d'une contenance de 5 litres à une profondeur de 5m. Un volume de 500ml a été fixé par du lugol. Avant sédimentation nous avons pré-concentré l'échantillon ; L'identification et le dénombrement des espèces phytoplanctoniques et des ciliés ont été effectués sous microscope inversé équipé d'une caméra HRC, selon la méthode d'Utermhöl.

#### Résultats et Discussion

Nous avons inventorié 192 espèces réparties entre les différents groupes phytoplanctoniques suivants: les Diatomées, Dinoflagellés, Coccolithophoridés, Cryptophycées et les silicoflagellés. Les Diatomées détiennent le premier rang avec 96 taxons, suivi des Dinoflagellés avec 62 espèces. Les principaux genres diatomiques sont : *Rhizosolenia, Nitzschia, Leptocylindrus, Thalassiosira Chaetoceros* et *Cerataulina.* En ce qui concerne les Dinoflagellés nous pouvons citer : *Scripsiella, Noctiluca scintillans, Ceratium furca, C.fusus, C.macroceros, Prorocentrum micans Oxytoxum scolopaxet le genre Dinophysis.* Ces genres et espèces ont déjà été signalés dans le bassin algérien [1]. En ce qui concerne les Ciliés, le nombre d'espèces répertoriées en est restreint ; nous signalons pour la première fois la présence dans les eaux côtières algériennes les espèces: *Mesodinium rubrum et Strombidinium wulfii.* 



Fig. 1. Proportion des groupes phytoplanctoniques rencontrés.

Les Diatomées dominent avec 366 692,13 ind. /litre et 428 316,78 ind. /litre (Fig.1) en juin et septembre respectivement. Durant le mois de septembre 2004 cette floraison phytoplanctonique est due principalement à un épanouissement mono spécifique de *Leptocylindrus danicus*. Ces

poussées printanière et automnale sont caractéristiques des eaux méditerranéennes. En revanche en juillet nous observons une baisse de la concentration du phytoplancton dont le maximum n'est que de  $50 \ge 10^3$  cell/l. Le phytoplancton est dominé par des Dinoflagellés notamment Scripsiella trochoida et le genre Ceratium. L'activité phytoplanctonique reprend en mars 2005 avec une concentration supérieure à 224 x10<sup>3</sup> cell/l. L'analyse microscopique montre que les densités des ciliées sont maximales en hiver, c'est à dire, lors de la régression de la production phytoplanctonique. Nos résultats montrent que la station et le mois (descripteurs qualitatifs) n'ont pas un effet significatif sur l'abondance et la richesse spécifique (descripteurs dépendants) ; ce résultat étant confirmé par l'analyse de variance multiple (MANOVA). L'interaction de ces deux facteurs n'est pas significative (p = 0.767). En revanche, le dendrogramme (Fig.2) illustre distinctement la ségrégation entre les principales espèces planctoniques (plus fréquentes et plus abondantes), et met en évidence l'effet temporel dans la structuration des peuplements phytoplanctoniques. Ces associations phytoplanctoniques ont déjà été observées dans les eaux Nord-ouest africaines. De plus notons la proximité des deux espèces de ciliées introduit dans l'analyse ce qui démontre la pertinence de ce type d'analyse multi varié.



Fig. 2. Dendrogramme des espèces les plus abondantes et les plus fréquentes.

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# DAILY VARIATIONS OF SUMMER PHYTOPLANKTON IN THE DARDANELLES

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# Abstract

Average temperature, salinity, pH, DO, TDS, TSS,  $NO_2^{-}+NO_3^{-}$ ,  $PO_4^{-3}^{-3}$ ,  $SiO_4$  and chlorophyll-a were found to be 25.0 °C, 23.3 ppt, 8.42, 9.26 mg L<sup>-1</sup>, 23.9 g L<sup>-1</sup>, 36.1 mg L<sup>-1</sup>, 1.90  $\mu$ M, 0.24  $\mu$ M, 3.61  $\mu$ M and 1.70  $\mu$ g L<sup>-1</sup>, respectively. Average N:P and S:P rates were calculated as values of 12.5 and 25.0, respectively. Total phytoplankton density and bio-volume varied between 2.86x10<sup>5</sup>-1.5x10<sup>7</sup> cell L<sup>-1</sup> and 5.98x10<sup>8</sup>-8.81x10<sup>10</sup>  $\mu$ m<sup>3</sup>L<sup>-1</sup>, respectively.

Keywords : Dardanelles, Phytoplankton, Eutrophication, Hydrography.

The Dardanelles is located between the Aegean Sea and the Sea of Marmara and has a 50 m mean depth. This study was carried out to determine the diurnal distributions of phytoplankton density, bio-volume and chlorophyll-a in relation to nutrients and CTD in surface waters of the Dardanelles (Fig. 1) in the summer period of 03 July 2002 and 04 August 2002. It was collected 99 surface (0.5m) samples for nutrient, chlorophylla and phytoplankton.



Fig. 1. Dardanelles and sampling station (D)

CTD parameters, nutrient and chlorophyll-a were measured by using YSI 556 MPS, Technicon Model Two Channel Autoanalizor and Jasco V-530 UV/VIS spectrophotometer, respectively [1]. For enumeration of the phytoplankton species, Uterhmöhl Sedimentation Chambers, Neubauer and Sedgwick-Rafter counting slides were used in combination according to the dimensions of the organisms. The phytoplankton was identified under phase-contrast microscopy to the taxonomic level of species.

Temperature, salinity, pH, DO, TDS, TSS, NO<sup>-2</sup><sub>2</sub>+NO<sup>-3</sup>, PO<sup>-3</sup><sub>4</sub>, SiO<sub>4</sub> and chlorophyll-a were varied between 22.5-26.5 (mean 25.0, SD 0.97 °C), 22.7-23.7 ppt (mean 23.3, SD 0.23 ppt), 8.31-8.49 (mean 8.42, SD 0.04), 8.46-10.1 mg L<sup>-1</sup> (mean 9.26, SD 0.48 mg L<sup>-1</sup>), 23.4-24.3 g L<sup>-1</sup> (23.9; SD 0.21 g L<sup>-1</sup>), 16.8-76.0 mg L<sup>-1</sup>(36.1; SD 10.7 mg L<sup>-1</sup>), 0.04-11.8  $\mu$ M (mean 1.90; SD 2.15  $\mu$ M), 0.02-0.97  $\mu$ M (mean 0.24; SD 0.20  $\mu$ M),0.64-8.50  $\mu$ M (mean 3.61; SD 2.15  $\mu$ M) and 0.21-5.62  $\mu$ g L<sup>-1</sup> (mean 1.70; SD 0.76  $\mu$ M), respectively. N:P and S:P rates were also varied between 0.44-142.8 (mean 12.5, SD 19.5) and mean 3.82-125.5 (25.0, SD 22.3), respectively. Diurnal variations of bio-physicochemical parameters in time interval between 08:00 and 19:00 were generally much higher than daily variations in period of 03 July and 04 August due to two counter flows system and domestic inputs of Çanakkale city.

On the other hand, the negative correlation between SiO<sub>4</sub> and diatom cell density (r=-0.295) was more significant than between SiO<sub>4</sub> and diatom bio-volume (r=-0.134). These correlations showed that utilization of SiO<sub>4</sub> by diatoms was more connected with diatom cell density than with diatom cell volume. This study showed that the relationship between chlorophyll-a and Bacillariophyceae (r=0.570) was more important than the relationship between chlorophyll-a and Dinophyceae (r=0.176) and between chlorophyll-a and other taxonomic groups (r=-0.145). These relationships between chlorophyll-a was highly controlled by Bacillariophyceae species than those of Dinophyceae and other taxonomic groups. In fact, very important relationship between Bacillariophyceae and total phytoplankton (r=0.702) also accurate important contribution of Bacillariophyceae to total phytoplankton.



Fig. 2. Daily variations in density (A) and bio-volume (B) of different phytoplankton groups in the Dardanelles in the period of 03 July 2002 and 04 August 2002

Total phytoplankton density and bio-volume varied between 2.86x10<sup>5</sup>- $1.5 \times 10^7$  cell L<sup>-1</sup> and  $5.98 \times 10^8$ -8.81×10<sup>10</sup>  $\mu$ m<sup>3</sup>L<sup>-1</sup>, respectively (Fig. 2). Due to Black Sea surface waters, rational contribution of Bacillariophyceae (66.5%) to total phytoplankton bio-volume was higher than contribution of Dinophyceae (31.0%). It has been showed that there are 8-10 population growth slopes by different species such as dinoflagellates Prorocentrum compressum (Bailey) Abé and Prorocentrum micans Ehrenberg, diatoms Pseudonitzschia pungens (Grunow ex. P.T. Cleve) Hasle, Pseudosolenia calcar-avis Schultze, Rhizosolenia fragilissima Bergon and a globally significant coccolitophore Emiliania huxlevi (Lohmann) Hay & Möller at different times and different densities in the Dardanelles. These species were also responsible for algal blooms in different times during the sampling period. In view of both cell density and bio-volume, although diatoms (Bacillariophyceae) showed some algal blooms in summer period, dinoflagellates (Dinophyceae) showed more regular and stabile fluctuations in the summer sampling period especially in bio-volume profile (Fig. 2). Phytoplankton community structure was observed to be controlled by these species in the summer period in the Dardanelles as shown like in the Black Sea ecosystems.

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# PICOPLANKTON DYNAMICS IN THE LEVANTINE BASIN

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# Abstract

Abundance and biomass of picoplankton (heterotrophic bacteria and cyanobacteria *Synechococcus*) were monitored monthly at three stations over a year in the northern Levantine Basin shelf waters. Relationships with other ambient chemical and physical parameters were also sought. An apparent decreasing trend in picoplankton content from inshore towards offshore was observed Bacterial population was found relatively low during winter. *Synechococcus* was most abundant at or near surface waters during the summer. In general, heterotrophic bacterial biomass surpassed the cyanobacterial (*Synechococcus*) biomass in the water column throughout the year. *Keywords : Cyanobacteria, Biomass, Levantine Basin.* 

Picoplankton samples for this study were collected from three stations offshore the Institute of Marine Sciences of Middle East Technical University, Turkey, located on the norteastern coast of the Mediterranean (Figure 1). Seawater samples taken from standard depths for picoplankton analysis were filtered onto 25 mm diameter, black, polycarbonate, nuclepore membrane filters with 0.2  $\mu$ m pore size. Total bacterial as well as the cyanobacterial abundance were estimated by acridine orange direct counts with epifluorescence microscopy (1). Counts were performed under a Nikon epifluorescence microscope with a filter combination of B-2A (blue excitation, dichroic mirror DM 505, excitation filter EX 450-490, barrier filter BA 520) and G-1A (green excitation, dichroic mirror DM 575, excitation filter EX 546/10, barrier filter BA 580). The main light harvesting pigment of Synechococcus is phycoerythrin which is responsible for the orange fluorescence of Synechococcus when excited with green light. Mean cell volumes were estimated using image analysis system composed of a digital camera, computer and the image analysis software. Cell volumes were determined using the volume formula for an ellipsoid (2). To calculate carbon content of bacteria and Synechococcus, 77 and 123 fg carbon per cubic micron were used, respectively (3, 4).



Fig. 1. Location of the sampling stations in the Levantine Basin.

In general shelf waters have a dynamic nature and strong mixing during winter effect greatly the concentration of nutrients as well as the distribution of suspended matter in the water column. Winter bacterial population was low in abundance and cells were distributed homogeneously in the water column. At the nearshore station surface bacterial biomass ranged from 3.05  $\mu$ gC l<sup>-1</sup> in December to a maximum of 32.27  $\mu$ gC l<sup>-1</sup> in September. The minimum and the maximum bacterial biomass ranged between 2.81 (at 100m depth in October) and 12.11  $\mu gC~l^{-1}$  (at 20m depth in September) at the middle station. At the offshore station bacterial biomass ranged from a low level of 0.99  $\mu$ gC l<sup>-1</sup> at 175 m in October to a high level of 10.7  $\mu$ gC l<sup>-1</sup> achieved at surface in September. In general, heterotrophic bacterial biomass surpassed the cyanobacterial ( Synechococcus) biomass in the water column throughout the year. Size of bacteria varied greatly with depth at all three stations. Cyanobacteria Synechococcus was found most abundant at or near surface waters during the summer. Changes in cell abundance with depth was insignificant during winter due to intense vertical mixing and remained at lowest levels compared to other seasons. At the nearshore station Synechococcus biomass ranged from 1.08  $\mu$ gC l<sup>-1</sup> (at 10 m depth in January) to a maximum of 11.59  $\mu$ gC l<sup>-1</sup> obtained at surface in July. At the middle station cyanobacterial biomass ranged between 0.04 (at 100m depth in October) and 7.55  $\mu$ gC l<sup>-1</sup> observed at 20 m depth in July. At the offshore station, to a highest value was reached in July at 20 m depth (6.31  $\mu$ gC l<sup>-1</sup>).

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# DISTRIBUTION AND ACTIVITY OF BACTERIA AND ARCHAEA IN THE DEEP NORTH ATLANTIC OCEAN

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# Abstract

We determined the distribution and activity of the major prokaryotic groups (Bacteria, *Cren-* and *Euryarchaeota*) in the deep water masses of the eastern North Atlantic. The bacterial contribution to total picoplankton abundance was rather homogeneous, comprising 50% of DAPI-stainable cells. *Euryarchaeota* cells were hardly present, while the percentage of *Crenarchaeota* ranged from <5 and >20% in subsurface and deep waters, respectively. Both Archaea and Bacteria were taking up D- and L-Aspartic acid, while we did not find any evidence that *Crenarchaeota* take up inorganic carbon, suggesting that they are heterotrophs incorporating mainly D-amino acids. *Keywords : Bacteria, Carbon, Deep Waters.* 

Prokaryotic (Bacteria and Archaea) plankton are the major drivers of biogeochemical cycles in the ocean. While the importance of bacteria in the biogeochemical cycles of marine ecosystems is well established, particularly for surface waters, little is known about the distribution and metabolic activity of the prokaryotic community in the meso- and bathypelagic realm of the ocean. Recent studies found that Archaea have the potential to use both inorganic and organic carbon [1-2] as energy source in the deep ocean. However, more information is needed in order to identify the distribution of group-specific prokaryotic activity in deep water. Sampling of meso- and bathypelagic waters was carried out along a 4000-km transect covering the major deep water masses of the eastern North Atlantic. Water samples were taken from the 100m layer (subsurface), the oxygen minimum zone (O2-min), the Mediterranean Sea Outflow Water (MSOW) in the subtropical gyre, the Antarctic Intermediate Water (AAIW) in the North Equatorial Counter Current, the Northeast Atlantic Deep Water (NEADW) and the Lower Deep Water (LDW). D- and L-aspartic acid (Asp) incorporation was measured on the bulk prokaryotic community and archaeal production via the incorporation of <sup>14</sup>C-bicarbonate. We compared bulk activity measurements with that on a single cell level using catalyzed reporter deposition fluorescence in situ hybridization combined with microautoradiography(MICRO-CARD-FISH)

The bacterial contribution to total picoplankton abundance ranged from 40 to 55% of DAPI-stainable cells both in the subtropical gyre and North Equatorial Counter Current stations. Generally, the vertical distribution was rather homogeneous and lacked a clear latitudinal pattern. *Euryarchaeota* were hardly present along the transect, comprising always <5% of DAPI-stainable cells. *Crenarchaeota* exhibited a more patchy distribution throughout the transect. The percentage of total picoplankton identified as *Crenarchaeota* ranged between<5% and >20% in subsurface waters (around 100m depth) and the LDW, respectively. In general, *Crenarchaeota* were less abundant in the subtropical gyre waters(<10% of the picoplankton community) than in the North Equatorial Counter Current stations (up to 25% of total picoplankton cells) (Figure 1).



Fig. 1. Abundance of Bacteria and Archaea enumerated with CARD-FISH in the different water masses of the North Atlantic.

Mean L-Asp bulk uptake rates decreased from 8.3 pmol  $L^{-1}h^{-1}$  at 100m depth to 0.03 pmol  $L^{-1}h^{-1}$  in the NEADW, while D-Asp decreased from

0.5 pmol L<sup>-1</sup>h<sup>-1</sup> at 100 m depth to 0.005 pmol L<sup>-1</sup>h<sup>-1</sup> in the NADW. The ratio of D-/L- Asp uptake by the prokaryotic community increased from the subsurface layer (D-/L- Asp uptake ratio ~0.09) to the deeper layers reaching a ratio close to 1 at 4000 m depth (Figure 2).



Fig. 2. D-/L-Asp uptake ratio derived from the bulk prokaryotic community measurements in the different water masses of the North Atlantic.

Archaeal production generally followed the same decreasing trend with depth as the prokaryotic production, declining from 295  $\mu$ mol C m<sup>-3</sup> day<sup>-1</sup> at a depth of 100 m to 85  $\mu$ mol C m<sup>-3</sup> day<sup>-1</sup> in the oxygen minimum layer at a depth of 500 m. However, in the deep ocean we could not measure any inorganic carbon incorporation. Using MICRO-CARD-FISH, we found that both *Archaea*and Bacteria were taking up D- and L-Asp. The percentage of *Crenarchaeota* taking up D-Asp was highest in the LDW of the North Equatorial Counter Current, while we did not find any evidence that *Crenarchaeota* take up inorganic carbon. Thus, in contrast to recent findings showing that *Crenarchaeota* are chemoautotrophic in the mesopelagic waters, using inorganic carbon as a carbon source and oxidizing ammonia as an energy source [4], in bathypelagic waters, *Crenarchaeota* are likely heterotrophs using efficiently D-amino acids.

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# PHYTOPLANKTON ASSEMBLAGES IN THE NORTHEASTERN SHELF OF MEDITERRANEAN SEA DETERMINED BY CHEMTAX ANALYSIS OF PIGMENT DATA

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# Abstract

Relative contributions of the major phytoplankton groups to the total chlorophyll a were estimated by the CHEMTAX analyses. Chemotaxonomic results for phytoplankton characterization showed mixed phytoplankton community and reflecting major contributions of cyanobacteria at the surface of the deep station. However, diatoms and dinoflagellates were the most abundant algal classes in shallow zone water.

Keywords : Eastern Mediterranean, Phytoplankton, Pigments.

# Introduction

The eastern Mediterranean is known as one of the oligotrophic seas over the world, due to limited nutrient input to its surface waters from external and internal sources. Chlorophyll concentrations previously recorded in the Levantine basin were low, not exceeding  $1\mu g/l$  even in coastal waters [1]. However, phytoplankton composition is quite diverse (minimum 70 spp.). Microscopic analysis of phytoplankton composition is a tedious and necessitates well-trained taxonomist. Unfortunately, there are almost no studies on the pigment characterization of phytoplankton in the NE Levantine basin. The main aim of this research was to use the chemotaxonomy for great improvement in our understanding of the distribution and composition of oceanic phytoplankton populations.

#### Material and Method

In this study, the distributions of phytoplanktonic community composition in the NE Mediterranean coastal waters were described by using chemotaxonomy of photosynthetic pigments. In the field, sampling was carried out from a deep (total depth is 200 m) (36.26 N 34.22 E) and a shallow (total depth is 20 m) (36.33 N 34.15E) stations. Measurements were conducted in these stations in monthly intervals during December 2001 - December 2003 period. Pigments were analyzed by improved HPLC method [2].

#### Results and Discussion

Average chl-a concentrations was 0.13  $\mu$ g/l (range 0.01-1.19  $\mu$ g/l) at the deep and 0.71  $\mu$ g/l (range 0.03-8.0  $\mu$ g/l) at the shallow station during the entire studied period. Chlorophyll-a concentrations at the deep station was within the range of oligotrophic waters. Maximum surface CHL *a* values in shallow and deep station (8.0 and 1.2  $\mu$ g/L) were recorded during January 2002 sampling period probably due to transport of nutrients by river water in shallow station and winter mixing processes in deep station (Figure 1). Higher nutrient concentrations in shallow station (average ( $\mu$ M)  $\pm$  StDev; PO<sub>4</sub>: 0.08 $\pm$ 0.08, NO<sub>3</sub>: 0.25 $\pm$ 0.23, Si: 1.39 $\pm$ 0.56) resulted in higher algal biomass.

The output marker pigment: CHL *a* ratios calculated by CHEMTAX [3] were used in the calculation of the relative abundance of each phytoplankton group and hence their contributions to the total CHL a (Fig. 1). In surface waters of the deep station, the composition of the phytoplankton population was generally dominated by cyanobacteria, contributing 8-96% CHL a (mean=52%, SD=24%). Recent studies in the area showed that cyanobacteria abundance were generally high [4]. Marty et al. [5] reported that high contribution of cyanobacteria was observed at DYFAMED timeseries station in the western Mediterranean Sea. The specific occurrence of cyanobacteria is related to possible N2 fixation of some of the species composing this group. Algal classes, constituted the bulk of the remaining CHL a, showed mixed phytoplankton assemblages in deep station. However, in January 2002 where the highest concentrations of CHL a were recorded, surface waters of deep station were dominated by diatoms (56%), prymnesiophytes (15%) and dinoflagellates (13%). In shallow station, different composition of algal class was observed, with a general shift from surface waters dominated by prokaryotic cyanobacteria to populated predominantly by the eukaryotic diatoms (mean=41%, SD=16%) and dinoflagellates (mean=20%, SD=12%) (Figure 1). Similar to deep station, diatoms (62%) and dinoflagellates (22%) were the dominant algal groups in January 2002 (Figure 1).



Fig. 1. Contribution of various algal classes to total CHL a biomass in surface waters of deep and shallow waters determined using CHEMTAX analysis.

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# THE LITTORAL AND PELAGIC DISTRIBUTION OF ASTERIONELLA FORMOSA ON THE SURFACE WATER OF SAPANCA LAKE

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# Abstract

The littoral and pelagic phytoplankton distribution in regions on the surface of the Sapanca Lake water was studied between December 1999 and February 2001 from 4 stations on a monthly basis. During the study, the dominant type of phytoplankton was the *Asterionella formosa* of the Bacillariophyta division.

Keywords : Diatoms, Surface Waters, Pelagic.

# Introduction

Phytoplankton is one of the top living species groups that react fast to pollution in lakes. The composition of phytoplankton in designated water mass shows there is a trophic structure [1]. The aim of this study was to determine the difference in composition of the phytoplankton in the littoral and pelagic regions and to study the distrubution of the dominant phytoplankton types.

#### Materials and Methods

Four stations were designated in the west side of the lake, in both the littoral and pelagic regions (Fig. 1).



Fig. 1. The research stations at Sapanca Lake.

The samples were taken in nansen bottles and were flipped with lugol [2]. The surface water temperature of the lake and the dissolved oxygen quantity was measured with Oxi330/set make temperatures and the oxygen by meters, the pH on the other hand, was measured with the Knick make pH-meter. Seki discs were used when measuring the permeability of the light. The rations of OrtoPhosphate (PO<sub>4</sub>-P) and Nitrate Azote (NO<sub>3</sub>-N) in the water samples, was done with the help of Dr. Lange make kits at only the sample station points which were by the shore (Table 1).

Tab. 1. The individual numbers (individual/cm<sup>3</sup>) of Phytoplankton and the physical and chemical parameters in the littoral and pelagic regions of Sapanca Lake.

|    | LITTORAL REGION |     |                  |            |               |                            | PELAGIC REGION           |             |     |                  |            |                          |
|----|-----------------|-----|------------------|------------|---------------|----------------------------|--------------------------|-------------|-----|------------------|------------|--------------------------|
| SL | Temp.<br>°C     | pH  | Secchi<br>disc m | O2<br>mg/l | NO3-N<br>mg/l | PO <sub>4</sub> -P<br>mg/l | Ind.<br>/cm <sup>3</sup> | Temp.<br>°C | pH  | Secchi<br>disc m | O2<br>mg/l | Ind.<br>/cm <sup>3</sup> |
| 1  | 15,8            | 8,1 | 1,98             | 8,36       | 0,172         | 0,028                      | 30,5                     | 15,5        | 8,2 | 3,98             | 8,63       | 86,8                     |
| 2  | 15,8            | 8,2 | 2,49             | 9,19       | 0,204         | 0,029                      | 65,2                     | 15,9        | 8,2 | 3,61             | 9,15       | 100,4                    |
| 3  | 15,8            | 8,2 | 2,59             | 8,52       | 0,150         | 0,024                      | 85,5                     | 15,8        | 8,2 | 3,58             | 8,64       | 108,0                    |
| 4  | 15,6            | 8,2 | 2,08             | 8,83       | 0,215         | 0,049                      | 83,8                     | 15,5        | 8,2 | 4,12             | 9,35       | 80,7                     |

# Results and Discussions

In the research period, 54 taxa was found in the seven divisions belonging to phytoplankton. Bacillariophyta, Chlorophyta and Cyanophyta were the dominant members of phytoplankton. Members of the Bacillariophyta group were found to be mostly dominant on the surface when it came to number of type and number of individual. *A. formosa* is the dominant type within the group. This species was found more in the pelagic region stations of 1., 2. and 3. than they were in the stations of the littoral regions. *A. formosa* was found more in the  $4^{th}$  station of the littoral region than in the pelagic region. The changes in the composition of species are a result of an increase in nutritional salt [1]. *A. formosa* is usually an indicator species of eutrophic structure. It has been stated that the taxa can be found in high numbers in mesotrophic and eutrophic and even in oligotrophic waters [3,4]. *A. formosa* was stated as being phytoplankton characteristic

and nutrionally rich in warm lakes in spring and when of high number has known to be the reason of the lessening in matter of dissolved Nitrate and Phosphate like nutrients in the water [5]. Nutrients seem to lessen in periods when *A. formosa* is of a higher number. In the research carried out by Numan [6] in1958, it was seen that the lake was of oligotrophic status, however in the research done by Aykulu at al. [7], it was seen that the lake was heading towards mesotrophic characteristic. In this study, it is obvious from the results that the lake is changing from oligotrophic character over to mesotrophic character.

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# MOLECULAR ANALYSIS OF *GYRODINIUM INSTRIATUM* EXCYSTMENT CELL USING FTA TECHNOLOGY

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# Abstract

*Gyrodinium sp.* (BgT3C2) strain isolated from a resting cyst in sediment from Bougrara lagoon (Tunisia) was used to investigate the utility of FTA Technology for the protection and purification of nucleic acid. We have used FTA cards to obtain the sequence of the LSU rDNA D1-D2 region from very low concentrated BgT3C2 strain culture. Nucleotide sequence analysis supported and confirmed identification of BgT3C2 strain to *Gyrodinium instriatum*.

Keywords : Biotechnologies, Genetics, Phytoplankton.

# Introduction

Using molecular approaches revolutionised the identification and taxonomic of the organisms with their genetic characterization, mostly based on nuclear ribosomal DNA markers [1]. DNA-based studies usually require highly concentrated clonally cultures. However, the culturing process is not always suitable. FTA enables the collection, storage and purification of nucleic acids from a wide variety of biological sources. The aim of this study is to investigate the suitability of FTA technology to obtain specific genes sequences for molecular identification of marine dinoflagellates avoiding highly concentrated cultures. Molecular data were compared to morphological characters of BgT3C2 strain to study the reliability of FTA in the species identification.

#### Materials and methods

*Gyrodinium sp.* cyst was isolated from sediment by core sampler from Bougrara Lagoon (Tunisia). The culture was maintained in L1 medium on a multiwell plate and grown at 22°C (12:12 L:D, 50  $\mu$ Em<sup>-2</sup>s<sup>-1</sup>). A monoclonal culture of *Gyrodinoium* (BgT3C2) was subsequently established and the growth phase of the BgT3C2 strain determined every 1-2 days.

Genomic DNA was extracted using FTA technology (Transgenomic) according to the manufacturer's recommendations. 65  $\mu$ l of the BgT3C2 strain culture was applied to FTA cards. After six months of storage, punches (2 mm) were removed from the FTA cards, washed and used as PCR template for the amplification of the LSU rDNA D1-D2 domains. The amplified rDNA fragment was purified and sequenced. PCR and sequencing reactions were performed using D1R, D2R, D1C and D2C primers [2].

### Results and discussion

Two different motile cell types emerged after 11 dormancy days from cysts in artificial medium  $L_1$ . The morphology of the cyst and motile cell of BgT3C2 strain seems to be similar to those described for *Gyrodinium instriatum* [3]. The lag phase of *Gyrodinium instriatum* lasted only for one day. The exponential stage lasted 30 days and maximum abundance was 40cells/ml. This low abundance prevent the use standard molecular method to identify the strain.

Using FTA cards, the D1-D2 region of rDNA LSU was successfully amplified from low density cultures of BgT3C2 strain. The D1R/D2C PCR product was purified and sequenced with D1R, D1C, D2R and D2C primers. We obtained a new sequence of approximately 650 bp using FTA cards as the source of PCR template. The new sequence of the LSU rDNA D1-D2 region of BgT3C2 strain has been deposited in GenBank under the accession number DQ997780. The LSU rDNA sequence analysis confirmed that the identity of the *Gyrodinium instriatum* cysts, BgT3C2 strain.

### Conclusion

Using FTA cards, allow obtaining specific gene sequences from marine dinoflagellates even at low abundance.

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# DIVERSITÉ MOLECULAIRE DE LA MICROFLORE INDIGENE BACTÉRIENNE D'EAU DE MER POLLUÉE PAR LES HYDROCARBURES DANS LA ZONE DE JARZOUNA-TUNISIE

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# Résumé

Dans cette étude la composition d'une microflore bactérienne d'eau de mer polluée par les hydrocarbures a été étudiée en se basant sur l'analyse de la diversité du gène du 16S rDNA. Nos résultats ont montré une diversité importante de la microflore (MA) et une composition se répartissant sur quatre groupes bactériens (l *es Protéobactérie, les Clostridia, les Flavobactérie et les Bactéroidètes*) avec dominance du sous groupe des *Beta-protéobactérie*. Sur les 94 clones analysés 59,2% sont affilés à des représentants cultivables et 22,2% sont affilés à des représentants non cultivables alors que 18,6% sont considérés comme des nouvelles séquences ayant moins de 97% de similarité avec les plus proches.

Mots clès : Bacteria, Genetics, Biodiversity, Pollution.

#### Introduction

Les microorganismes jouent un rôle important dans la bioremédiation des milieux pollués par les hydrocarbures. La plupart des études s'intéressent à un nombre limité d'espèces bactériennes cultivables connues par leurs capacités dégradatives. Cependant, il serait plus intéressant d'étudier la composition des écosystèmes bactériens complexes pour contribuer à la compréhension des phénomènes de dégradation des hydrocarbures. L'émergence des techniques moléculaires liée au développement de la phylogénie moléculaire basé généralement sur l'ADNr 16S comme marqueur évolutif universel [1] a contribué à l'amélioration des recherches dans ce thème.

# Matériels et Méthode

Une approche moléculaire a été appliquée pour étudier la composition de la microflore bactérienne indigène adaptée à partir d'eau de mer polluée par les hydrocarbures pétroliers. La microflore adaptée (MA) a été utilisée dans des tests de dégradation in vitro d'un pétrole brut tunisien et les capacités dégradatives de cette microflore ont été déterminées. Une banque de clone a été construite après extraction d'ADN génomique, amplification par PCR du gène du 16S rDNA, clonage et séquençage. Le traitement des séquences (nettoyage et "contigage") a été effectué [2]. Les séquences chimériques sont au préalable recherchées [3]. Toutes les séquences ayant plus de 1200 nucléotides sont importées dans la base de données ARB, après avoir été comparées à la base de données GenBank grâce à une analyse de type BLAST. Lorsque le pourcentage d'homologie des séquences obtenues est supérieur ou égal à 97 %, ces séquences sont regroupées en OTUs (Unité Taxonomique Opérationnelle). La raréfaction de l'échantillon et les indices de diversités sont étudiés grâce au logiciel DOTUR.

#### Résultats et discussion

Les résultats de l'analyse de la composition de la microflore indigène acclimatée, obtenue par extraction directe des acides nucléiques totaux à partir d'eau de mer polluée par les hydrocarbures, a montré une hétérogénéité mise en évidence par la construction de la courbe de raréfaction relative aux séquences analysées. En effet l'analyse de cette courbe a montré que d'autant d'autre clone peuvent être séquencés. D'autre part, parmi les 94 clones analysés 59,2% sont affilés à des représentants cultivables et 22.2% sont affilés à des représentants non cultivables alors que 18,6ù sont considérés comme des nouvelles séquences ayant moins de 97% de similarité avec les plus proches représentant dans la base GenBank.

Quatre divisions du domaine *Bacteria* ont été représentées dans cette microflore : les *Protéobactéries* (*Alpha-, Beta- et Gamma-protéobactéries*) respectivement avec 40.8 %, 18,5%, 14,8%; les *clostridia* qui contribue avec 18,5 % ; les *Actinobacteria* (3,7%) et les *Flavobactérie* avec aussi (3,7%). L'ensemble des clones analysés sont regroupés en 27 OTUs et les pourcentages de similarité avec les plus proches parents sont comprises entre (92,12 % et 100%). La prédominance des *Protéobactérie* dans les zones contaminées par les hydrocarbures a été constatée par d'autres travaux [4].

Cette analyse phylogénétique montre des affiliations des séquences obtenues avec des phylums connus comme colonisateurs des milieux pollués par les hydrocarbures comme les *Pseudomonas*, *Marinobacter* 

*et Alcanivorax* [5]. Cependant plusieurs autres phylums sont considérés comme des nouvelles séquences qui n'ont jamais été cités dans la littérature et qui peuvent avoir un rôle non négligeable dans la dégradation des hydrocarbures.

Cette microflore a montré des hautes performances de biodégradation d'un pétrole brut de type zarzatine ; Ainsi après une dégradation de 28j les pourcentages de biodégradation sont respectivement : 92,6% pour les hydrocarbures saturés et insaturés non aromatiques (HNA) et 68,7% pour les hydrocarbures aromatiques (HCA).

#### Conclusion

Au terme de l' étude de la diversité bactérienne de la microflore indigène de l'eau de mer dans une zone polluée par les hydrocarbures pétroliers on peut conclure que l'analyse moléculaire de la diversité du gène16S rDNA, dans le domaine Bacteria, permet une meilleure compréhension de la contribution directe ou indirecte des différents groupes bactériens dans les phénomènes de biodégradation. Ainsi la connaissance de la composition réelle de la microflore du milieu pollué constitue une étape préliminaire dans la sélection des espèces à haute performance de dégradation dans une éventuelle bioremédiation des sites pollués par les hydrocarbures.

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Comité 5

# Ressources vivantes et écosystèmes marins

Co-Présidents : Bella Galil & Kostas Stergiou

# SOFT BOTTOM SIPUNCULANS IN ILDIR AND GERENCE BAYS (AEGEAN SEA)

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# Abstract

Soft bottom benthic samples were collected at 11 stations in Ildir and Gerence Bays at the depths 15-60 m between the years 2003 and 2006. A total of 480 individuals belonging to 3 species were encountered; *Aspidosiphon (Aspidosiphon) muelleri, Golfingia (Golfingia) vulgaris* and *Onchnesoma steenstrupii steenstrupii.* Among the biotopes, *Posidonia oceanica* was represented by the highest number of species (3 species). The most dominant and frequent species in the area was *Onchnesoma steenstrupii steenstrupii.* The biometrical features of specimens of the species found in this study were also given.

Keywords : Zoobenthos, Biometrics, Systematics, Aegean Sea, Eastern Mediterranean.

# Introduction

Thirty-three sipunculan species are known from the Mediterranean Sea (3), but the Turkish fauna is poorly known: Demir (1) and Ergen et al. (2) reported 2 and 4 species in the Sea of Marmara and Aegean Sea, respectively. The aim of this study was to identify the soft bottom sipunculans in two neigbouring bays in the Aegean Sea, and to investigate their distributional and biometrical features.

#### Material and Methods

The benthic samples were collected by a dredge and Van Veen Grap at Ildir (5 stations) and Gerence Bays (6 stations) at depths ranging from 15 to 60 m, between 2003 and 2006 (Figure 1). The samples were sieved through a 0.5 mm mesh, fixed with 10% formalin. In the laboratory, sipunculans were identified, counted and preserved in 70% ethanol. A number of biometrical features (lengths of trunk and introvert etc.) of the smallest and largest individuals of each species were measured by using an ocular micrometer.



Fig. 1. Map of the investigated area with location of sampling sites.

# Results and discussion

Faunistic analysis of 37 benthic samples collected in 11 stations in Ildir and Gerence Bays yielded a total of 480 specimens belonging to 3 species; Aspidosiphon (Aspidosiphon) muelleri Diesing, 1851 (Aspidosiphoniidae), Golfingia (Golfingia) vulgaris (De Blainville, 1827) (Golfingiidae) and Onchnesoma steenstrupii steenstrupii Koren & Danielssen, 1875 (Phascolionidae). Phascolosomatidae was the dominant family in the area (348 specimens; 72.5% of the total), followed by Aspidosiphonidae (131 specimens, 27.3%) and Golfingiidae (1 specimens, 0.2%), respectively. Among the biotopes, Posidonia oceanica was represented by the highest number of species (3 species) and sandy mud had the highest number of individuals (45.2%) (Table 1). Golfingia (G.) vulgaris occurred only on P. oceanica at 35 m (Table 1). Only Aspidosiphon (A.) muelleri was found between 10 and 20 m depth on sand and P. oceanica. In terms of the frequency values of the species, Onchnesoma steenstrupii steenstrupii ranked first, occurring in 26 samples (70.3%), followed by Aspidosiphon (A.) muelleri (48.6%) and Golfingia (G.) vulgaris (2.7%). Onchnesoma steenstrupii steenstrupii had the highest frequency score between the depth interval 41-60 m (88%). The majority of specimens of sipunculans were determined between 41 and 60 m. In the shallow waters (10-40 m depth), P. oceanica had the highest number of specimens of the sipunculans. The

Jaccard similarity index showed that there was a weak similarity between the co-occurrence of species in samples. The highest similarity score was found between *Aspidosiphon (A.) muelleri* and *Onchnesoma steenstrupii steenstrupii (32%)*.

Tab. 1. List of sipuncula species found in Ildir and Gerence Bays with the total number of their individuals at the depth intervals and on biotopes (Po: *Posidonia oceanica*, S: Sand, Sm: Sandy mud, Ms: Muddy sand).

| Depth Interval (m)                      |    | 1  | 0-20 |    |    | 2  | 1-40 |    |    | 4   | 1-60 |    |
|-----------------------------------------|----|----|------|----|----|----|------|----|----|-----|------|----|
| Biotope                                 | S  | Sm | Ms   | Po | s  | Sm | Ms   | Po | s  | Sm  | Ms   | Po |
| Golfingia (G.) vulgaris                 | -  | -  | -    | -  | -  | -  | -    | 1  | -  | -   | -    | -  |
| Aspidosiphon (A.) muelleri              | 12 | -  | с÷   | 73 | -  | -  | -    | 19 | 15 | 4   | 8    | -  |
| Onchnesoma steenstrupii<br>steenstrupii | -  | ÷  | -    | -  | 12 | -  | ÷    | 2  | 52 | 213 | 69   | -  |

The biometrical features of the specimen (1 specimen) of *Golfingia* ( *Golfingia*) *vulgaris* in the area are; trunk 6 mm long, 1.4 mm wide; introvert 2.7 mm long, 0.7 mm wide; papillae on base of introvert 23-40  $\mu$ m height, 18-35  $\mu$ m in diameter; papillae on caudal end of trunk 38-45  $\mu$ m in length, 25-33  $\mu$ m in diameter; hooks 53-105  $\mu$ m in height. This species is distributed in the Atlantic, Pacific and Indian Oceans and, Mediterranean Sea at depths ranging from 0 to 6000 m depths (see 4).

The biometrical features of specimens (131 specimens) of Aspidosiphon (Aspidosiphon) muelleri in the area are; trunk 2.9-5.6 mm long, 1.2-1.6 mm wide; introvert 3-6.8 mm long, 0.4-0.5 mm wide; introvert longer than trunk length; introvert with 30-50 rings; bidentate hooks 13-30  $\mu$ m tall, 15-30  $\mu$ m wide; unidentate hooks 15-25  $\mu$ m long, 15-28  $\mu$ m wide; longitudinal grooves on anal shield numbering 13-20; radial grooves on caudal shield numbering 18-24. This species was previously reported from the northeast Atlantic, Mediterranean, Red Sea, and Indian and Pacific Oceans at the depth interval 0-1470 m (see 4).

The biometrical features of the specimens (348 specimens) of *Onchnesoma steenstrupii steenstrupii* in the are; the spherical trunk, 0.7-1.2 mm long, 0.5-0.8 mm wide; introvert partly everted, 0.5-5 mm long, 0.2-0.4 mm wide; small wart-like papillae on surface of trunk 13-18  $\mu$ m long, 15-25  $\mu$ m in diameter; trunk has 20-24 keel-like structures; some specimens with elliptical eggs; longer axis 110-145  $\mu$ m in diameter, smaller axis 90-120  $\mu$ m in diameter. This species is distributed in the North Atlantic, south eastern Atlantic, western Pacific and south western Indian Ocean, Mediterranean Sea between 0 and 3362 m depths (see 4).

The future studies to be undertaken in the region will shed more light on the real biodiversity of sipunculan species and their functional roles in benthic communities.

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# STATUS OF EURO-MEDITERRANEAN COASTAL MARINE HABITATS: LOSS AND TRENDS

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# Abstract

We have reviewed estimates of large-scale trends in the distributions and status of Euro-Mediterranean coastal habitats. Conspicuous declines of coastal wetlands, seagrasses, biogenic reefs, and complex macroalgae have been observed in several countries. In some regions, most valuable habitats were already severely degraded or driven to virtual extinction well before 1900. Nowadays less than 15% of the coastline is considered in "good" condition. Those fragments of native habitats that remain are under threat, and their management is not informed by adequate knowledge of their distribution and status

Keywords : Biodiversity, Coastal Management, Ocean History.

In terrestrial environments, understanding and abating the effects of habitat loss and fragmentation are a huge focus in science, conservation and management [1]. Habitat loss is also well recognized as an important threat in the marine environment [2] but has not been as much a focus of science and conservation as in terrestrial environments.

We have compiled and reviewed estimates of large-scale trends in the distribution and status of coastal habitats along European coastlines [3], which has included the Mediterranean and Black Sea. Over the centuries, land reclamation, coastal development, overfishing and pollution have nearly eliminated coastal wetlands, seagrass meadows, shellfish beds, biogenic reefs and other productive and diverse coastal habitats. It is estimated that every day between 1960 and 1995, a kilometre of coastline was developed, with the greatest urban developments occurring along the Euro-Mediterranean coasts. More than 50 % of the Mediterranean coasts are dominated by concrete with >1500 km of artificial coasts, of which about 1250 km are developed for harbours and ports [4]. Most countries for which documentation is available have estimated losses of coastal wetlands exceeding 60% of original area, with peaks above 80 % for countries such as Italy and France [3]. Documentation of seagrass loss is more limited, but there are suggestions that there may have been historical losses of Posidonia oceanica ranging from 40 to 80%. Conspicuous declines, sometimes to virtual local disappearance of fucoids and other complex macroalgae have been observed along the coasts of the Mediterranean and Black Sea.

A few dominant threats have led to these losses over time [3]. The greatest impacts to wetlands have consistently been land claim and coastal development. The greatest impacts to seagrasses and macroalgae are presently associated with degraded water quality while in the past there have been more effects from destructive fishing and diseases. Coastal development remains an important threat to seagrasses. For biogenic habitats, some of the greatest impacts have been from destructive fishing and over- exploitation with additional impacts of disease, particularly to native oysters. Coastal development and defence have had the greatest known impacts on soft sediment habitats with a high likelihood that trawling has affected vast areas. The concept of 'shifting baselines', which has been applied mostly to the inadequate historical perspective of fishery losses, is extremely relevant for habitat loss more generally. Most habitat loss estimates refer to a relatively short time span primarily within the last century. However, in some regions, most estuarine and nearshore coastal habitats were already severely degraded or driven to virtual extinction well before 1900. Native oyster reefs were ecologically extinct by the 1950s along many coastlines and in many bays well before that. These shellfish reefs are one of the most endangered coastal habitats, but some of the least protection is being directed at them. Nowadays less than 15 % of the European coastline is considered in 'good' condition [5], with the Mediterranean coastlines among the most severely depleted. Those fragments of native habitats that remain are under continued threat, and their management is not generally informed by adequate knowledge of their distribution and status.

There are many policies and directives aimed at reducing and reversing these losses but their overall positive benefits have been low. Further neglecting this long history of habitat loss and transformation may ultimately compromise the successful management and future sustainability of those few fragments of native and semi-native coastal habitats that remain in the Mediterranean and Black Sea.

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# ABUNDANCE OF SCOMBRID LARVAE IN MERSIN BAY (NE MEDITERRANEAN)

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# Abstract

Distribution and abundance of Scombrid larvae were determined for the period January 1998-2001, at three stations in Mersin Bay (NE Mediterranean). Scombrid larvae were composed of a total of 10 taxa (6 species, 2 genera and 2 families). Among the most abundant scombrid species were the bluefin tuna Thunnus thynnus, observed during June-August at offshore station, the albacore Thunnus alalunga, found during June-September at the second station, and Atlantic mackerel Scomber scombrus, observed at the offshore station during January-April. These species together contributed 48% of the total scombrid larvae catch. Keywords : Ichthyoplankton, Larvae, Eastern Mediterranean.

# Introduction

Scombrid species are of high commercial value to fisheries, world-wide [1]. This family contains 15 genera and 51 species all around the world [1] of which only 10 genera, including 12 species, live in the Mediterranean [2]. The already published data on the ichthyoplankton of the northeastern Mediterranean Turkish waters is limited [3]. The distribution and abundance of Thunnus thynnus, Auxis rochei and Euthynnus alletteratus larvae have been reported only for a short period (in June) for this region [4]. This work aims to study the abundance, distribution and spawning period of all species present over a period of three years.

# Material and methods

Sampling was performed in Mersin Bay (NE Mediterranean) at three stations (34° 16'E, 36° 33'50 N; 34° 18' E, 36° 32'N; 34° 22' E, 36° 30'N) which are located within about 10 km from the coast. Samplings were made from January 1998 to June1999 weekly all stations (20, 80, 100 m depth) and from July 1999 to January 2001 biweekly at two stations (20, 100 m depth). Vertical net tows were carried out from bottom to surface with Nansen net (112  $\mu$ m mesh size). The collected ichthyoplankton material was then preserved in 5% neutralized formalin. Scombrid larvae were separated from zooplankton under a stereoscopic microscope in the laboratory.

#### Results and discussion

10 different scombrid larvae were identified from the region throughout the study period. A total of 68 scombrid larvae were collected at three stations (Table 1).

Tab. 1. Abundance of Scombrid larvae during 1998-2000 in Mersin Bay (NE Mediterranean).

|                                     |       |      |      | Stat  | ions |      |       |      | -     |
|-------------------------------------|-------|------|------|-------|------|------|-------|------|-------|
|                                     | 1     | 2    | 3    | 1     | 2    | 3    | 1     | 3    |       |
| Species                             | 100 m | 80 m | 20 m | 100 m | 80 m | 20 m | 100 m | 20 m | Total |
|                                     |       | 1998 |      |       | 1999 |      | 20    | 00   | -     |
| Euthynnus alletteratus (Raf., 1810) |       | 2    |      |       |      |      |       |      | 2     |
| Katsuwonus pelamis (L., 1758)       | 2     | -    | -    | -     | -    | -    | -     | -    | 2     |
| Scomber japonicus (Hout., 1752)     | -     | 6    | 1.0  | -     | 1    | 1    |       |      | 8     |
| Scomber scombrus (L., 1758)         | 6     | 1    | 1.1  |       |      | 2    |       |      | 9     |
| Scomber sp.                         |       | 6    |      | -     |      |      |       |      | 6     |
| Thunnus alalunga (Bonn., 1788)      | 100   | 7    | 1    |       |      | 1    | 1     |      | 10    |
| Thunnus thymnus (L., 1758)          | 4     | 4    |      | -     | 2    | 1    | 3     | -    | 14    |
| Thunnus sp.                         | -     | 4    |      | -     | -    |      |       | -    | 4     |
| Scombridae sp1.                     | -     | 5    | -    | -     | -    | -    | 1     | -    | 6     |
| Scombridae sp2.                     | 1     | 2    |      |       | 1    |      | 2     | 1    | 7     |
| Total                               | 13    | 37   | 1    | -     | 4    | 5    | 7     | 1    | 68    |

Scombrid larvae were more abundant at the second station during sampling except from July 1999 to January 2001 (Fig. 1). Since the larvae were found at low number at the coastal station, it is concluded that they prefer offshore waters. Contribution of the bluefin tuna T. thynnus larvae to the total was 21% of all scombrid larvae collected, followed by albacore Thunnus alalunga (14.5%) and Atlantic mackerel Scomber scombrus (12.7%). Larvae of bluefin tuna were abundant during June-August with peaks during June at the first station (offshore). Albacore larvae were abundant from June to September at the second station in 1998. Previous works have also reported similar high values for this species during this period for different areas of the Mediterranean [5]. During 1998-1999, larvae of Atlantic mackerel were only found between January-April, being most abundant at the offshore station. Larval abundance of chub mackerel Scomber japonicus peaked during March at the second station in 1998. Little tunny E. alletteratus at the second station in July and skipjack tuna Katsuwonus pelamis at the offshore station in June were found in relatively low numbers only during 1998. In general, Scombrid larvae were more abundant at the second station in 1998. Tuna larval survey conducted earlier in the Levantine basin has revealed three species (bluefin tuna, bullet tuna and little tunny) of scombrid larvae for June 2004.



Fig. 1. Weekly changes in abundance of Scombrid larvae at stations 1, 2 and 3 during 1998-2001.

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# ALIEN AND INVASIVE SEAWEEDS DISTRIBUTION ALONG THE TURKISH COAST OF THE AEGEAN SEA

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# Abstract

The distribution of alien invasive species, *Caulerpa racemosa var. cylindracea*, *Stypopodium schimperi* and *Halophila stipulacea*, was observed along the Aegean coastline. The distribution areas of these species were also mapped. *Keywords : Aegean Sea, Algae, Migration.* 

### Introduction

Mediterranean and Aegean coastline has a very rich biodiversity however it is threatened and affected from intensive coastal settlement, transportation, tourism, industrial fisheries, aquaculture activities and alien invasive species which enters the Mediterranean from channels (Suez and Gibraltar). At the beginning of this century the number of lessepsien migrated species was at level of tens but nowadays this number comes to hundreds and it is thought to reach to thousands at 2020 [1-2].

*Caulerpa racemosa var. cylindracea* was observed to be distributed intensely among the other alien and invasive species along the southern half of the Aegean Sea. In this study, special emphasis was given to *Caulerpa racemosa var. cylindracea* because of the problems this species creates with regard to biodiversity. The distribution of these species at the base stations were mapped with the aid of GPS. The spreading charasteristics of these three species were compared.

# Materials and Methods

In this study, the alien invasive seaweeds distribution areas were observed, mapped, sampled and water quality parameters were measured. *Caulerpa racemosa var. cylindracea* is the species which affects the biodiversity and distributes more than other observed species, so three base stations where this species shows an intense distribution in the northern, central and southern Aegean Sea were determined. Sampling were taken place seasonally to indicate these species life cycles and effects to the ecosystem by scuba diving. The diving equipments, underwater cameras, fishermen observations and trawl materials were used for the investigation. The deep sea observations were made by ROV, so the deepest points of distribution were determined. GPS was used to map the distribution of the species at the sampling sites.

#### Results and Discussion

It is observed that, alien invasive species have negative effect on biodiversity and ecosystem[1-3]. Besides that, the new distribution areas of *Caulerpa racemosa var. cylindracea*, *Stypopodium schimperi* and *Halophila stipulacea* are determined as an addition to previous studies[4-6].

As a result, among alien invasive species Caulerpa racemosa var. cylindracea observed intensely along Aegean Sea coasts especially at the southern half of the coastline. While because of its tropical origin Stypopodium schimperi's northernmost distribution range was Cesme coasts, subtropical Halophila stipulacea showed more northernly range until Dikili coasts. When the spreading characteristics of these three species were compared, Caulerpa racemosa var. cylindracea was determined to be the fastest spreading weed, Stypopodium schimperi was markedly faster, and Halophila stipulacea was reasonably faster. While first two species affects the biota and biodiversity of the site that they occur greatly, Halophia stipulacea was found to be spreading without affecting the surrounding biota. When the spreading kinetics were taken into account, Caulerpa racemosa var. cylindrecea has the capacity to influence the whole Turkish Mediterranean coasts. Furthermore, with such kind of distribution and spreading mechanism, the eradication of the species has not been foreseen. Under the light of the present information, the distribution of this algea should be monitored with a big scale programme.



Fig. 1. Caulerpa racemosa var. cylindracea.

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# GILL HISTOLOGY OF PATELLA LINNEAUS, 1758 (MOLLUSCA: GASTROPODA)

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# Abstract

The gill structure was studied in representative species of genus *Patella*, using histology. Secondary gill consisted a single layer of wavy lamellae covered with cuboidal end interspersed columnar epithelium. Hemocytes and nefrocytes were commonly observed. This normal morphological characteristics are to be a reference point for further research in natural and aquacultured specimens of this genus. *Keywords : Mollusca, Gastropods, Rocky Shores.* 

Introduction - Genus *Patella*, known as limpet, is a widespread gastropod on the rocky shores and is characterized by a cone-shaped shell. These organisms become more important as serving an alternative food with increasing human populations in the world. The respiration in gastropods is generally achieved by gills located within the mantle cavity and regarded as a pallial organ [1]. In the *Patellidae*, however, the respiratory organ have lost ctenidial structure and become monobranchiate body [2-3]. The respiratory current is created by a complete ring of single layer of secondary pallial gills [1]. The external effects, before progressing into the visceral body, are first initiated on the gills as they are the first contact point with water except the thick shells and the foot of the animal. The main purpose of this study is to define the normal structure of the

*Patella* gills and to provide a basis to interpret more efficient results in further research on natural or cultured populations of these organisms.

Materials and Methods - Specimens of *Patella caerulea* and *P. rustica* were collected from Antalya Bay (between  $36^{\circ}53'04.26 \text{ N}-36^{\circ}36'25.22 \text{ N}$  and  $31^{\circ}46'31.30 \text{ E}-30^{\circ}42'03.62 \text{ E}$ ) on Southwestern coast of Turkey. Gills were dissected and fixed in Bouin's solution. Samples were taken through graded alcohol, cleared in xylene and embedded in wax. Sections were stained by Ehrlich's hematoxyline [4], examined by light microscopy and photographed at 3X digital zoom.

Results - The monobranchial structure extends along the pallial groove. The gill has long slender tubules which are are anchored to the body surface by the mantle border and shows no ramification. Two gill folds face each other along the sagittal plane.



Fig. 1. Light micrograph showing general organization of pallial gills of *Patella*.

The tubules afferent openings are clearly seen in oblique sections (Fig 1). The lamellae have wavy borders. The epithelium covering the external face of the gill folds is made made up by a single layer of large, cuboidal cells, but some columnar cell groups are scatterred among them with a puff-like appearance forming bursicles (Fig. 2a). Epithelial cells, with very thin cuticle layer, are mostly equipped with cilia. None chitonous support for the filaments has been observed. But thin muscle stripes are attached to each lamella separately. Vascular channels are divided into hemocoelic spaces by trabecula. Large number of hemocytes and some nephrocytes, cells of vascular system, are commonly observed within the vascular spaces of the gill folds (Fig. 2b).

Discussion - Pallial structures have been evolved into secondary gills in limpets [5], although ctenidium is well developed in other Patellogastropods [6]. The wavy border of each gill filament have increased the contact surface with sea water. The free movement was achieved by muscle fibres under control of pallial nerves as no skeletal rod exist in Patellacea [2]. Hemocytes are the best characterized cells in hemocoelic areas of the *Patella* gills. They have been described to play mediating role in immune function in mollusks [7-9].



Fig. 2. Histological micrograph of gill lamellae of *Patella*; a) Puffs of columnar epithelia. b) Hemocytes (thick arrow) and nephrocytes (long arrow) within vascular spaces covered by cuboidal epithelia (\*).

Histological observations of the respiratory organ is means to asses the adequacy of the environment. The increase in the industrialization and world population presents antropologic effect on natural populations. Once the anatomic and physiological characteristics of normality is known, they establish a reference point for further research to challenge with unnatural effects as well as to achieve a good management for development of aquaculture of alternative organisms.

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# ENVIRONMENTAL EFFECTS OF THE THREE FISH FARMS IN IZMIR BAY (AEGEAN SEA-TURKEY) ON WATER COLUMN AND SEDIMENT

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# Abstract

In order to detect environmental impacts of three fish farms; water and sediment samplings were carried out on a monthly basis between June 2001 and May 2002. Physico-chemical variables, chlorophyll -*a*, particulate organic carbon values of water samples, organic carbon values of sediment samples were investigated. We found that each of the fish farms affected the marine environment adversely, but the effects of the fish farm situated in a less protected cove compared to the other two were more apparent due to wrong feeding strategies and its shallow depth.

Keywords : Aegean Sea, Aquaculture, Monitoring, Pollution.

# Introduction

Turkish efforts in aquaculture started in 1970's and developed rapidly with the contribution of marine aquaculture in 1980's. Uncontrolled expansion of fish farms have led to environmental problems [1]. Uneaten feeds and feces adversely effected water column and sediment especially in closed and semi-enclosed coves. Our aim was to determine environmental effects of the three fish farms located in the Izmir Bay.

#### Materials and Methods

Samplings were carried out at three fish farms in Izmir Bay (Aegean Sea-Turkey) between June 2001 and May 2002 on a monthly basis (Fig. 1). All farms produced sea bream (*Sparus aurata*) and sea bass (*Dicentrarcus labrax*); 60, 240 and 160 tons/year and depths in the farms were 8, 20 and 10 m. respectively (Farm 1, 2 and 3). Two stations were chosen for sampling in each farm, one at the cage unit and a control station 200 meters away. Water samples were collected by Nansen Sampling Bottle, sediment samples were obtained using an Van-Veen grab. Visibility was measured by Secchi disc. Temperature and dissolved oxygen (Winkler titration) measurements were carried out *in situ*, pH, salinity (Mohr-Knudsen) analyses were done at the laboratory. Nutrients, chlorophyll-a and Particulate organic carbon (POC) concentrations were obtained according to standard methods [2]. Organic carbon values of sediment were determined as described [3]. In order to detect statistical difference between samples at the cage and the control stations, T-test was performed.



Fig. 1. Map showing the location of the studied fish farms.

# Results and Discussion

Results of analyses of the three fish farm stations (cage and control) are given in table 1. Temperature, salinity and pH values fluctuated throughout the sampling period in relation to seasonal changes. DO concentrations were low in the summer months at all stations due to increased temperature and there were no significant differences between cage and control stations. Secchi disc readings were higher at all control stations. Nitrate+nitrite values were higher at cage stations than control stations in summer samplings in all fish farms. But these differences were not important statistically.

Tab. 1. Range of variables troughout the sampling period in the fish farms.

|                      |             | 1           |             | 2           | 3           |             |
|----------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Variables            | Cage        | Control     | Cage        | Control     | Cage        | Control     |
| Temperature (°C)     | 14,0-27,0   | 14,5-26,0   | 14,5-27,2   | 13,8-27,0   | 15,0-26,5   | 15,0-27,0   |
| РН                   | 7,76-8,13   | 7,68-8,10   | 7,54-8,20   | 7,60-8,29   | 7,75-8,12   | 7,74-8,12   |
| Salinity (ppt)       | 33,93-41,54 | 33,93-41,54 | 33,64-40,95 | 33,35-42,41 | 33,93-42,12 | 33,64-42,12 |
| Secchi disc (m)      | 6,83-7,88   | 8,10-15,75  | 3,15-8,93   | 4,73-20,10  | 3,68-9,45   | 7,88-17,85  |
| DO (mg/L)            | 6,0-10,0    | 5,8-8,4     | 6,0-8,4     | 6,0-9,2     | 6,0-7,6     | 6,0-9,2     |
| Nitrate+Nitrite (µM) | Nd-5,77     | Nd-3,97     | 0,04-4,22   | Nd-4,56     | Nd-5,21     | Nd-6,43     |
| Ammonium (µM)        | Nd-11,40    | Nd-3,13     | Nd-5,76     | Nd-4,01     | 0,24-2,25   | Nd-1,80     |
| Phosphate (µM)       | Nd-0,87     | Nd-0,62     | Nd-0,87     | Nd-0,46     | 0,07-0,85   | Nd-1,20     |
| Silicate (µM)        | Nd-7,47     | Nd-5,66     | Nd-9,56     | Nd-11,10    | Nd-5,45     | 0,06-5,83   |
| Chl-a (µg/L)         | Nd-2,56     | Nd-2,56     | Nd-3,36     | Nd-2,56     | Nd-4,17     | Nd-4,59     |
| POC (mg/L)           | 0,174-1,094 | 0,226-1,096 | 0,236-1,044 | 0,132-1,012 | 0,264-1,000 | 0,219-0,953 |
| Org. carbon (%)      | 2,42-10,54  | 0,21-1,40   | 0,66-3,67   | 0,80-2,04   | 2,50-3,50   | 0,48-1,35   |

Significant increases in concentrations of ammonium were detected at cage stations over control stations in the first and the third farms. Phosphate concentrations were significantly higher at cage station only in the first farm. However, no significant differences were found between cage and control stations for chlorophyll-a and POC. This lack of POC and chl-a respond to nutrients is consistent with other studies in the Mediterranean [4,5]. In the first and third fish farms, organic carbon concentrations at cage stations were very significantly higher than control stations. Similar increased nutrient and organic material concentrations at cage stations have been also reported in the Mediterranean [4, 5, 6]. We found that the fish farms examined, impacted adversely the marine environment, and although the first fish farm was situated in a less protected cove compared to the other two farms, its effects were more apparent due to overfeeding and shallow depth of the area.

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# CROISSANCE ET REPRODUCTION D' ARTEMIA SP. DE LA SEBKHA EZ-ZEMOUL (ALGERIE NORD-EST) DANS LES CONDITIONS D'ELEVAGE

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# Résumé

La population d'élevage d'*Artemia* de la Sebkha Ez-Zemoul  $(34^{\circ}03'N - 06^{\circ}20'E)$  est caractérisée du point de vue de sa croissance et de sa reproduction. Le taux de croissance est de 0,33 mm/jour. Les femelles, plus grandes que les mâles, atteignent leur première maturité sexuelle à une longueur de 6,54 mm (âge = 22 jours) et produisent en moyenne 13 cystes/portée. La population, composée essentiellement d'individus mâles (SR = 1,86), est bisexuelle et ovipare.

Mots clès : Aquaculture, Crustacea, Growth, Reproduction.

# Introduction

Le genre *Artemia* est un complexe d'espèces bisexuelles et parthénogénétiques qui vivent dans les milieux hyperhalins, situés généralement dans des régions arides et semi-arides. Au sein de la même espèce, les populations de différentes origines ont des réponses physiologiques différentes en fonction des conditions du milieu qu'elles fréquentent, se traduisant par des phénotypes différents [1]. Les nauplii de ce crustacé sont très utilisés en larviculture de poissons marins. En Algérie, les travaux effectués sur ce crustacé sont relativement rares et assez récents [2, 3, 4, 5]. Dans le présent travail, la croissance et la reproduction de la population d'élevage d'*Artemia* de la Sebkha Ez-Zemoul sont abordées.

# Matériel et méthodes

Des cystes (0,2 g) originaires de la Sebkha Ez-Zemoul ( $34^{\circ}03$ 'N -  $06^{\circ}20$ 'E) sont incubés dans une eau marine (salinité = 37 psu, température =  $25^{\circ}$ C) durant 30 h. Les nauplii récupérés dés l'éclosion sont mis en élevage dans les mêmes conditions, à raison de 1500 ind/l. Ils sont nourris de levure de bière (85%) et d'un complexe vitaminé [6]. Tous les trois jours, les individus sont mesurés de la tête à l'anus après anesthésie au chloroforme. Le taux de croissance est mesuré par le gain moyen de taille linéaire (en mm) par jour.

Le sex-ratio est exprimé par le rapport du nombre de mâles sur le nombre de femelles. La taille à la première maturité sexuelle est déterminée lorsque 50% des femelles présentent des signes de reproduction. Le mode de reproduction est défini en fonction de la dominance des cystes (oviparité) ou des nauplii (ovoviviparité). Les sacs ovigères sont disséqués sous une loupe binoculaire et le nombre moyen de cystes ou de nauplii par femelle est compté et représente la fécondité.

#### Résultats

Le taux de croissance est de 0,33  $\pm$  0,3 mm/j. Le stade juvénile est le plus long (10 jours) où les métanauplii passent d'une longueur totale de 1,73 mm à 5,11 mm pour devenir des pré-adultes. Le sexe se différencie à partir de 22 jours.

Les femelles sont plus grandes que les mâles (7,98 mm contre 6,78 mm; t<sub>obs</sub>= 2,72; P  $\leq$  0,05). Le sex-ratio est de 1,86. La taille à la première maturité sexuelle est de 6,54 mm et correspond à un âge de 24 jours. Le mode de reproduction est l'oviparité (100 %). La fécondité est de 13,5  $\pm$ 5,12 cystes/portée. Elle est significativement corrélée à la longueur totale des individus (r = 0,897; P  $\leq$  0,05).

#### Discussion

Le taux de croissance chez la population d'élevage d' *Artemia* de la Sebkha Ez-Zemoul est plus élevé que celui des populations mexicaines et celles de San Francisco Bay appartenant à l'espèce *A. franciscana* (0,159 et 0,183 mm/j) [7]. Les femelles sont plus grandes que les mâles ce qui est commun chez le genre *Artemia* [1]. Les adultes d'élevage de la Sebkha Ez-Zemoul sont plus petits de taille que les sauvages [5] et sont parmi les plus grands en comparaison avec les autres populations méditerranéennes [3, 6, 8, 9].

Le sex-ratio est en faveur des mâles comme chez la majorité des populations bisexuelles d' *Artemia* [1]. Les femelles sauvages de la Sebkha Ez-Zemoul deviennent matures à une taille (8 mm) plus importante que celle de la population d'élevage [5]. Elles sont plus fertiles (13-105 zygotes/portée) et se reproduisent jusqu'à 10% par ovoviviparité [5]. Les femelles d'élevage de la saline d'Arzew (Nord-Ouest algérien) [2] et celles d'Egypte [6] sont également plus fertiles (40 et entre 29 et 40 zygotes/portée respectivement). Selon [9], les conditions du milieu, en particulier la salinité, ont une influence directe sur la morphométrie et la reproduction du genre *Artemia*. Son augmentation entraîne une réduction de la longueur totale de la fécondité et une maturité précoce [9].

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# MORPHOMETRIC ANALYSIS OF THE DEEP FISH CHLOROPHTHALMUS AGASSIZI IN THE IONIAN SEA(GREECE )

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# Abstract

Morphometric relationships of *C. agassizi* (B.1848) from the Ionian Sea are presented for the first time and may be a useful reference for future studies. Analysis of Variance indicates significant relationships for several parameters (p<0.01). *Keywords : Eastern Mediterranean, Deep Sea Ecology, Fisheries.* 

C. agassizi is the dominant species in the uppermost layer of Ionian Sea. Although it undoubtedly plays an important role in the eastern Mediterranean deep-fish assemblages [1, 2], information is still scarce regarding its population status, biology and habitat needs. In the Ionian Sea it has been studied monthly over the course of a year recording biometry, growth, reproduction and dietary requirements [3]. Morphologic variation between populations is used in stock identification. Community structure, stock identification, and productivity are important factors in the development of management strategies as well as for experimental design of sampling programs [4]. The objective of this paper is to present morphometric relationships of the species from the Ionian Sea. Specimens were collected monthly from December 1996 to November 1997 by a commercial bottom trawler using a net with a cod end mesh size of 14 mm from knot to knot. Sampling was carried out at 92 stations between 300 and 800 m depths, covering an area of about 1500  $\mathrm{km}^2.$  As the species is synchronously hermaphroditic, data collection did not record gender. In all, 2309 specimens were measured. All morphometric relationships between parameters were calculated using linear regression. To test for isometry, the allometric index values obtained were compared with the expected values using a student t- test. Morphometric ranges for various parameters were: TL (total length): 48-201 mm (SD=  $\pm 30.6$ ); the FL (fork length): 45-181 mm (SD=  $\pm 27.3$ ); SL (standard length): 41-169 mm (SD=  $\pm 25.4$ ); HL (head length): 11-52 mm (SD=  $\pm 7.7$ ); BH (body height): 4-35 mm (SD=  $\pm 4.9$ ); DFL (length of dorsal fin): 3-19 mm (SD=  $\pm$ 3.9); D\_AL (distance from the end of the dorsal fin till the origin of the adipose fin): 13-144 mm (SD=  $\pm 8.2$ ). All morphometric relationships are summarized in Table 1.

Tab. 1. Relationships and allometry of *C. agassizi* measured characters. N=number of individuals, SD=standard deviation of the slope b, t=values of the student's t-test for the type of allometry (Ho:b=1 for all the occasions). In each relationship P<0.01.

| Relationship | Equation                   | N    | Allometry | $r^2$ | SD(b) | t        |
|--------------|----------------------------|------|-----------|-------|-------|----------|
| TL-SL        | SL= -0,6785 + 0,9989 * TL  | 2304 | Isometry  | 0,998 | 0,046 | -1,15    |
| TL-FL        | FL = -0,2002 + 0,8942 * TL | 2283 | Isometry  | 0,998 | 0,045 | 0,21     |
| FL-SL        | FL = 0,0312 + 1,0002 * SL  | 2282 | Isometry  | 0,998 | 0,038 | 0,27     |
| HL-TL        | HL= -0,7073 + 0,2395 * TL  | 2223 | Negative  | 0,931 | 0,065 | -551,61  |
| HL-FL        | HL= -0,5801 +0,2673 * FL   | 2202 | Negative  | 0,93  | 0,073 | -469,68  |
| HL-SL        | HL= -0,5678 + 0,2876 * SL  | 2213 | Negative  | 0,932 | 0,077 | -453,22  |
| BH- TL       | BH= -2,9822 +0,1407 * TL   | 2224 | Negative  | 0,809 | 0,068 | -596,81  |
| BH- FL       | BH= -2,9385 +0,1574 * FL   | 2199 | Negative  | 0,811 | 0,076 | -520,6   |
| BH-SL        | BH= -2,9459 + 0,1692 * SL  | 2222 | Negative  | 0,81  | 0,082 | -478,86  |
| DFL-TL       | DFL=-0,6498 + 0,0958 * TL  | 2232 | Negative  | 0,918 | 0,029 | -1493,66 |
| DFL-FL       | DFL=-0,6013 + 0,1069 * FL  | 2209 | Negative  | 0,918 | 0,032 | -1311,72 |
| DFL-SL       | DFL=-0,6021 + 0,1150 * SL  | 2231 | Negative  | 0,915 | 0,035 | -1194,32 |
| D_AL-TL      | D-AL=1,4620 + 0,2599 * TL  | 2214 | Negative  | 0,962 | 0,051 | -682,84  |
| D_AL-FL      | D-AL=1,6038 + 0,2899 * FL  | 2196 | Negative  | 0,961 | 0,058 | -573,74  |
| D_AL-SL      | D-AL=1,5086 + 0,3127 * SL  | 2221 | Negative  | 0,963 | 0,061 | -530,96  |

Three relationships (TL- FL; TL- SL; FL-SL) indicated an isometric growth while all the others indicated negative allometric growth. In figure 1 the relationships between HL- TL, BH-TL, DFL- TL and D\_AL-TL are presented. The relationships between the different lengths of the species (TL, FL, SL) showed  $r^2$  =0.998. Statistically significant relationships were observed in all cases. Unfortunately, there is no any other morphometric information for this species, except some data available at www.fishbase.org where the relationship TL-FL: b=1.113 and TL-SL:

b=1.151 but the measurements were based on only two individuals. Future studies on stock identification need to be conducted over a larger study area as population structure is considered a basic element of conservation biology and finally for fisheries management. Poor understanding of the biology of fishes in a fishery management could lead to dramatic changes in the biological attitudes and productivity of species [4].



Fig. 1. Relationships of head length (HL), body height (BH), dorsal fin length (DFL) and distance dorsal-adipose fin with the total length of C. *agassizi* (TL).

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# THE ASCIDIA STYELA PLICATA AS A NATURAL EUTROPHICATION CONTROL. PRELIMINARY RESULTS OF AN EXPERIMENTAL APPROACH

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# Abstract

The potential of the solitary ascidia *Styela plicata* as a natural eutrophication control was investigated at the inner Thermaikos Gulf. Experimental work was carried out in the laboratory to estimate filtration efficiency, and in the field to study the colonization potential. *S. plicata* specimens halved the original concentration of particulate organic matter in about 2 hours, and successfully colonized a variety of artificial substrates within 3 months. These results support the abilities of this species as biological filter. *Keywords : Aegean Sea, Tunicata, Eutrophication, Diet, Recruitment.* 

# Introduction

Suspension feeders dominate benthic communities in eutrophic environments [1]. In Thermaikos Gulf the species *Styela plicata* (Lesueur, 1823) is among the dominant biota, both in terms of population density and expansion [2]. The purpose of this work was to investigate the abilities of *S. plicata* as a natural eutrophication control, by estimating the filtration efficiency, *i.e.* the amount of retained particulate organic matter (POM), and the colonization success on various artificial substrates.

# Materials and Methods

Thirty specimens of *Styela plicata* were collected with SCUBA diving from the inner Thermaikos Gulf, weighted and transferred to three experimental aquariums (10 each) with continuous airflow. After three days of acclimatization, 15g of phytoplankton were added in two aquariums (the third one served as control). Three water samples (100 ml each) were collected from each aquarium at 30-min intervals, for the estimation of POM [3]. To study the colonization of *S. plicata*, ropes (2 x 10 m, each), wooden and plastic plates (3 replicates of 30 x 30 cm each) were deployed (40° 30'49" N 22°54'25" E) at 10 m depth in March 2005 (Figure 1), and visually sampled every 15 days for 6 consecutive months.



Fig. 1. Map of the study area and location of experimental artificial sub-strates.

# Results and Discussion

The filtration efficiency of *Styela plicata* was equal at both experimental aquariums (Krüskal-Wallis statistic 6.48, p>0.05). Mean concentration of particulate organic matter (POM) dropped within the first two hours of the experiment to 50% of its original level, showing that *S. plicata* can assimilate half of the input food (15g POM) in about two hours. Thereafter POM started to increase again and stabilized to a lower concentration than the original input (around 9g POM), as the specimens started to produce faeces [4] and the experimental aquariums were closed circuits, so the seawater was not renewed. The colonization process started within the first 15 days with the development of the biological film. Thereafter, and within the first month, organic matter started to accumulate as well as the eggs of squids and cuttlefishes. Next, a dense population of the amphipod *Corophium sextonae* appeared, followed by *Mytilus galloprovincialis* recruits. Finally, after about 2 cm) were recorded. These results, although

preliminary, support the use of *Styela plicata* as a biological filter to reduce particulate organic matter. Considering the importance of the species as human food (Japan) and fishing bait (Europe), the produced biomass can be exploited respectively [5].

#### Acknowledgements

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# DENSITY, DISPERSION AND GENETIC STRUCTURE OF *PARACENTROTUS LIVIDUS* (LAMARCK, 1816) NATURAL STOCKS IN THE SOUTH AEGEAN

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# Abstract

Population structure of the edible sea urchin, *Paracentrotus lividus*, was studied over a three-year period in a South Aegean island. Spatial variations in population density and dispersion patterns were estimated. Sampling was carried out with a non-destructive method, the randomly placed frames technique, combined with *in-situ* registration of data. Mean population density was  $13 \pm 3.86$  individuals/m<sup>2</sup>, while the pattern of dispersion was random. The population genetic structure was also determined, using RAPD fingerprinting. *P. lividus* populations in Hellenic waters appeared to be panmictic and should be considered as a mixture stock over a large geographic scale. *Keywords : Aegean Sea, Echinodermata, Density, Population Dynamics, Genetics.* 

#### Introduction

Sea urchins are among the most important elements of the hard bottom benthos. In the Mediterranean Sea *Paracentrotus lividus* is one of the most abundant and widely distributed echinoderms. This edible and commercial sea unchin presents low mobility in adult stages. Therefore, its populations may exhibit high gene flow only when strong ecological or biogeographical barriers to dispersal are absent [1]. *P. lividus* is a well studied species, especially in the Western Mediterranean, where the depletion of its natural populations have lead to intense research effort for the management of its stocks [2], [3]. Contrarily, very few studies have been conducted in the Eastern Mediterranean, and even fewer in the South Aegean, where *P. lividus* has been traditionally harvested. The present work contribute to the study of *P. lividus* population structure in the Aegean Sea.

#### Materials and Methods

Sampling was carried out with SCUBA diving at three sites (A, B, C) along the coastline of Astypalea Island, at depths ranging from 2 to 10 m, in August 2003, November 2003, March 2004, October 2004, December 2004, June 2005, September 2005 and June 2006. The method of randomly placed frames, permitting in-situ counting, was applied to estimate population density and spatial dispersion (20 frames of 50 x 50 cm each) [4]. Morisita's index (I) was calculated to assess spatial dispersion and a chi-square test was used to determine the significance of deviation from random distribution [4]. Adult specimens from Astypalea (n=40), Amvrakikos Gulf (n=53, Ionian Sea), Pagasitikos Gulf (n=75, Central Aegean) and Chalkidiki (n=40, North Aegean) were used to determine the genetic structure of P. lividus populations in Hellenic waters. Genomic DNA was extracted from the gonads of each specimen using a modified Levitan's protocol [5]. Seven RAPD primer markers and eight loci were used for distance computation between and within populations. Analysis of Molecular Variance (AMOVA) was performed among and within populations. Total population differentiation value (Fst) was estimated, as well as its overall and pairwise gene flow (Nm) values. A UPGMA tree of genetic distance [6] was produced.

# Results and Discussion

Mean population density of P. lividus, over all sites and sampling periods, was  $13 \pm 3.86$  individuals/m<sup>2</sup>. At each site a decrease in population density was evident at least twice during the study period. Two-way ANOVA showed significant spatial differences on mean population density (F=9.37 p<0.05), as well as temporal ones (F=19.98 p<0.05). The spatial differences were restricted to the reduced density of P. lividus at station A. Temporally, the abundance of sea urchins increased, gained maximum values in November 2003 and remained at high levels till March 2004; thereafter it declined, started to upturn in September 2005 and reached a second peak in June 2006. P. lividus individuals were randomly dispersed in most cases (I ranged from 1.05 to 1.32). These results indicate that P. lividus stocks undergo temporal fluctuations, probably linked to its reproductive output. The population seems to sustain the pressure of the local fisheries, since it retains overall high density, with no significant reduction on the mean test diameter (unpublished data). AMOVA permutation showed significant differences either among or within studied populations (Fst=0.077 p < 0.001). Pairwise Fst values were statistically significant for all populations at all loci. These data, along with the high value of migrants per generation (Nm=13.95), imply near panmixis among populations. Cluster analysis showed low values of genetic distance even between the Aegean and Ionian populations (Figure 1). Echinoderm species dispersal may occurs over long distances [8]. *P. lividus* populations in the Atlantic Ocean and the Mediterranean Sea appear to be panmictic within each, as gene flow occurs over large distances with no evidence of isolation by distance, indicating formidable plasticity to environmental or other pressures [1]. *P. lividus* populations, due to their panmictic nature in Hellenic waters should be considered as a mixture stock over a large geographic scale.



Fig. 1. UPGMA cluster analysis using Slatkin's genetic distance between the studied populations of *P. lividus*.

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# GENETIC STRUCTURE OF FOUR MARINE SPECIES FROM THE GULF OF PAGASITIKOS (GREECE) BASED ON ALLOZYMES, RAPD AND MTDNA MARKERS

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# Abstract

In the present work we used three molecular techniques (allozymes, RAPDs and mtDNA RFLPs) in order to study the genetic structure of four marine species (*Mullus surmuletus, Mullus barbatus, Merluccius merluccius* and *Pagellus erythrinus*). Each species was sampled from three regions of the Gulf of Pagasitikos as well from two neighbour regions outside the Gulf (Trikeri and Allonissos). Values of genetic heterozygosity and genetic diversity found for all populations studied were above the mean values observed in marine fishes. None of the three methods used reveal diagnostic patterns which could allow the identification of individuals to one of the populations. The results revealed that the three populations within Pagasitikos were homogenous representing thus a panmictic stock. However, there were evidences of genetic population subdivision between localities from inside and outside of the Pagasitikos Gulf. *Keywords : Aegean Sea, Fishes, Genetics.* 

#### Introduction

Gene flow through larval exchange is assumed to be the major mechanism in homogenizing spatially discrete marine populations. However, several studies of marine species have illustrated examples where apparently panmictic or neighbor populations demonstrate surprisingly high levels of genetic structuring. Genetic structuring in marine populations might be caused by several factors such as by differences in local selection pressures, or by local hydrographic conditions 1. The Gulf of Pagasitikos (west central Aegean Sea) presents particular interests and advantages for such kind of analyses due to local topographical and managerial peculiarities of the area i.e. it is a shallow, semi-enclosed basin where trawling is by low prohibited. The work presented here is part of a larger research project aiming on understanding the structure, function and dynamics of the Pagasitikos Gulf ecosystem, with a final target to achieve its sustainable management. It is well established that for a proper fishery management knowledge of the genetic population structure is important [2]. In the present study we examined both nuclear (allozymes and RAPDs) and mitochondrial DNA (mtDNA) variation in collections of four commercial marine species made in five different regions within and outside the Gulf of Pagasitikos with the goal of describing their genetic population structure.

### Materials and Methods

The four studied species were red mullet ( Mullus barbatus L.) striped red mullet ( Mullus surmuletus L), European hake ( Merluccius merluccius) and common pandora (Pagellus erythrinus). An average of 200 individuals of each species were collected at five locations (average 40 individuals per location), three from the Pagasitikos Gulf and two from neighbour areas that is from Trikeri and Allonissos. Samples of white muscle, liver and eye were taken from each individual and stored at  $\ensuremath{-}40^0 C$  until further treatment. Allozyme analysis was carried out employing standard horizontal starch-gel electrophoresis. Fourteen enzymic systems coding for a total of 20 (16 in *P. erythrinus*) putative loci were analysed for each species except for hake where 12 loci were analysed. The electrophoretic data were analyzed using BIOSYS-1 [3]. For the purposes of DNA analyses, DNA was extracted from muscle tissue following protocols reported in Mamouris et al [4]. RAPD analyses were performed using initially 40 decamer primers, 5-10 of which were used for intraspecific analyses. Experimental conditions as well as data analyses for the RAPD method are documented in Mamuris et al [4]. Finally, mitochondrial DNA variation was analysed by restriction fragment length polymorphisms (RFLPs) performed on four PCR-amplified mtDNA regions: control region (D-loop), COI, 12S-16S rRNA and cytochrome b. The amplified segments from each specimen were subsequently screened for polymorphism with 15 restriction endonucleases. The restriction site pattern data was analysed using the REAP [5] computer packages.  $N_{ST}$  [6] was used to estimate the degree of population subdivision at the nucleotide level within each species.

# Results and Discussion

Mean heterozygosity is considered the most important way of measuring genetic variation. The results of the present study revealed that the values of heterozygosities and nucleotide diversities found from allozyme/RAPD

and mtDNA analyses, respectively, were above the average values found for other marine teleosts using the same methods. For example the values of the observed heterozygosity found from allozyme analyses range from 0.062 to 0.137 while the average for all marine teleosts has been estimated as 0.064 [7]. The large values of heterozygosities imply that the populations studied have had a long unbroken history in the area without population bottlenecks.

None of the three methods used for each of the four species studied succeed to yield any diagnostic marker that could lead to unambiguous identification of the various geographical populations. Regardless of the method used, genetic population subdivision was not evident for any species within the Pagasitikos Gulf, suggesting homogeneity within the Gulf. On the other hand, there was some evidence of genetic population subdivision between localities from within and outside of the Pagasitikos Gulf. The estimated values (through allozyme and RAPD analyses) of effective migration rates (Nem) for the populations sampled range from 6.2 to 9.7 depending of the method used. These values were much smaller than the mean value for marine fishes (Nem=22.76) but they were close to those estimated for other marine species in the Mediterranean Sea [1]. These values of effective migration rates were small enough to allow significant divergence of gene frequencies among samples, although large enough to counteract the effect of genetic drift if one assumes an infinite island model.

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# THE BRYOZOA FAUNA OF BOZCAADA ISLAND (NE-AEGEAN SEA)

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# Abstract

The Bryozoa of Bozcaada Island (NE Aegean Sea) were studied at 11 stations during 2000-2001. Bottom depths of the stations ranged from 0.5-40 m. The samples were collected by means of dredging, drift netting, bottom trawl and scoop netting. Sixteen species, belonging to 12 families, were identified, in total, 46 species are known from Bozcaada Island.

Keywords : Bryozoa, Aegean Sea, Dardanelles.

# Introduction

Bryozoans have an abundant fossil record stretching back over 400 million years. In aquatic habitats, bryozoans may be found on all types of hard substrates: sand grains, rocks, shells, wood, and blades of kelp and other algae may be heavily encrusted with bryozoans. While some species have been found at depths of 8200 meters, most bryozoans inhabit much shallower water.Most bryzoans are sessile and immobile, but a few colonies are able to creep about, and a few species of non-colonial bryozoans live and move about in the spaces between sand grains. Bryozoans feed on small microorganisms, including diatoms and other unicellular algae. These are trapped by the protrusible ciliated feeding tentacles, or lophophore. In turn, bryozoans are preyed on by grazing organisms such as sea urchins and fish, and are also subject to competition and overgrowth from sponges, algae, and tunicates [1].

The Aegean Sea is one of the four major basins of the Eastern Mediterranean. In the north it is connected to the Black Sea through the Strait of Dardanelles, the Sea of Marmara and the Strait of Bosphorus, and in the south to the Ionian Sea and the Levantine Sea, which are two of the other major basins of the Eastern Mediterranean.

Bozcaada Island which is located of the Aegean Sea  $(39^{\circ} 47' 30" - 39^{\circ} 50' 90"N)$ , and  $25^{\circ} 57' 80" - 26^{\circ} 05' 00" E)$  has an area of 42 km<sup>2</sup> and is situated nearly 5 km off the coast of the mainland, between the Strait of Dardanelles and Bababurnu (Figure 1).

Unsal, 1975 [2] studied Bryozoa species and reported 112 species from all of the Turkish coast and 35 species of them were from Bozcaada Island.

# Materials and Methods

The samples were obtained during 2000 and 2001 from 11 stations (Fig. 1) at the depths of 0.5-40 m by dredging, drift netting, bottom trawling and scoop netting.



Fig. 1. The maps of the Agean Sea and Bozcaada Island.

Samples were sieved with 0.5 mm mesh size. The residuals on the mesh were fixed in 3% formalin solution. In the laboratory Bryozoa were then sorted under magnification, preserved in 70% alcohol and identified to species level.

#### Results

A result of this study, totally 16 Bryozoa species belonging to 12 families were determined from Bozcaada Island. These species were as follows: *Crisia eburnea* (Linnaeus, 1758), *Idmonea bidenkapi*Kluge, 1955, *Aetea truncata* (Landsborough, 1852), *Electra crustulenta*(Pallas, 1766), *Electra monostachys* (Busk, 1854), *Caberea boryi* (Audouin, 1826), *Adeona vio-*

lacea (Johnston, 1847), Fenestrulina malusii Audouin, 1826, Cryptosula pallasiana (Moll, 1803), Calpensia nobilis (Esper, 1796), Reteporella couchii (Hincks, 1878), Reteporela beaniana (King, 1846), Hippaliosina depressa (Busk, 1854), Alcyonidium mamilatum Alder, 1857, Alcyonidium polyoum (Hassal, 1841), Mimosella gracilis Hincks, 1851.

#### Discussion

Eight species were newly recorded for Bozcaada Island. Unsal [2] reported 35 species from Bozcaada Island, so in total 43 species are now known from Bozcaada Island.

Ünsal [2] reported 130 Bryozoa species from the Turkish Seas. On the other hand, 255 species are known from the Ionian Sea, the Aegean Sea, the Black Sea and the Levantine Seas [3]. While Italian Seas bryozoans where 305 species have been recorded [4], the total number of recorded species is 222 from the Eastern Adriatic [5]. Since around 400 species have been recorded in the Mediterrenean so far, future research is expected to yield more species in the Eastern of Mediterranean Sea.

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# ÉTUDE DESCRIPTIVE DE L'INFESTATION DE LA PALOURDE (*RUDITAPES DECUSSATUS*) À *PERKINSUS OLSENI* DANS LE LAC DE BIZERTE EN TUNISIE

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# Résumé

Un suivi de l'infestation parasitaire de la palourde *Ruditapes decussatus* à *Perkinsus olseni* (protozoaire, *Apicomplexa*) au lac de Bizerte a été effectué pendant deux ans (2004-2006). Les prélèvements ont été réalisés au niveau de deux sites de production naturelle : Faroua et Menzel Jemil. La méthode d'analyse utilisée est l'histologie. Les résultats ont montré que la prévalence de cette parasitose varie notablement aussi bien dans le temps que dans l'espace. Cette variation est indépendante de la taille, du sexe et du stade de maturité sexuelle de la palourde, ce qui suggère l'influence d'autres paramètres du milieu. *Mots clès : Bivalves, Lagoons, Parasitism.* 

# Introduction

La palourde (*Ruditapes decussatus*) est présente dans le lac de Bizerte (nord de la Tunisie) surtout dans les secteurs nord est (Menzel Jemil) et nord ouest (Faroua). Sur le plan économique, elle est considérée l'espèce de mollusque bivalve la plus importante pour le pays. Elle fait par conséquent l'objet d'une surveillance zoo sanitaire pour la recherche d'une maladie à déclaration obligatoire: La Perkinsiose dont l'agent pathogène est *Perkinsus olseni* (protozoaire, *Apicomplexa*). Le présent travail n'est qu'une analyse rétrospective des résultats obtenus après deux années de surveillance. Il a consisté à suivre l'évolution spatio-temporelle de cette parasitose et à étudier les paramètres qui en sont influents. Ainsi, nous avons cherché des éventuelles associations entre les prévalences de l'infestation parasitaire et certains paramètres biologiques de la palourde comme la taille, le sexe et le stade de maturité sexuelle.

#### Matériel et méthodes

Le suivi a été réalisé pendant une période qui s'est étalée de janvier 2004 à janvier 2006. Les prélèvements ont été effectués dans le lac de Bizerte au niveau de deux sites (Menzel Jemil et Faroua). Les échantillons, composés chacun d'une cinquantaine d'individus, ont été prélevés tous les six mois (hiver et été). Pour chaque palourde, nous avons déterminé la taille et fixé les organes dans une solution de Davidson pour une étude histologique. L'examen microscopique de chaque coupe nous a révélé le sexe, le stade de maturité sexuelle ainsi que la présence éventuelle du parasite. En fonction de l'état de maturité des gamètes, nous avons fixé trois stades de maturité sexuelle à savoir le stade A: sexe indéterminé (absence de gamètes), le stade B: gamètes non mâtures et le stade C: gamètes mâtures.



Fig. 1. Variation de la prévalence de la perkinsiose et de la moyenne des tailles des échantillons de palourde *Ruditapes decussatus* au niveau Menzel Jemil (MJ) et Faroua (F).

# Résultats et discussion

Les prévalences de l'infestation parasitaire au site Menzel Jemil sont plus importantes que celles du site Faroua (figure 1). Cette différence est significative uniquement pendant les trois premières campagnes (p<0,001). Ces résultats signifient que la différence de prévalence entre le site Faroua et le site Menzel Jemil ne serait pas liée à la période de prélèvement (hiver, été). Par ailleurs, la comparaison annuelle et saisonnière des prévalences de l'infestation parasitaire au niveau de chaque site ne montre une différence significative qu'en juin 2005 pour les palourdes du site Menzel Jemil et

qu'en janvier 2006 pour les palourdes du site Faroua (p <0,001). Ceci indique que le facteur saison ou année ne serait pas associé aux prévalences de l'infestation à Perkinsus olseni. Certes, ces résultats concordent avec certains travaux [1,2] mais, d'autres études [3,4] ont enregistré une variation saisonnière significative des prévalences de l'infestation à Perkinsus. Les données biologiques relatives au sexe et aux stades de maturité sexuelle ont montré qu'en période estivale la majorité des individus sont mâtures. Cependant, leurs variations ne sont pas liées aux prévalences de l'infestation parasitaire. De même, la figure 1 montre l'absence de corrélation entre les moyennes des tailles des échantillons et les prévalences de l'infestation parasitaire. Ces résultats nous incitent, par conséquent, à considérer d'autres facteurs tels que les fortes densités des palourdes qui accroîtraient le taux de transmission des parasites et les paramètres physico - chimiques de l'eau qui moduleraient le cycle de vie parasitaire. Il serait ainsi intéressant de vérifier ces deux hypothèses, sachant que des travaux récents [5] ont indiqué que les deux sites de prélèvement, étant très influencés par les eaux de ruissellement, sont différents sur le plan physico-chimie. De plus, le site Faroua, de part sa situation géographique, est dominé par les entrées d'eau salée du canal qui relie la lagune à la mer.

#### Conclusion

La variation des prévalences de la perkinsiose dans le temps et dans l'espace ne serait liée ni à la taille ni au sexe ni au stade de maturité sexuelle de la palourde. Les caractéristiques physico-chimiques de l'eau qui sont *a priori* différentes au niveau des deux sites de prélèvement ainsi que les densités de la population hôte pourraient influer les prévalences et expliquer la variation spatio-temporelle de cette parasitose.

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# VARIATION SAISONNIÈRE DU RYTHME LOCOMOTEUR DE *TALORCHESTIA DESHAYESII*, ISSU DE LA PLAGE DE BIZERTE (TUNISIE)

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# Résumé

Le rythme de l'activité locomotrice de *Talorchestia deshayesii* (Amphipode, supralittoral) a été enregistré au niveau de la population de Bizerte (Nord de la Tunisie). L'étude de la variation saisonnière des caractéristiques du rythme locomoteur a montré une période circadienne plus longue au printemps et un temps d'activité plus étendu en automne. Par ailleurs, l'étude du rythme de l'activité locomotrice des animaux expérimentés a révélé l'existence d'une composante circatidale dont la période est proche de12 heures. *Mots clès : Behaviour, Crustacea, Supralittoral.* 

# Introduction

*Talorchestia deshayesii* est un Amphipode nocturne [1] qui vit dans l'étage supralittoral le long des côtes sableuses de la Méditerranée et de l'Atlantique orientale. Ce talitre occupe la même niche spatiale qu'un autre talitridé, *Talitrus saltator* [2]. Le but de ce travail est d'évaluer la persistance et la précision du rythme endogène de cette éspèce face aux fluctuations saisonnières.

# Matériel et Méthodes

L'activité locomotrice de cette espèce a été enregistrée chez une population issue de la plage de Bizerte (Nord de la Tunisie), au mois de septembre (photophase naturelle = 12h16) et au mois de mai (photophase naturelle = 14h14). Les individus adultes, ont été collectés à main nue et ont été transférés, au laboratoire, individuellement dans des actographes. Ces derniers sont placés dans une enceinte climatique qui permet de contrôler aussi bien la température que la photopériode.

Les individus de *Talorchestia deshayesii* ont été maintenus sous une température constante de  $18\pm0.5^{\circ}$ C. Ces spécimens ont été d'abord, soumis à la photopériode naturelle (sous le cycle nLD) du jour de la collecte puis ils ont été maintenus en libre cours (obscurité continue).

#### Résultats et discussion

L'analyse des actogrammes en double plot, ainsi que les courbes d'activité locomotrice moyenne par heure et par jour ont permis de mettre en évidence une sensibilité plus importante des individus testés vis-à-vis de l'aube expérimentale et ceci quelque soit la saison considérée (Fig.1).



Fig. 1. (a) Actogramme en double plot et (b) courbe d'activité moyenne/h/j ; la barre noire représente la nuit expérimentale.

L'étude des caractéristiques du rythme de l'activité locomotrice (période circadienne sous cycle nLD ; période circadienne en libre cours; stabilité du rythme (SNR) ; pourcentage de rythmicité, rapport temps d'activité/temps de repos et déphasage), a montré que quelque soit la saison (automne ou printemps), le taux de rythmicité circadienne de *Talorchestia deshayesii* est sensiblement le même aussi bien en obscurité continue (DD) qu'en conditions d'entraînement (alternance lumière/obscurité) ; il est supérieur ou égal à 87%. Par contre l'analyse statistique (test non paramétrique de Wilcoxon) a révélé que le temps d'activité et la période circadienne du rythme locomoteur sont significativement plus courts en automne qu'au printemps, et ceci quelque soit le régime photopériodique imposé (Tableau1). De même, la stabilité du rythme de cette espèce (calculée à l'aide du rapport SNR= Signal Noise to Ratio) la plus élevée, est observée au printemps (Tableau1). Par ailleurs, les individus présentent une avance et un retard de phases respectivement en automne et au printemps. La différence entre les déphasages moyens des deux saisons est hautement significatve.

Tab. 1. Variabilité saisonnière des caractéristiques du rythme locomoteur de *Talorchestia deshayesii*. LD : alternance lumière/obscurité ; DD : Obscurité continue ; SNR : Signal Noise to Ratio.

|             |     | Automne               | Printemps             | Test Wilcoxon |
|-------------|-----|-----------------------|-----------------------|---------------|
| Période     | LD  | $\tau = 23h20\pm1h01$ | $\tau = 23h52\pm0h40$ | p< 0.01       |
| circadienne | DD  | $\tau = 23h54\pm0h28$ | $\tau = 24h30\pm0h19$ | p≺ 0.05       |
| SNR         | LD  | 0.262±0.079           | 0.415±0.190           | p≺ 0.05       |
| Temps       | LD  | 932±135               | 608±176               | p< 0.01       |
| ďactivité   | DD  | 786±208               | 565±117               | p≺ 0.05       |
| Déphasage   | Į , | 169±118               | -135±124              | p< 0.01       |

L'allongement de la période circadienne et le raccourcissement du temps d'activité peuvent être expliqués par l'augmentation de la photophase naturelle durant le printemps ; la scotophase devenant de plus en plus courte, les individus ajustent leur activité locomotrice nocturne en fonction de ces variations.

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# NOTES ON THE REPRODUCTIVE CONDITION OF EARLY COLONIZING S. LURIDUS IN THE SICILY STRAIT (MEDITERRANEAN SEA)

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# Abstract

This paper summarizes some observations on gonad development and fecundity of the Lessepsian migrant Siganus luridus (Osteichthyes: Siganidae), recently settled in the islands of Malta and Linosa (Sicily strait, Mediterranean sea). The analysis of ovarian and testicular development showed that these early colonizers attain final gonad maturation and have the potential for successful reproduction. Keywords : Sicilian Channel, Fishes, Water Convection.

# Introduction

Siganus luridus (Osteichthyes: Siganidae) is an Indo-pacific species which entered into the Mediterranean through the Suez Canal [1], becoming one of the most successful exotic fishes in this sea [2]. Recently, the finding of new settled populations in the Sicily strait [3] offered a valuable opportunity for studying a Lessepsian migrant during the early phases of colonization [4]. As far as we know, these individuals, together with Tunisian siganids [5] represent the westernmost propagules of the species in the Mediterranean.

# Materials and Methods

The study is based on a sample of 49 individuals (13.5-24.6 cm total length) captured in Linosa (N=43) and Malta (N=6) in July-August 2003 and October 2006, respectively. These specimens represented the first siganids to be recorded in these two islands. Gonads were processed trough routine histological analyses; oocyte dynamics were reconstructed by oocyte size frequency histograms and fecundity estimates were made on (N=11) ripe ovaries, according to the gravimetric method. Gonads were staged on the basis of macroscopic [2] and microscopic [4] criteria and follicular atresia was estimated by counting the number of atretic follicles included in 10 sectors of 0.39 mm<sup>2</sup> randomly selected in the histological sections.

# Results and Discussion

Both males and females had reached final stages of gonad maturation and reproductive behaviors were observed. In August at Linosa, mature individuals were represented by a number of 8 ripe (13.8-17.0 cm TL) and 4 spawning (16.5-21.8 cm TL) females plus N=20 running males (13.5-24.5 cm TL); in October at Malta, a number of 3 ripe females (23.8-24.6 cm TL) plus 2 running males (23.0-24.0 cm TL) were found.



Fig. 1. Size frequency distribution of secondary growth oocytes in (N=6) ripe S. luridus captured in August at Linosa (a) and in October at Malta (b). N=500 oocyte/ovary were measured.

Absolute fecundity ranged from 115,739 to 740,433 oocytes per female and relative fecundity ranged from 1,239 to 3,162 oocytes  $g^{-1}$ . Fecundity of Linosa and Maltese individuals were within the range of values found in a Lebanese population [2]. The atresia rates in these new colonizers appeared moderate and analogous to what is known for other teleost species during the pre-reproductive stage [6]. In developing and ripe females, the percentage of secondary growth phase oocytes (SGP) in atresia was

always below 15%, with the exception of a female which presented the 46.7% of attetic SGP. Attetic oocytes were not detected in immature nor in spawning females.

As emerged by oocyte size distribution analyses, females at advanced maturity stage presented a bimodal size frequency distribution of SGP oocytes (Fig.1). This finding was validated by histological observations and indicated an ovarian development of the group-synchronous type. The comparison with Lebanese individuals [2] showed relevant differences in the distribution of maturity stages and suggests that the reproductive season of S. luridus in the Sicily strait could be delayed with respect to the eastern Mediterranean. To conclude, our results showed that S. luridus has the potential for successful reproduction in the newly colonized areas and indicated the potential of this species to spread across new sectors in the central and possibly western Mediterranean. It is clear that extensive temporal and spatial samplings would allow to a proper description of their reproductive cycle, but up to date, their small abundances both in Linosa [4] and Malta (Azzurro unpublished data) rendered this task impracticable.

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# EFFECTS OF SEWAGE DISCHARGES ON COASTAL FISH ASSEMBLAGES IN MALTA, STRAIT OF SICILY, MEDITERRANEAN SEA

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# Abstract

This paper presents the preliminary results of the effects of sewage pollution on a shallow fish community along the NW coasts of Malta (Sicily strait, Mediterranean sea). Clear differences in the abundance, structure and composition of fish assemblages were highlighted by means of univariate and multivariate analyses. At the sewage outfalls, the decline in species richness testified the severity of the impact, moreover the great increase of two benthic fishes gave evidence of enduring alteration in the fish community. *Keywords : Fishes, Sewage Pollution, Sicilian Channel.* 

#### Introduction

Sewage discharges are known to have profound effects on diversity, abundance and structure of Mediterranean coastal fish communities [1,2]. To assess these effects, "BACI" designs (Before-after control-impact) are the ideal tools but often the "before impact" data are missing and "after" study are the only way to detect some aspects of disturbance. Our purposes were to assess the effects of two sewage outfalls on the rocky-reef fish community along the NW coast of Malta.

# Materials and Methods

Underwater visual censuses were performed, between 5 and 8m of depth, at fixed point of a standard surface of  $25m^2$ [2]. This technique was chosen among the available visual methods as the most appropriate in highly heterogeneous substrata. Surveys were carried out at four locations on the NW Maltese coasts: two putatively disturbed locations (where the outfalls directly discharge waste waters on the coastline) and two controls. At each location, four sites were randomly selected and four repeated censuses were performed. Abundance data were analyzed by means of univariate (one-way ANOVA) and multivariate (nMDS, PERMANOVA and SIMPER) procedures. Based on the null-hypothesis that there are no differences between disturbed and control areas, a PERMANOVA design was created on two factors (Disturb, fixed with two levels and Site, random nested in Disturb with four levels).

#### Results

Overall 41 fish taxa were identified. The nMDS plot (Fig. 1) showed a good separation (Stress = 0.18) between fish counts at disturbed (D) and control (C) sites. A symmetrical PERMANOVA (Table 1) provided evidences for significant differences both for factor Disturb and for Location.



Fig. 1. Non-metric Multidimensional Scaling (nMDS) ordination plot comparing fish assemblages from sewage-disturbed locations (D1 and D2) and control (C1 and C2) locations. Centroids of single sites are represented.

According to SIMPER procedure, the average dissimilarity between the two groups was 78%. *Gobius bucchichi* and *Parablennious rouxi* were the most typifying species in disturbed locations, whilst *Oblada melanura* and *Symphodus roissali* contributed mostly to the similarity of the controls. One-way ANOVA detected significant differences in species richness and total abundance between the two groups. Total abundance resulted higher in D than at C whilst species richness showed the opposite pattern. Significant differences also occurred among single locations.

Tab. 1. PERMANOVA based on the Bray-Curtis dissimilarities of log (x+1) transformed data (41 taxa).

| Source             | df | SS       | MS     | Pseudo-F | P(perm) | perms |
|--------------------|----|----------|--------|----------|---------|-------|
| Disturb            | 1  | 40553    | 40553  | 4.1845   | 0.027   | 999   |
| Location (Disturb) | 2  | 19383    | 9691.3 | 6.7989   | 0.001   | 999   |
| Res                | 60 | 85526    | 1425.4 |          |         |       |
| Total              | 63 | 1.4546E5 |        |          |         |       |

#### Discussion

The present study provided evidence that the two sewage outfalls affect assemblage structure and fish abundances. According to the few studies which dealt with the sewage impact on Mediterranean fish communities [1,2], these changes may be mostly ascribable to the increase of nutrients and particulate organic matter due to the outfalls. At moderate levels, this enrichment can influence the fish assemblage by attracting gregarious and planktivorous fishes and our results showed a small but significant increase of the abundances of these species (e.g. *Chromis chromis* and *O. melanura*). However, the most striking differences were related to the decline in species richness which usually reflects a severe impact on fish community [1]. Fishes such as the labrids *Simphodus spp, Thalassoma pavo* and the sexard *Sparisoma cretense* resulted to be particularly affected by the sewage. Some ecological requirements of these species were probably not satisfied in the polluted areas, e.g. food availability and nesting grounds.

At the disturbed locations, the high abundance of *G. bucchichi* and *P. rouxi* resulted to be remarkable. In fact, the mobility of these benthic fishes is minimal and they are reliably indicators of the effect of different levels of sewage impact [1]. To conclude our results highlighted profound alterations to the marine environment caused by the sewage outfalls. Given the reasonable inconceivability of these sources of pollutions with the need of environmental protection and tourist activities, appropriate measures should be taken, in accordance with the current guidelines.

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# DIET OF THE LESSEPSIAN *FISTULARIA COMMERSONII* (TELEOSTEI, FISTULARIIDAE) OFF THE COAST OF LEBANON: PRELIMINARY RESULTS

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# Abstract

Stomach content analysis showed that *F. commersonii* preys exclusively upon fish, mainly Atherinidae, Sparidae, Centracanthidae and Blenniidae. The seasonal variation showed a preference for anchovies in summer, blennies in autumn and silversides in both winter and spring. *F. commersonii* seems to feed mostly on native Mediterranean fish regardless of the habitat type in which it lives in. *Keywords : Diet, Teleostei, Species Introduction, Levantine Basin, Eastern Mediterranean.* 

# Introduction

The opening of the Suez Canal (1869) removed a natural biogeographic barrier which separated the temperate Atlantico-Mediterranean biota from the Indo-Pacific organisms of the Red Sea. This connection resulted in a massive introduction of marine organisms (Lessepsian migration) into the eastern Mediterranean [1, 2]. *Fistularia commersonii* Rüppell, 1838 is a Lessepsian fish that has established large populations in the eastern basin and has been spreading towards the western Mediterranean Sea [3, 4]. The purpose of this study was to examine the stomach contents of the invasive predator as a first step towards assessing its feeding ecology in the new environment.

# Material and methods

Sampling took place from May 2003 to April 2004 in different localities off the coast of Lebanon. Measurements included total fish length (T<sub>L</sub>) and gutted fish weight (W<sub>G</sub>), and all prey items were identified to the lowest taxon possible. Percentage frequency of occurrence (%F), percentage composition by number (%Cn), percentage composition by weight (%Cw), and the index of relative importance (IRI) were calculated [5]. Prey items were separated into "bottom" *vs.* "water column" species according to the environment in which they live.

Tab. 1. Composition of stomach contents of F. commersonii.

| Family          | %N <sub>TP</sub> | %F    | %Cn                                          | %Cw   | %IRI  |
|-----------------|------------------|-------|----------------------------------------------|-------|-------|
|                 |                  |       |                                              |       |       |
| Atherinidae     | 16.62            | 14.74 | 26.15                                        | 26.25 | 42.04 |
| Blenniidae      | 14.01            | 7.69  | 10.46                                        | 9.92  | 8.53  |
| Callyonimidae   | 0.33             | 0.64  | 1.30                                         | 1.30  | 0.09  |
| Centracanthidae | 8.14             | 9.61  | 16.15                                        | 15.94 | 16.78 |
| Clupeidae       | 1.63             | 0.64  | 1.30                                         | 1.30  | 0.09  |
| Engraulidae     | 10.10            | 3.85  | 6.23                                         | 5.62  | 2.48  |
| Gobiidae        | 3.27             | 3.85  | 3.81                                         | 3.90  | 1.61  |
| Labridae        | 4.56             | 4.49  | 6.71                                         | 6.88  | 3.32  |
| Mugilidae       | 0.65             | 0.64  | 0.87                                         | 1.08  | 0.07  |
| Mullidae        | 0.33             | 0.64  | 1.30                                         | 1.30  | 0.09  |
| Myctophidae     | 0.33             | 0.64  | 1.30                                         | 1.30  | 0.09  |
| Pomacentridae   | 0.65             | 1.28  | 1.95                                         | 1.71  | 0.26  |
| Scaridae        | 0.33             | 0.64  | 0.43                                         | 0.33  | 0.03  |
| Siganidae       | 1.96             | 2.56  | 2.99                                         | 2.40  | 0.75  |
| Sparidae        | 8.15             | 11.54 | 17.62                                        | 19.46 | 23.28 |
| Trypterygiidae  | 2.28             | 3.21  | 1.45                                         | 1.33  | 0.48  |
| Unid. fishes    | 26.71            | 32.69 | 2000 AND AND AND AND AND AND AND AND AND AND | -     | -     |

Results and discussion

A total of 156 *F. commersonii* specimens were collected. Size varied between 36.2 and 112.1 cm T<sub>L</sub> (79.60  $\pm$  14.79 cm TL) with 80-90 cm T<sub>L</sub> being the most frequent size-class. W<sub>G</sub> varied between 22.3 and 1033.2 g (371.85  $\pm$  198.63 g).

Sixteen families, represented by 21 species of fish prey, were identified from the stomach contents. Atherinidae represented 16.6% of the total number of prey ( $(N_{TP})$  ingested; Blenniidae (14.1%) and Engraulidae (10.1%). Sparidae, Centracanthidae and Labridae were found at 8.2, 8.1 and 4.6% respectively (Table 1). The majority of the identified food items were fishes native to the Mediterranean Sea; Lessepsian prey were *Atherinomorus lacunosus, Callionymus filamentosus, Siganus luridus* and *S. rivulatus* and accounted for only 3.3% of fish prey. This showed that the earlier presence of Lessepsian prey in the Mediterranean was not one

of the reasons for the success of *F. commersonii* in its new environment. Atherinidae and Sparidae showed the highest %F, with respectively 14.7% and 11.5%. They were followed by Centracanthidae and Blenniidae. In contrast, Labridae, Engraulidae and Gobiidae had a lower %F, despite their relative high presence in the examined stomachs (Table 1). Similarly %Cn, %Cw and %IRI showed that Atherinidae, Sparidae, Centracanthidae and Blenniidae were the most represented families by number and in terms of biomass.

Seasonal fluctuation of ingested prey showed a clear temporal pattern where one species *E. encrasicolus* (Engraulidae, 38.7%) was favoured in summer and *A. lacunocus* in winter (Atherinidae, 38.5%) and spring (Atherinidae, 56.9%). Blenniidae (34.5%) was the most represented prey in autumn. Centracanthidae seemed to be an important forage fish in the diet during most of the year (summer to winter) (Fig. 1).



Fig. 1. Seasonal variation of F. commersonii diet based on % F values.

"Water-column" species represented 59.1% of the consumed prey, mainly Atherinidae (22.7%), Engraulidae (13.8%), Centracanthidae (11.1%) and Sparidae (7.1%). "Bottom" species represented 40.9% with Blenniidae (19.1%), Labridae (6.2%) and Gobiidae (4.5%) being the most important ones. No significant differences (Wilcoxon test, P>0.05) existed between the two habitat groups. This implies that *F. commersonii* does not feed selectively in any of the two habitats considered, which might be one of the reasons for its success in the Mediterranean.

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# DIET OF COMMON GUITARFISH (*RHINOBATOS RHINOBATOS L.*, 1758) IN THE ISKENDERUN BAY (NORTHEASTERN MEDITERRANEAN)

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# Abstract

Food composition of common guitarfish (*Rhinobatos rhinobatos*) was studied in the Iskenderun Bay (northeastern Mediterranean). A total of 115 common guitarfish were caught and examined. Fish ranged in total length (TL) from 39 to146 cm and in weight between 121 and 13042 g. Males ranged from 39 to 124 cm TL, while females ranged between 42 and 147 cm TL. Of the fish examined, 49 individuals (43%) were males and 66 (57%) females. Out of 115 stomachs examined, 18 (15.7%) were empty, and 97 (84.3%) contained prey. A total of 392 prey items, belonging to 14 prey taxa, were counted. The main prey items found in the stomachs were unidentified shrimps (IRI%=35.89), unidentified teleosts (IRI%=34.51), unidentified crabs (IRI%=16.91), *Squilla mantis* (IRI%=5.11), and *Crangon crangon (IRI*%=4.69). Overall, the food of *R. rhinobatos* in the study area was mainly consisted of crustaceans (IRI%=72.04). *Keywords : Diet, Elasmobranchii, Eastern Mediterranean*.

# Introduction

Elasmobranchs are among the top predators in the marine environment, thus affecting the populations of both fish and invertebrates at the lower trophic levels [1]. Information on feeding habits of species contributes to a better understanding of the trophic dynamics and food webs, which is essential for fisheries management [2]. The common guitarfish (*Rhinobatos rhinobatos*) is a shallow water bottom-living elasmobranch found in the Eastern Atlantic, including the Mediterranean. The purpose of this study was to examine the feeding habits of common guitarfish caught in the Iskenderun Bay (Northeastern Mediterranean).

# Material and Methods

Specimens were caught with longlines and otter trawl at depths 20 -120 m in all seasons in the Iskenderun Bay (36°33' N - 35°34' E, 36°18' N -35°46' E, 36°54' N - 36°00' E, 36°35' N - 36°11' E) from April 2004 to May 2005. Stomachs with contents were placed in plastic bags and frozen for subsequent analysis. The gross stomach contents were noted and whenever possible, the fish remains were identified to species level. Account was taken of the fullness of the stomach. Prey groups were weighed to the nearest 1 g. Stomach content was analyzed using the percentage frequency of occurrence (O%), numerical percentage (N%), percentage by weight (W%), the index of relative importance (IRI), and percent of IRI (IRI%) for each prey type [3, 4]. The weights of the digested prey were estimated with two ways (1) length-weight relationships from the literature (e.g., www.fishbase.org) were used for calculating the weight of species having measurable parts (carapace width, vertebrae length or cephalothorax length) in the stomachs, and (2) the mean weight of the species found in the stomachs as a whole were used for estimating the weight of some digested species [5].

#### Results

A total of 115 common guitarfish were caught and examined. Fish ranged in size from 39 to 146 cm (TL) and in weight between 121 and 13042 g. Males ranged from 39 to 124 cm TL, while females ranged between 42 and 147 cm TL. Of the fish examined, 49 individuals (43%) were males and 66 (57%) females. Out of 115 stomachs examined, 18 (15.7%) were empty, and 97 (84.3%) contained prey. A total of 392 prey items, belonging to 14 prey taxa, were counted. The main prey items found in the stomachs were unidentified shrimps (IRI%=35.89), unidentified teleosts (IRI%=34.51), unidentified crabs (IRI%=16.91), *Squilla mantis* (IRI%=5.11), *Crangon crangon* (IRI%=4.69) and other species (IRI%=2.90).

# Discussion

Generally, skates and rays are benthic feeders, eating organisms such as small fish, mollusks, crustaceans and worms [1, 6]. Beretovski [6] concluds that skates could not feed in the water column because of their morphology and suggests that pelagic fishes traumatized by trawls in the fishing grounds were subsequently preyed upon by skates. However, some researchers state that rays are active predators and able to feed semipelagically [7, 8]. According to Parin [8], the ability of skates to hunt in the water column, even reaching the sea surface, is well known.

In the current study, pelagic species were also found in the stomachs. The total IRI% of the identified pelagic species was 1.57. Differences in diet

composition of species reflect the faunal composition of the region [9]. Consequently, it may be concluded that common guitarfish do prey upon bony fishes and crustaceans, and is an indiscriminate predator preying upon those species that are most abundant and available in the area and season.

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# DIET COMPOSITION OF THE CHUB MACKEREL, *SCOMBER JAPONICUS* (PISCES: SCOMBRIDAE), IN CANDARLI BAY (AEGEAN SEA, TURKEY)

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# Abstract

Stomach contents of 223 *Scomber japonicus* specimens collected from Candarli Bay, Aegean Sea (Turkey) have been analyzed. Overall, crustaceans (copepoda and amphipoda) were the most significant prey in terms of IRI%, followed by teleosts and thaliaceans. *Keywords : Aegean Sea, Fishes, Diet.* 

# Introduction

The chub mackerel, *Scomber japonicus* Houttuyn, 1782, is a cosmopolitan species inhabiting the warm and temperate transition waters of the Atlantic, Indian and Pacific oceans, as well as in their adjacent seas [1]. Chub mackerel is a commercially important pelagic species of the Turkey seas.

Because of the worldwide importance of the chub mackerel fishery, several studies have been carried out mainly related to its biology and feeding regime [2, 3, 4, 5]. Quantitative studies on its feeding ecology are scarce in Turkish coast. The biology of *S. japonicus* inhabiting the Sea of Marmara has been studied in [6, 7] and [8] studied the diet composition of juvenile chub mackerel in Izmir Bay (Aegean Sea).

The purpose of the present study is to examine the diet of chub mackerel on the Candarli Bay (Aegean Sea coast of Turkey), with a quantitative determination of the food based on the seasonal analysis of stomach contents.

### Material and Method

Scomber japonicus specimens, with total lengths ranging from 13.20 to 25.40 cm, were sampled seasonally during 2005 from commercial purseseine boats operating in Candarli Bay. Candarli Bay, located between the coordinates  $38^{\circ}$  43.8' N -  $39^{\circ}$  01.8' N and  $26^{\circ}$  32.0' E -  $27^{\circ}$  07.2' E (Fig.1), is one of the most important fishing ground in the Aegean Sea. Stomachs were removed immediately from all of the fish after capture and preserved in 4% formalin for later analysis. A stomach was considered empty when the food items in the stomach weighed <0.01 g. Quantitative description of the diet followed [9]. Besides, IRI% was calculated in order to determine ratios of food groups in the stomach to overall food groups.

#### Results

The overall diet composition revealed that the chub mackerel fed mainly on crustaceans during all seasons except summer (Table 1).

Tab. 1. Diet composition of chub mackerel from the Aegean Sea during all seasons. (N%: percentage numerical; F%: frequency of occurrence; W%: percentage weight; IRI%: index of relative importance expressed as percentage).

|              |       | Winte | r (n=57) |       |       | Spring | (n=51)   |       |
|--------------|-------|-------|----------|-------|-------|--------|----------|-------|
| Prey         | F%    | N%    | W%       | IRI%  | F%    | N%     | W%       | IRI%  |
| Siphonophora | 0.06  | 1.75  | 6.88     | 0.06  | 1.96  | 0.82   | 0.16     | 0.01  |
| Polychaeta   | 0.08  | 5.26  | 0.03     | *     | 1.96  | 0.08   | 0.05     | *     |
| Crustacea    | 94.63 | 70.18 | 23.91    | 41.59 | 70.59 | 91.47  | 86.75    | 62.90 |
| Gastropoda   | *     | *     | *        | *     | 5.88  | 0.37   | 0.13     | 0.01  |
| Cephalopoda  | 0.02  | 1.75  | 0.02     | *     | 1.96  | 0.04   | 5.06     | 0.05  |
| Thaliacea    | 4.74  | 35.09 | 22.87    | 4.84  | 43.1  | 6.72   | 1.28     | 1.73  |
| Teleostei    | 0.47  | 29.82 | 46.29    | 6.97  | 9.80  | 0.49   | 6.56     | 0.35  |
|              |       | Summe | er (n=56 | )     |       | Autum  | n (n=59) |       |
| Prey         | F%    | N%    | W%       | IRI%  | F%    | N%     | W%       | IRI%  |
| Siphonophora | 0.91  | 14.29 | 0.31     | 0.09  | 1.51  | 11.86  | 0.10     | 0.10  |
| Polychaeta   | 0.13  | 3.57  | 0.35     | 0.01  | *     | *      | *        | *     |
| Crustacea    | 42.59 | 82.14 | 6.28     | 20.07 | 84.47 | 59.32  | 1.98     | 25.64 |
| Gastropoda   | 0.39  | 5.36  | 0.04     | 0.01  | 0.11  | 1.69   | 0.02     | *     |
| Cephalopoda  | 0.13  | 3.57  | 9.32     | 0.17  | 0.11  | 1.69   | 2.08     | 0.02  |
| Thaliacea    | 51.95 | 76.79 | 24.87    | 29.50 | 8.63  | 18.64  | 0.37     | 0.84  |
| Teleostei    | 3.90  | 51.79 | 58.83    | 16.24 | 5.18  | 49.15  | 95.43    | 24.73 |

Only in summer thaliaceans were the main prey group. Copepods identified from stomachs are given in Table 2. An examination of the previous literature shows that *S. japonicus* is an opportunistic and non-selective species with diet varying according to specimen size, locality, season etc. Tab. 2. Copepod species identified from chub mackerel stomachs according to seasons.

| Copepoda Species         | Winter<br>IRI% | Spring<br>IRI% | Summer<br>IRI% | Autumn<br>IRI% |
|--------------------------|----------------|----------------|----------------|----------------|
| Calanoida                | 5.27           | 10.02          | 4.52           | 12.65          |
| Nannocalanus minor       | 0.01           | 0.22           | *              | *              |
| Temora stylifera         | 0.24           | 4.42           | 0.64           | 2.27           |
| Centropages typicus      | *              | 0.49           | *              | 0.37           |
| Candacia simplex         | *              | 0.42           | *              | 0.15           |
| Acartia clausi           | 0.44           | 5.79           | 0.00           | 1.58           |
| Oncaea media             | 0.02           | 0.13           | 0.13           | 0.82           |
| Sapphirina nigromaculata | 6.97           | 0.25           | 0.01           | 0.45           |
| Farranula rostrata       | 0.41           | 0.19           | 0.37           | 0.36           |
| Euterpina acutifrons     | 0.01           | 0.83           | 0.02           | 2.14           |

\*Prey category present but made up <0.01.

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# SELECTIVITY OF TWO DIAMOND MESH SIZE COD-ENDS IN THE TRAWL FISHERY OF THE NORTHERN TYRRHENIAN SEA (WESTERN MEDITERRANEAN)

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# Abstract

Experimental fishing trials were carried out to compare the size selectivity of the 40 mm stretched diamond mesh size cod-end, commonly used in the Italian waters, and the 60 mm stretched diamond mesh size cod-end. In total, 24 tows were carried out in summer 2003 and spring 2004 between 20 and 350 m depth. Selection curves were estimated through the covered cod-end method. The experimental net was more selective for most of the commercial species, showing a reduction of the percentage of retained fraction and a consistent increase of the  $L_{50}$  retention length.

Keywords : Demersal, Fisheries, Tyrrhenian Sea.

#### Introduction

Mediterranean trawling is typically multi-species. In addition to the target species, an important contribution to the commercial value of the catch is provided by the accessory species; most of the marketed species are of small size, as many cephalopods and crustaceans. This implies the use of gears with reduced selectivity, especially in the case of trawling. A previous study in the same area showed the high multi-specificity of the commercial landing and the importance of discards in trawl activity [1]. In the context of the reform of the EU Common Fisheries Policy, in 2003 the Commission proposed a regulation concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea based on the Community action plan for the conservation and sustainable exploitation of fishery resources in the Mediterranean Sea (COM(2002) 535 final of 9 October 2002). The proposal introduces technical measures to improve the selectivity of the current 40 mm mesh size for towed nets by increasing the minimum mesh size to 60 mm. The aim of the present study was to compare the selectivity parameters of the 40 mm commercial diamond mesh cod-end and of an experimental 60 mm mesh cod-end.

# Materials and methods

The study was performed in the northern Tyrrhenian Sea (western Mediterranean). Two trawl nets were used: a commercial net, provided with nominal 40 mm diamond mesh cod-end, and an experimental net, provided with a 60 mm diamond mesh cod-end.

Experimental trials have been carried out onboard of a demersal fishing vessel in summer 2003 and spring 2004, at depths ranging from 20 to 350 m. The nets were enclosed in an enveloping small mesh cover to trap the escaping fish. In order to maintain a good flow of water and to avoid the masking effect, the cover was held from the cod-end by means of two hoops placed outside the cover.

For each net, six 1-hour experimental hauls were carried out every season for a total of 12 hauls. The selection curve for each net, commercial and experimental, was estimated through the covered cod-end method [4]. The selectivity of the net was estimated by comparing the catches at length in the cod-end with those in the cover. Estimation of the 50% retention length ( $L_{50}$ ), of the selection factor (SF) and of the selection range (SR) were done by fitting the experimental data to a logistic curve using the SELECT statistical package (Trawl function package for R) [2, 3]. Due to the small number of specimens collected in most individual hauls, it was necessary to merge the survey data. The retained fraction R in the cod-end was estimated by the following equation:

 $R = [(N_{cod-end})/N_{total}] x 100, where N_{cod-end} was the number of specimens in the cod-end and N_{total} the total number of specimens caught (cod-end plus cover cod-end).$ 

#### Results and discussion

The species richness of the catches was not affected by the use of a larger mesh size in the cod-end. During the experimental trials, 142 species were caught, belonging to four major taxa: teleosts (88), crustaceans (28), cephalopods (20) and elasmobranchs (6). Table 1 shows the number of species caught in each survey, according to the major taxa.

The experimental net showed higher selectivity for most of the commercial species (Tab. 2), with a consistent decrease of the percentage of retained fraction. For almost all species, the  $L_{50}$  estimated from the 60 mm cod-end mesh size was higher than the  $L_{50}$  obtained from the 40 mm cod-end mesh size; in addition, the  $L_{50}$  from the 60 mm mesh was higher than the minimum landing size established by the EU regulation for the Mediterranean.

Tab. 1. Number of species caught in each survey.

|                    | Comme   | rcial cod-er     | nd 40 mm m | esh size         | Experimental cod-end 60 mm mesh size |                  |         |                  |  |  |
|--------------------|---------|------------------|------------|------------------|--------------------------------------|------------------|---------|------------------|--|--|
| Taxonomic<br>group | Summer  |                  | Spring     |                  | Sum                                  | mer              | Spring  |                  |  |  |
|                    | cod-end | cover<br>cod-end | cod-end    | cover<br>cod-end | cod-end                              | cover<br>cod-end | cod-end | cover<br>cod-end |  |  |
| Teleosts           | 52      | 36               | 50         | 39               | 43                                   | 43               | 53      | 48               |  |  |
| Crustaceans        | 14      | 13               | 14         | 22               | 4                                    | 10               | 13      | 19               |  |  |
| Cepahalopds        | 14      | 10               | 13         | 11               | 10                                   | 10               | 13      | 9                |  |  |
| Elasmobranchs      | 2       | 1                | 3          | 1                | 2                                    | 0                | 5       | 1                |  |  |

Tab. 2. Selectivity parameters.

|                               | COMMERCIAL NET D40 |      |       |      | EXPERIMENTAL NET D60 |        |      |          |       |      |
|-------------------------------|--------------------|------|-------|------|----------------------|--------|------|----------|-------|------|
| specie                        | Niotal             | R    | L50   | SR   | SF                   | Niotal | R    | $L_{50}$ | SR    | SF   |
| Argentina sphyraena           | 183                | 69.4 | 11.31 | 4.23 | 2.83                 | 539    | 8.9  | 23.12    | 9.95  | 5.78 |
| Arnoglossns laterna           | 66                 | 10.6 | 12.63 | 4.21 | 3.16                 | 214    | 10.7 | 10.58    | 2.49  | 2.65 |
| Cholorophtalmus agassizi      | 223                | 4.0  |       |      |                      | 3209   | 6.1  |          |       |      |
| Galens melastomus             | 34                 | 67.6 |       |      |                      | 97     | 30.9 |          |       |      |
| Helicolenus d. dactylopterus  | 309                | 74.4 | 6.73  | 1.96 | 1.68                 | 478    | 23.0 | 10.31    | 3.17  | 2.58 |
| Lepidopus caudatus            | 1555               | 96.5 |       |      |                      | 256    | 25.0 |          |       |      |
| Lepidorhombus boscii          | 61                 | 98.4 |       |      |                      | 95     | 72.0 |          |       |      |
| Lepidotrigla cavillone        | 73                 | 95.9 |       |      |                      | 85     | 69.4 |          |       |      |
| Merluccius merluccius         | 6976               | 76.5 | 9.17  | 2.56 | 2.29                 | 5769   | 21.6 | 18.10    | 10.62 | 4.53 |
| Micromesistins pontasson      | \$15               | 14.7 |       |      |                      | 1792   | 5.9  |          |       |      |
| Mullus barbatus               | 15122              | 16.5 |       |      |                      | 5695   | 1.9  | 16.63    | 3.01  | 2.77 |
| Phycis blennoides             | 160                | 33.8 | 11.95 | 3.17 | 2.99                 | 308    | 21.1 | 17.23    | 5.38  | 4.31 |
| Spicaris smaris               | 1238               | 0.7  |       |      |                      | 1358   | 12.6 |          |       |      |
| Trachurus m. mediterraneus    | 190                | 62.1 |       |      |                      | 153    | 58.2 |          |       |      |
| Trachurus trachurus           | 485                | 52.2 | 10.28 | 3.04 | 2.57                 | 494    | 26.1 | 19.83    | 10.52 | 4.96 |
| Trisopterus minutus capelanus | 903                | 56.1 | 10.94 | 4.54 | 2.74                 | 747    | 25.5 | 16.13    | 5.14  | 4.03 |
|                               | Niotal             | R    | L50   | SR   | SF                   | Niotal | R    | L50      | SR    | SF   |
| Eledone cirrhosa              | 267                | 85.8 | 4.60  | 3.62 | 1.15                 | 297    | 60.6 | 5.45     | 3.01  | 1.36 |
| Illex coindetii               | 1071               | 92.1 | 4.10  | 2.00 | 1.00                 | 548    | 48.0 | 7.92     | 3.93  | 1.32 |
|                               | Nutal              | R    | L50   | SR   | SF                   | Ntotal | R    | $L_{50}$ | SR    | SF   |
| Parapenaeus longirostris      | 1714               | 95.1 | 12.98 | 5.32 | 3.25                 | 1625   | 52.9 | 22.25    | 11.96 | 5.56 |

These results encourage further investigations on alternative methods, such as selection grids, square mesh panels, separator trawls, etc., to increase the escape of small sized fish.

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# ÉTUDE DES MACROINVERTÉBRÉS ASSOCIÉS ET ACCOMPAGNATEURS DE L'HERBIER DE POSIDONIE À *POSIDONIA OCEANICA* DANS LA RÉGION DE RAS JEBEL (NORD EST DE LATUNISIE)

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# Résumé

Dans le présent travail, nous avons procédé à l'étude des macro invertébrés de l'herbier de posidonie, *Posidonia oceanica*, au niveau du site de Ras Jebel, localisé dans le Nord Est de la Tunisie, afin d'apprécier la richesse spécifique et l'état de ce dernier. Un échantillonnage saisonnier a été effectué durant la période allant de septembre 2004 à Août 2005. Au cours de ce suivil, nous avons identifié 152 espèces appartenant à 10 phylums.

Mots clès : Biodiversity, Phanerogams, Posidonia.

Les herbiers à *Posidonia oceanica* (L.) Delile sont largement répandus sur les côtes méditerranéennes [1]. Ils constituent des habitats permanents ainsi qu'une source trophique pour plus que 400 espèces végétales et plusieurs milliers d'espèces animales [2]. Cette importance écologique nous a incité à connaître la macrofaune benthique associée et accompagnatrice de cet herbier.

Les prélèvements ont été effectués au niveau de trois transects parallèles allant de la plage vers le large. Au total, 9 stations, localisées au niveau des trois transects, ont été prospectées. Elles sont réparties sur une profondeur qui varie de 1.5 à 5 m. Au niveau de ces stations, le prélèvement de la macrofaune a été réalisé au moyen d'un quadrat de 20 cm de côté [3]. Les prélèvements sont réalisés en scaphandre autonome. Une fois prélevés, les échantillons sont amenés au laboratoire, triés par ordre zoologique et identifiés. Par la suite, nous avons pris en compte divers indices écologiques pour caractériser l'état de l'habitat et du peuplement. Ainsi, nous avons calculé la richesse spécifique (nombre d'espèces), l'indice de Simpson (Is), l'indice de Shannon - Weaver (H') et l'indice d'équitabilité.

Ainsi, nous avons rencontré au total 152 espèces réparties comme suit : 1 Spongiaire, 2 Cnidaires, 62 Mollusques, 1 Bryozoaire, 1 Némertien, 3 Tuniciers, 9 Echinodermes, 4 Sipunculidés, 21 Annélides et 48 Crustacés. La richesse spécifique varie en fonction des saisons avec un maximum de 81 espèces pendant l'hiver et un minimum de 45 espèces durant l'automne. Au cours du printemps et de l'été, la richesse spécifique n'a pas beaucoup fluctué.

Le suivi saisonnier de l'indice de Simpson (Is) montre une variation de sa valeur entre un minimum de 23,54 bits, enregistré en été et un maximum de 27.51 bits observé en hiver. Ces résultats indiquent que 24 à 28 espèces ont les mêmes abondances durant toutes les saisons. L'importante valeur de l'indice de Simpson durant l'hiver est expliquée par le fait que les espèces sont représentées par un nombre élevé d'individus.

Le suivi des fluctuations de l'indice de Shannon - Weaver (H') en fonction des saisons (Tab. 1) révèle une valeur moyenne maximale égale à 5.39 bits en hiver, ce qui témoigne du nombre important d'espèces rencontrées pendant cette saison. La valeur moyenne minimale de cet indice, enregistrée durant toute la période d'étude, est égale à 4.92 bits. Cette valeur classe le site d'étude comme étant un secteur à peuplement normal [4].

Les valeurs moyennes de l'indice d'équitabilité, calculées en fonction des saisons, montrent un maximum automnal (0.89) et un minimum hivernal (0.84). Ces valeurs révèlent que la totalité des effectifs recensés se répartissent sur 84 à 89 % des espèces collectées.

En outre, nous avons remarqué que la valeur de l'indice d'équitabilité est toujours supérieur à 0.8 au niveau des différentes stations prospectées, ce qui indique que les différentes populations sont bien équilibrées dans les différentes profondeurs prospectées et durant toute la période d'échantillonnage.

Sur les côtes tunisiennes, plusieurs travaux se sont intéressés aux macro invertébrés associés à l'herbier de posidonie. Ces travaux ont été réalisés pendant l'année 2004 au niveau du grand golfe de Tunis. Sur les côtes de Port aux Princes, Ben Ismail [5] à identifié 87 espèces alors qu'au niveau du récif barrière de Sidi Rais, Telahigue [6] a récolté 84 espèces. Au niveau de la baie de Gammarth, le travail de Chabbi [7] a permis de révéler 66 espèces.

Comparé à ces travaux, nous constatons que le site étudié est caractérisé par une richesse spécifique très importante et par des indices écologiques qui témoignent des populations bien équilibrées. Ces résultats s'expliqueraient par les faibles activités anthropiques exercées sur les côtes de cette région. De ce fait, cette zone devrait faire l'objet d'un programme de protection contre toutes les activités anthropiques vu son importance écologique comme frayère sous marine.

Tab. 1. Variations saisonnières des indices écologiques dans la région de Ras Jebel durant la période d'échantillonnage.

|           | ls (bits)    | H' (bits)   | E           |
|-----------|--------------|-------------|-------------|
| Automne   | 25           | 4.92        | 0.89        |
| Hiver     | 27.51        | 5.39        | 0.84        |
| Printemps | 26.23        | 5.2         | 0.85        |
| Eté       | 23.54        | 5.23        | 0.85        |
| Moyenne   | 25,57 ± 1,70 | 5,18 ± 0,19 | 0,85 ± 0,02 |

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# RÉPARTITION SPATIALE DE LA FAUNE MALACOLOGIQUE DE LA LAGUNE DE BIZERTE : ANALYSES **ECOLOGIQUES**

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# Résumé

Une analyse des paramètres synthétiques descriptifs des peuplements malacologiques da la lagune de Bizerte a été effectuée afin d'identifier les différentes associations faunistiques dans la lagune. La répartition spatiale de la richesse indique la présence de 93 taxons. L'analyse des divers indices écologiques révèle l'importance de la zone Ouest à Nord-Ouest sous influence marine caractérisée par des eaux plus fraîches, qui est la plus peuplée et qui présente une forte diversité malacologique. Mots clès : Biodiversity, Lagoons.

La lagune de Bizerte qui est la plus vaste étendue lagunaire du nord de la Tunisie, constitue un site d'un grand intérêt économique vu la présence de diverses activités (pêche, conchyliculture, agriculture, industrie, activités portuaires et militaires). Toutes ces activités engendrent nécessairement des nuisances par le déversement de différents produits chimiques et organiques dans les eaux de la lagune. Le benthos constitue un véritable piège à polluants d'où l'importance de son étude pour la biosurveillance des systèmes aquatiques.

L'échantillonnage de la macrofaune benthique a été effectué à travers une centaine de stations réparties selon un maillage régulier couvrant toute la lagune. Les échantillons ont été récoltés à l'aide d'une benne Van Veen pour les stations lagunaires et à l'aide d'un quadrat métallique (de 0,25  $m^2$ ) de surface pour les stations. Les échantillons recueillis sont tamisés, triés et enfin identifiés en se basant sur les manuels typiques de la macrofaune méditerranéenne [1,2, 3]. La diversité spécifique a été étudiée à trois niveaux : la recherche du nombre d'espèces d'une communauté ; la détermination de la densité totale (D) de ces différentes espèces et le calcul des indices de biodiversité : indice de Shannon (H') et Indice d'équitabilité (E).

L'inventaire spécifique de la faune malacologique de la lagune de Bizerte révèle la présence de 93 espèces réparties sur 3 classes et 41 familles. La richesse spécifique globale varie de 4 à 28 espèces par station avec des densités spécifiques allant de 0 à 15872 individus par mètre carré ; cette densité numérique est favorisée par les espèces de petite taille. L'indice de Shannon a varié entre 0 et 3.48 avec une tendance élevée au niveau du chenal ainsi que dans la partie Sud-Ouest de la lagune (Figure 1). Celui d'équitabilité reflète la même répartition (Figure 2)



Fig. 1. Répartition spatiale de l'indice de diversité de Shannon (bits)



Fig. 2. Répartition spatiale de l'Equitabilité dans la lagune de Bizerte

Nous avons distingué 2 principales zones:

- Des zones montrant des valeurs d'indice de Shannon et d'équitabilité maximales (H'>3bits et 0,8<E<1). Les peuplements appartenant à ces stations sont en état d'équilibre et présentent une très forte compétition interspécifique.

- Des zones où les valeurs de diversité de Shannon et d'Equitabilité sont très faibles (o<H'<1bits et 0<E<0.4), reflètent le caractère de stagnation d'eau et l'influence anthropique par la pollution. De telles conditions entraînent impérativement un très fort déséquilibre au niveau des peuplements expliquant ainsi les valeurs quasi nulles de l'équitabilité.

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# TOWARDS A CENSUS OF TORRE GUACETO MARINE RESERVE MALACODIVERSITY THROUGH NO-IMPACT METHODS

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# Abstract

Methods with no impact on biocoenoses are being used in the Torre Guaceto Marine Reserve (Italy; south-western Adriatic Sea) to describe the biodiversity of its malacofauna. The results of a previous survey on death assemblages of stranded mollusc shells were complemented by data gathered by collection of washed ashore shells, underwater collection of empty shells, and underwater visual census. In this way 30 additional species (10 gastropods, 19 bivalves and 1 cephalopod) were recorded. The overall list of shelled molluscs presently includes 144 species: 96 gastropods, 46 bivalves, 1 scaphopod, and 1 cephalopod.

Keywords : Adriatic Sea, Biodiversity, Marine Parks, Mollusca.

Marine Reserves (MR) play an important role in the conservation of marine biodiversity. In order to observe possible changes in biodiversity it is necessary to monitor it through periodical surveys. Standard methods may be harmful to living organisms, hence methods have been developed to study marine biocoenoses that avoid harming biota, such as visual and photographic censuses [1]. In order to investigate the diversity of the malacofauna, one of the main components of the Mediterranean diversity [2], a no-impact method - examination of thanatomalacocoenoses - was tested in the Torre Guaceto MR (Italy, Brindisi province, SW Adriatic Sea). Such a method is based on fidelity, i.e. the manifold verified correspondence between the qualitative compositions of thanatocoenoses and nearby living malacocoenoses [3, 4]. The examination of mollusc shells found in death assemblages of a Torre Guaceto MR beach showed the presence of 114 different species: 86 gastropods, 27 bivalves, and 1 scaphopod [5]. Advantages and disadvantages of such a method have also been dealt with [6, 7]. Indeed, in the case of Torre Guaceto MR, some drawbacks of this technique to document the overall diversity of molluscs were apparent. An implied deficiency was the exclusion from the survey of all shell-less molluscs, which however are just a numerical minority (but photographic surveys of nudibranchs are underway.) An unforeseen and somewhat surprising weakness was the absence in the examined death assemblage

samples of many shelled molluscs common in the MR, mainly mediumand large-sized species (from a few to many cm). But also certain micromolluscs were absent, e.g. all members of the Caecidae (Gastropoda: Neotaenioglossa). In fact, most shells belonged to small size species (<1 cm) and only a small fraction was from juveniles of larger species; overall mean size = 5.1 mm [5].

Tab. 1. List of additional shelled molluscs recorded in the Torre Guaceto Marine Reserve. S: shells collected from the beach or the sea floor; A: alive individuals observed underwater.

| GASTROPODA                                | S | A |
|-------------------------------------------|---|---|
| Haliotis tuberculata Linnaeus, 1758       | x | x |
| Bolma rugosa (Linnaeus, 1767)             | x |   |
| Vermetus triquetrus Bivona, 1832          | x | x |
| Luria lurida (Linnaeus, 1758)             | x | x |
| Natica hebraea (Martyn, 1784)             | x |   |
| Natica stercusmuscarum (Gmelin, 1791)     | x |   |
| Bolinus brandaris (Linnaeus, 1758)        | x | x |
| Hexaplex trunculus (Linnaeus, 1758)       | x | x |
| Stramonita haemastoma (Linnaeus, 1766)    | x | x |
| Fasciolaria lignaria (Linnaeus, 1758)     |   | x |
| BIVALVIA                                  |   |   |
| Solemya togata (Poli, 1795)               | x |   |
| Glycymeris insubrica (Brocchi, 1814)      | x |   |
| Lithophaga lithophaga (Linnaeus, 1758)    |   | x |
| Pinna nobilis Linnaeus, 1758              | x | x |
| Mimachlamys varia (Linnaeus, 1758)        | x |   |
| Pecten jacobaeus (Linnaeus, 1758)         | × |   |
| Spondylus gaederopus Linnaeus, 1758       |   | x |
| Anomia ephippium Linnaeus, 1758           | x |   |
| Pododesmus patelliformis (Linnaeus, 1761) | x |   |
| Limaria tuberculata (Olivi, 1792)         | x |   |
| Neopycnodonte cochlear (Poli, 1795)       | x |   |
| Loripes lacteus (Linnaeus, 1758)          | x |   |
| Tellina planata Linnaeus, 1758            | x |   |
| Gastrana fragilis (Linnaeus, 1758)        | x |   |
| Donax trunculus Linnaeus, 1758            | x |   |
| Callista chione (Linnaeus, 1758)          | x |   |
| Ruditapes decussatus (Linnaeus, 1758)     | x |   |
| Pholas dactylus Linnaeus, 1758            | x |   |
| Barnea candida (Linnaeus, 1758)           | x |   |
| CEPHALOPODA                               |   |   |
| Sepia officinalis Linnaeus, 1758          | x | x |

In order to improve the checklist of Torre Guaceto shelled molluscs with-

out breaching the no-impact guiding principle, additional data were gathered through the following actions: A) collection of washed-ashore shells during beach-combing; B) hand collection of empty shells on the sea floor during underwater surveys; C) underwater visual census.

In all, 30 species - 10 gastropods, 19 bivalves and 1 cephalopod - were recorded in addition to those already found during the death assemblage survey [5]. They are listed in Table 1.

The checklist of shelled molluscs recorded in the Torre Guaceto MR presently contains 144 species: 96 gastropods, 46 bivalves, 1 scaphopod, and 1cephalopod. The species recorded correspond to about 22 and 58% respectively of the shelled gastropods and bivalves reported in the southwestern Adriatic Sea in the Checklist of the Italian marine fauna [8, 9]. However, one should note that the latter checklist includes many deepwater species, whereas the Torre Guaceto list comprises only infralittoral molluscs.

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# BIODIVERSITY OF HARDBOTTOM COMMUNITIES GROWN ON ARTIFICIAL SUBSTRATA IN THE SARONIKOS GULF (AEGEAN SEA) - A PILOT STUDY

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# Abstract

In this pilot study, we monitored for the first time the biodiversity of hardbottom communities grown on artificial substrata in two shallow water habitats of the Saronikos Gulf, Greece. Here we report preliminary results from the analysis of assemblages that established at a disturbed and an undisturbed study site as well as a list of macrofouler species. This research was performed within the framework of the German-Greek collaboration for the advancement of knowledge exchange among young scientists (IKYDA, 2006). Keywords : Aegean Sea, Monitoring, Biodiversity, Artificial Reefs, Fouling.

Intertidal and shallow water subtidal coastal ecosystems are more impacted by human activities than any other marine habitat. Therefore, they can be a useful tool to measure human-induced changes in the marine environment [1]. One promising approach to detect and quantify these changes is to compare the composition and stability of hardbottom communities from impacted and non-impacted areas. The aim of this pilot study was to describe and analyse the structure of assemblages grown on artificial substrata that were deployed at a disturbed and an undisturbed site in the Saronikos Gulf.

#### Study sites

Settlement panels were exposed to natural fouling at two study sites in the Saronikos Gulf: Agios Kosmas (AGK) and Mavro Lithari (ML) (Figure 1). The Inner Saronikos Gulf is one of the most heavily polluted regions of the Greek coast, mainly due to domestic and industrial effluents [2]. Mavro Lithari lies in the Outer Saronikos Gulf far from these effluents, while Agios Kosmas is located only a few kilometres SE of Piraeus Port and has lately been heavily disturbed by the construction of the Sailing Center for the Olympic Games 2004 [3].



Fig. 1. Study sites in the Saronikos Gulf: Agios Kosmas (AGK) and Mavro Lithari (ML).

# Methods

At each study site 6 PVC carrier rings (each with 10 PVC settlement panels, 15 x 15 cm in size) were deployed in March 2006. The communities that established on these 60 settlement panels were sampled randomly every two to four weeks. All macrofouler species larger than 1 mm were identified and their abundances were estimated as percent cover.

In order to compare community structure between study sites, species number (N), the Shannon index (H', loge), and Evenness (J') were calculated for each sampling event. We tested for differences in mean community parameters with the t-test. Additionally, significant differences in community composition between sites were identified using Analysis of Similarity (ANOSIM) conducted on the base of the abundance data.

# Results and Discussion

Until the 10<sup>th</sup> week the assemblages at both sites consisted only of

biofilms. Macroufoulers were then observed from the 12<sup>th</sup> monitoring week on. A total of 29 macrofouling species were identified until the  $26^{t\tilde{h}}$ week (Table 1). Hydrozoa and the red alga Polysiphonia sp. were the first settlers and became dominant taxa in ML, while in AGK Serpulidae settled first and dominated the communities up to the 20<sup>th</sup> week.

Tab. 1. Species monitored on artificial settlement panels.

| Commo              | on to both sites        | May 10 Lithari         | Agios Kosmas              |
|--------------------|-------------------------|------------------------|---------------------------|
| Schizoporella sp.  | Cladophora sp.          | Hydrozoa               | Colpomenia sinuosa.       |
| Miriapora          | Laurencia sp.           | Serpulidae sp. B       | Ectocarpus sp.            |
| Dictyota dichotoma | Champia parvula         | Bivalve sp. A          | Bivalve sp 2              |
| Ceramium sp.       | Wrangelia pericillata   | Sycon sp.,             | Leuconia sp.              |
| Chondria sp.       | Acetabularia acetabulum | Mytilus sp.,           | Acanthophora nayadiformis |
| Chaetomorpha sp.   | Balanus (amphitrite)    | Gastropoda             |                           |
| Polysiphonia sp.   | Serpulidae sp. A        | Diplosoma listerianium |                           |
| Jania sp.          | Corallinales            | Botryllis (schlosseri) |                           |

Between sampling sites we found a significant difference (p <0.05) in species number (N) and Shannon index (H', loge) for each sampling event, while the communities differed in their evenness (J', p <0.001) from the 6<sup>th</sup> month on. Significant differences in the composition of hardbottom communities from the two study sites were also observed for all sampling events ( $R \ge 0.77$ ,  $p \le 0.001$ ).

Since communities from the impacted site were always less diverse than the assemblages from the non-impacted habitat, we assume that the composition and structure of the hardbottom communities reflect the ecological conditions at the two study sites. Differences between assemblages from Agios Kosmas and Mavro Lithari should therefore not only be due to different colonizer pools. This assumption will be tested in the future course of this study in order to establish hardbottom communities grown on artificial substrata as a tool in the ecological monitoring of Mediterranean coastal waters.

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# PREMIER SIGNALEMENT DU BRYOZOAIRE CHEILOSTOME CRIBRILINA PUNCTATA DANS LE GOLFE DE TUNIS

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## Résumé

Nous signalons, pour la première fois, la présence de l'espèce Cribrilina punctata (Hassall, 1841) dans les eaux tunisiennes à Sidi Raies, dans le Golfe deTunis (Famille Cribrilinidae, Sous-Ordre Ascophorina, Ordre Neocheilostomina). Mots clès : Bryozoa, Posidonia.

Onze espèces de la famille des Cribrilindae (Hincks, 1879) ont été signalées en Tunisie [1]. Une seule d'entre elles appartient au genre Collarina (C. balzaci), quatre au genre Cribrilaria, une au genre Figularia ( Figularia figularis) tandis que le genre Puellina est représenté par cinq espèces. Nos recherches sur les Bryozoaires des eaux tunisiennes nous ont permis d'ajouter à cette liste une nouvelle espèce : Cribrilina punctata (Hassall, 1841). Nous en avons collecté un unique échantillon, en août 2005, lors d'une plongée en scaphandre autonome, à une profondeur de 3m dans la zone de Sidi Raies située à 39°46'09 Nord et 10°32'49 Est. La colonie était fixée sur une petite portion de rhizome de Posidonie. Le zoarium est circulaire, aplati et encroûtant, de couleur blanc-jaûnatre, mesure  $600\mu$  x  $450\mu$  ; il s'agit d'une très jeune colonie, seulement constituée par 5 autozooécies cribrimorphes. La face supérieure est calcifiée ; elle présente des pores de forme arrondie et de taille variable apparemment disposés de manière irrégulière, les côtes frontales étant très peu distinctes chez cette espèce. Les zooïdes mesurent  $230\mu$  long et  $140\mu$ de large ; leurs orifices semi-circulaires portent 4 à 5 épines distales. Un petit aviculaire, pointu à bec orienté distalement vers l'extérieur, est situé à coté de l'orifice. Nous n'avons pas observé de zoécie ovicellée, ce qui est logique compte tenu du très jeune âge de la colonie (probablement quelques semaines), et étant donné par ailleurs qu'elle a été récoltée (et s'est développée) en dehors de la période de reproduction de l'espèce (trouvée ovicellée en Méditerranée durant les mois d'avril et d'octobre par Gautier [2]. Les caractères observés concordent avec les descriptions de cette espèce données par Hincks [3], Prenant et Bobin [4], Bishop [5] ainsi qu'Hayward et Ryland [6], et l'exactitude de l'identification a été confirmée par comparaison avec des spécimens de référence conservés dans les collections du Muséum National d'Histoire Naturelle de Paris. Les auteurs précédents indiquent toutefois des dimensions autozoéciales supérieures aux nôtres (0,40-0,54 mm x 0,26-0,45 mm) ; la très petite taille de loges observées dans le cas présent s'explique par le fait qu'il s'agit des premières jeunes autozoécies péri-ancestrulaires du zoarium. Cribrilina punctata est une espèce boréo-atlantique qui se retrouve depuis l'Arctique jusqu'à l'Atlantique tempéré chaud, et qui serait plus rare en Méditerranée. Gautier [2], qui l'a récoltée à Marseille, a récapitulé les localités méditerranéennes des auteurs antérieurs (Corse, Capri et Naples) ; nous renvoyons à son travail pour les références bibliographiques correspondantes.L'espèce n'avait pas encore été mentionnée, ni de Tunisie ni plus largement des côtes du Maghreb ; l'échantillon que nous avons récolté correspond donc au premier signalement de cette espèce sur les côtes tunisiennes et sur le littoral sud de la Méditerranée. Le fait qu'elle n'ait encore jamais été récoltée sur les côtes d'Afrique du Nord peut impliquer, soit qu'elle y soit peu fréquente et/ou localisée, soit qu'elle y ait été introduite, et peut-être à une date assez récente. Lors de sa révision du genre Cribrilina, Bishop [5] précise curieusement qu'il n'a pas eu la possibilité de consulter de spécimens de C.punctata provenant de Méditerranée (alors que les échantillons de Gautier existent pourtant dans les collections du Muséum National d'Histoire Naturelle de Paris), et émet par ailleurs l'hypothèse qu'il pourrait s'y rencontrer une espèce nouvelle du genre Collarina susceptible d'être confondue avec elle. D'après Hayward et Ryland [6], cette espèce vit dans toute la zone littorale, aussi bien sur les algues, que sur les pierres, que sur les coquilles de Mollusques. Selon Gautier [2], qui l'a recueillie sur des fragments de coquilles et d'oursins, elle se rencontre jusqu'à 50m de profondeur.

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# ECOLOGICAL CORRELATES OF ESTABLISHMENT SUCCESS IN LESSEPSIAN FISHES

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## Abstract

A database on Lessepsian fish species occurrences from 1869 until 2006 was built and the colonization rate of each species was estimated. Data about geographic distribution and ecological traits were gathered from the literature. Classical test of hypothesis were used to investigate the relationships between fish ecological attributes and establishment success. Among the ecological variables studied, the climate match and the propagule characteristics are significantly related to the establishment success of Lessepsian species: the subtropical species and the species with pelagic propagules may have an advantage in the colonization process of the Mediterranean Sea. *Keywords : Species Introduction, Red Sea, Suez Canal.* 

#### Introduction

The completion of the Suez Canal in 1869 has led to spectacular biotic exchanges between the Mediterranean and Red seas which are both hotspots of endemism. Despite the importance of the phenomenon, determinants of establishment success for Lessepsian fishes in the Mediterranean Sea have been poorly investigated. In this study we reconstructed the spatiotemporal dynamic of all the Lessepsian fish species and we analysed the relationship between ecological variables and invasion rate.

#### Methods

By compiling the existing bibliography, we reconstructed the chronological history of fish species invasions since their first Mediterranean record in 1896 until 2006. Each record was plotted on a map using a Geographical Information System (GIS) software (Arcview). Through this GIS application, we measured the distance covered by each fish species during a period of time and then we estimated the invasion rate.

All the species were classified into three categories according to their ability to spread over the Mediterranean Sea: (1) absence of colonization; (2) limitation to the Levantine basin; (3) widespread colonization. A database containing some predictor variables for each species was elaborated from the literature and from FishBase [1]. Then, we formulated some hypotheses:

- Climate matching: the establishment success of some exotic species was positively related to the match between their native and their colonized environment [2,3]. Based on this prediction, the subtropical species are more likely to colonize the Mediterranean Sea than the tropical species because they are more tolerant to cooler waters.

- Location in the water column: our prediction suggests that pelagic species have higher colonization ability than benthic species owing to their swimming performance and their hydrodynamic body shape.

- Maximum length: fishes with rapid growth, high reproduction rate and early sexual maturity would be better colonizers because invaders have to breed quickly to avoid extinction [4]. We may expect that small species, with earlier sexual maturity, are more likely to colonize the Mediterranean Sea than larger species.

- Propagules: species whose propagules have wider dispersal ability are expected to reach larger geographic range sizes [5,6]. Our hypothesis posits that fishes with pelagic egg would expand more widely their geographic range size than fishes with benthic egg.

- Confamilial resistances: it has been demonstrated that exotic taxa less related to native species are more invasive [7]. In our case confamilial resistance predicts that invading species with no or few confamilial counterparts in the Mediterranean Sea would be more likely to successfully colonize than species that encounter close relatives.

The non parametrical test of Kruskal-Wallis was used to test the hypothesis including quantitative variables and the Khi2 was used to test hypothesis involving qualitative variables.

#### Results

When species are split between the benthic and pelagic categories no significant relation with the invasion success was observed, the null hypothesis is not rejected. Neither species size nor confamilial resistance have an effect on the establishment success in the Mediterranean Sea or influence species colonization.

The Khi2 test revealed a significant dependence (P=0.024) between the latitudes of species and their invasion success in the Mediterranean Sea.

Tropical species spread less than expected by chance while the spread of subtropical species was greater than expected, colonising areas outside the Levantine basin. This result confirms that establishment success depends on the suitability of the abiotic environment for the exotic species at the introduction site: the Mediterranean Sea water temperature seems more appropriate for the subtropical species than for the tropical ones.

When we test the effect of propagule on the colonization, it appears that species with pelagic propagules tend to colonize more the northern side of the Mediterranean Sea than the benthic propagules species can do. Pelagic propagules are more exposed to the general circulation of sea waters than benthic propagules. It may explain why fishes with pelagic propagules are more likely to colonize the north side while fishes with benthic propagules colonize more proportionally both south and north sides of the Mediterranean Sea. Thus, the counterclockwise circulation in the Levantine basin appears to be one the main forcing factors in the Lessepsian species propagation.

Conclusion

Overall 28% of the Lessepsian species succeeded in colonizing the Mediterranean Sea. The northern side is more rapidly invaded than the southern one because of the counterclockwise oceanic circulation in the Levantine basin. In conclusion, crossing the Suez Canal does not guarantee the establishment and the widespread colonization for fish populations. Instead, it appears that some life-history and functional traits are key determinants for invasion (climate matching, propagules). Some Lessepsian fishes, favoured by warmer temperatures and selected according to their ecological attributes, may establish to the detriment of the Mediterranean species. This phenomenon may accelerate with the global warming occurring nowadays.

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# SUR LA PRÉSENCE DE NOUVELLES ESPÈCES EXOTIQUES DANS LA GRANDE ET LA PETITE SYRTE

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## Résumé

Des observations récentes faites au cours de campagnes de prélèvements d'organismes benthiques dans la zone infralittorale du golfe de Gabès (petite Syrte) et de la grande Syrte (Libye) nous ont permis de mettre en évidence l'installation d'espèces d'origine lessepsienne, à savoir 3 gastéropodes: le *Cypraea annulus, Strombus persicus, Erosaria turdus* et un ophiuride *Ophiactis savigny. Mots clès : Species Introduction, Eastern Mediterranean.* 

Des échantillonnages benthiques faits dans les eaux kerkeniennes (Tunisie) et tripolitaines (Libye) nous ont permis de récolter plusieurs spécimens d'un Cypreidae que nous avons pu identifier en tant que *Cypraea annulus* Linnaeus, 1758. Cette petite porcelaine littorale, réputée comme typique des eaux tropicales de l'Océan Indien, a été trouvée, au cours du printemps 2006, en plusieurs points de l'horizon infralittoral supérieur de la partie nord de l'archipel des Kerkena et au large de la ville de Tripoli. Les exemplaires récoltés (3 à Kerkena, 1 à Tripoli mesurent entre 14 mm et 22 mm).



Fig. 1. Cypraea annulus - Kerkena ( $i \pounds_i$  droite et  $i \pounds_i$  gauche) et Tripoli (au centre).

Cette espèce, comme le soulignent les auteurs de l'Atlas des espèces exotiques en Méditerranée [1], serait à bannir de la liste des "envahisseurs" car elle serait à ranger dans le groupe des objets "égarés" en mer dans les temps anciens! Ces coquilles seraient, en conséquence, les témoignages des civilisations ayant eu ce gastéropode comme monnaie d'échange ou comme ornement. Ceci est possible, mais il existe des arguments permettant de contredire cette assertion. Le premier est que nous avons récolté cette espèce vivante dans une fourchette bathymétrique et un contexte biocénotique voisins de ceux de son milieu originel. Le second argument, nous permet de situer cette acclimatation à partir d'une date très récente, car nous disposons de nombreuses listes malacologiques concernant la zone littorale kerkenienne. A ce titre, une étude [2] que l'on peut considérer comme quasi exhaustive a été faite en 1979 sur plus de 300 prélèvements répartis sur l'ensemble du pourtour de l'archipel des Kerkena. Les résultats de ces observations ont permis de mettre en évidence la présence de 96 espèces de gastéropodes parmi lesquels l'auteur n'a pas rencontré notre porcelaine. Il faut, par ailleurs, souligner que l'acclimatation de cette espèce suit celle de l'espèce allochtone voisine Erosaria turdus qui, en moins de 10 ans, est devenu fréquente et abondante dans les eaux de la strate infralittorale inférieure du golfe de Gabès [3, 4] et d'Italie du sud [5]. A cette répartition nous devons ajouter sa présence dans la grande Syrte. On assisterait donc, à l'heure actuelle, à une prise de relais progressif, aussi bien dans l'infralittoral supérieur avec Cypraea annulus qu'inférieur avec Erosaria turdus des espèces indigènes Luria lurida et Zonaria pyrum. Un spécimen du strombe Strombus persicus Swainson, 1821 (l'exemplaire mesure 45 mm de hauteur) a, quant à lui, été récolté dans les seules eaux infralittorales tripolitaines (Libye). Cette espèce originaire du golfe Persique a été signalée à partir de 1983 depuis les côtes méditerranéennes du Moyen Orient jusqu'à la Grèce avec une petite incursion en Adriatique [1].

Des prélèvements du benthos de substrat dur faits sur le littoral nord est de l'île de Jerba nous ont permis de récolter l'ophiure *Ophiactis savigny* (Müller & Troschel, 1842). Cette minuscule ophiure à 6 bras et de 3 mm de diamètre de disque a été trouvée à 3 m de profondeur dans une zone de blocs rocheux (elle a été déterminée par Mme Sabine Sthör du muséum d'Histoire Naturelle de Stockholm que nous remercions ici). Cette espèce indo-pacifique qui a déjà été récoltée en Méditerranée orientale et, plus bizarrement, à Banyuls [6] est donc signalée, ici, pour la première fois, en Méditerranée méridionale.





Au vu de ces récentes découvertes, il est certain que la liste des espèces invasives originaires de l'Océan Indien et de la mer Rouge s'allonge de manière continue dans le sud de la Méditerranée. On peut évoquer, pour cela, non seulement, le rôle, de plus en plus important, des transits pétroliers dans les grande et petite Syrtes, via les ports de Tripoli, Gabès ou la Skhira, mais aussi, l'influence croissante d'un courant oriental le long des côtes de la Méditerranée méridionale.

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# SEASONALITY OF GELATINOUS MACROZOOPLANKTON OFF SINOP, SOUTHERN BLACK SEA, IN 2002-2003

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## Abstract

Seasonal distribution, biomass and abundance values of gelatinous macrozooplankton (*Aurelia aurita, Pleurobrachia pileus, Mnemiopsis leidyi, Beroe ovata*) in the central southern Black Sea were studied during January 2002 - December 2003. The highest values of gelatinous macrozooplankton abundance were obtained from vertical tows in February and July of 2002, and in June and July of 2003, respectively. The maximum biomass of gelatinous macrozooplankton was recorded in March and July of 2003. *Keywords : Black Sea, Biomass, Cnidaria, Ctenophora.* 

Gelatinous macrozooplankton is one of the key components of the Black Sea ecosystem. In particular, the invasive ctenophore, *M. leidyi* is the agent responsible for the decrease of mesozooplankton and anchovy fishery in the Black Sea [1], most notably at the end of the 1980s, but also in mid 1990s. However, there are signs that the ecosystem of the Black Sea began to improve substantially due to sharp decreases in *M. leidyi* population as a result of appearance of its predator *Beroe ovata* in the late 1990s. The present study was carried out to determine gelatinous macrozooplankton structure in the pelagic ecosystem of the southern Black Sea. Seasonal distribution, biomass and abundance values of average gelatinous macrozooplankton in the Sinop peninsula of the central southern Black Sea were studied.



Fig. 1. Seasonal distribution of total gelatinous macrozooplankton (A) and species composition (B) of Sinop, in 2002 - 2003

The maximum abundance and biomass of total gelatinous macrozooplankton was obtained from vertical tows was 42,5 n.m<sup>-2</sup> and 224.4 g.m<sup>-2</sup> in September and July 2002. In June and July 2003, highest abundance values were 80.8 n.m<sup>-2</sup> and 91.3 n.m<sup>-2</sup> respectively. Maximum average biomass of gelatinous macrozooplankton were determined in March (1073.5 g.m<sup>-2</sup>), April (365 g.m<sup>-2</sup>) and July (397 g.m<sup>-2</sup>) 2003 (fig. 1,A). Minimum abundance and biomass values were found in winter periods in both years.

In terms of annual abundance, *A. aurita* was the dominant species in 2002 and 2003. The highest abundance value of *A. aurita* was found in 2003 (55%). Abundance of *A. aurita* was 50 n.m<sup>-2</sup>and 53,3 n.m<sup>-2</sup>in 2002 and 2003, these walues were higher than in 2000. In terms of abundance the contribution of *P. pileus* was 21 % in 2002 and 23 % in 2003. In 2000, *P. pileus* was the most abundant species with approximately 80%,

abundance value was 360 n.m<sup>-2</sup> [2], whereas total percent of *P. pileus* decreased compared with the study of Unal (2002) for 1999 (49.5%) and its abundance was 734 n.m<sup>-2</sup> [3]. In 2002 and 2003, abundance of *P. pileus* decreased to 29,1 n.m<sup>-2</sup> and 253,5 n.m<sup>-2</sup>. Maximum abundance of *P. pileus* was observed June 2003 (74,17 n.m<sup>-2</sup>) (fig. 1,B).

Our samples show that the abundance of *M. leidyi* was  $42.5 \text{ n.m}^{-2}$  and  $115 \text{ n.m}^{-2}$  in 2002 and 2003. *M. leidyi* decreased compared to 1999 (546,5 n.m<sup>-2</sup>) [3], and its abundance low in 2000 (30 n.m<sup>-2</sup>) [2]. Maximum abundance of *M. leidyi* was determined in july 2003 (86,25 n.m<sup>-2</sup>) (fig. 1,B). Abundance and biomass of *M. leidyi* showed oscillations until 1998, when its values declined [1]. In our study the percentage of *B. ovata* was significantly higher the 2002 ( $22,5 \text{ n.m}^{-2}$ ) than the 2003 (7,91 n.m<sup>-2</sup>). In 2000, *B. ovata* was found to constitute 2% of total gelatinous species [2], and its abundance 10 n.m<sup>-2</sup>. In the northern Black Sea in 1999-2001, development of *B. ovata* and *M. leidyi*. *M. leidyi* was more abundant from mid-spring to autumn. Its autumnal decline closely coincided with the appearance of *B. ovata*. This pattern was repeated in 2002-2003.

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# CONTRIBUTION OF THE RED SEA ALIEN SPECIES TO STRUCTURING SOME BENTHIC BIOCENOSIS IN THE LEBANON COAST (EASTERN MEDITERRANEAN)

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## Abstract

Some Red sea alien species and thermophilic species have successfully colonized the coast of the Levantine basin and formed a particular facies in the infralittoral biocenosis. With regard to this, the Lebanon coast represents an excellent natural laboratory to check those important biotic and climatic changes.

Keywords : Eastern Mediterranean, Phytobenthos, Zoobenthos, Species Introduction.

#### Introduction

Pérès and Picard [1] pointed out the high frequency of thermophilic species in the Levantine basin, but did not mention Red Sea alien species (RA). Possibly, the role of those species in structuring the Mediterranean biocenosis was still insignificant 40 years ago. The coast of Lebanon represents an interesting area to study the biotic changes related to the RA [2] and the 'tropicalisation' of the Mediterranean [3], since the study of the lebanese biota has progressively increased [4-9]. Actually, RA have outcompeted or replaced native species locally in the inshore benthic communities (0-40m depth).

The biota of the supralittoral-midlittoral rocks and the littoral fringe (0-2m depth) are similar to the rest of the Mediterranean coast [1], with the addition of the corallinacea facies *Lithophyllum trochanter*, *Tenarea undulosa* and *Neogoniolithon brassica-florida* with the vermetid *Dendropoma petraeum*. However, the Red Sea bivalve *Brachidontes pharaonis* is particularly dominant on eutrophic sectors; and, together with *Balanus* perforatus and *B. trigonus*, forms a facies on exposed shallow zones (0-2m depth).

Biocenosis of small boulders and pebbles (0-1m depth): This interesting habitat (in sheltered sites) presents some frequent RA, as Cerithium scabricum and Ergalatax obscura (gastropods) and Pyura momus, Rhodosoma turcicum and Phallusia nigra (ascidians) . Biocenosis of the infralittoral algae (0-35m depth): The RA macroalgae Codium taylori and Cladophoropsis patentiramea (chlorophytes) and Stypopodium schimperi (phaeophyte) dominate that biocenosis in late summer. Among the sessile fauna, some RA are abundant: Lytocarpus philippinus (hydrozoan), Malvufundus regulus, Spondylus spinosus and Chama pacifica; (bivalves) and P. nigra (ascidian). In exposed shallow zones (1-5m depth), S. spinosus and Ch. pacifica cover completely the rock, and forming a particular facies. Among the more frequent RA and/or warm benthic mobile fauna: Hermodice carunculata (polychaete), Strombus persicus (gastropod), Charybdis helleri (decapod), Synaptula reciprocans (holothurian) and the fishes, Siganus luridus, S. rivulatus, Sparisoma cretense and Sargocentrum rubrum. Fouling community (0-20m depth): B. perforatus and B. trigonus, and B. pharaonis have been the dominant species at the shallower zone (0-5m depth). Deeper (5-20m depth), ascidians dominane, with the cosmopolitan Styela plicata, S. partita and Microcosmus exasperatus, and the RA P. momus, P. nigra and Symplegna brakenhielmi. Other RA are frequent: Spirobranchus tetraceros (polychaete), and the bivalves S. spinosus, M. regulus and Pinctada radiata.

Biocenosis of the coralligenous (35-40m depth): Although impoverished with regards to the other Mediterranean sectors, it present the typical components of the Mediterranean: macroalgae ( Lithophyllum, Mesohyllum, Peyssonnelia, Osmundaria, Palmophyllum spp.). The poriferans are dominant (Axinella, Agelas, Dysidea, Petrosia, Phorbas, Spirastrella spp.); with the madreporarians ( Phyllangia and Madracis spp.) and bryozoans (Sertella, Margaretta spp.). Although the influence of the RA species does not appear significant, some of them are frequent: S. persicus, S. spinosus, Ch. pacifica, S. reciprocans and S. rubrum. Biocenosis of the semi-dark and dark caves (0-10m): The poriferans (Sycon, Axinella, Chondrosia, Cliona, Crambe, Ircinia, Petrosia, Phorbas, Pleraplysilla, Microscleroderma, Gastrophanella spp.) and the madreporarians (Polycyathus, Phyllangia, Oculina, Madracis spp.) are dominant. Some RA species are present in that biocoenosis: the serpulid Pomatoleios kraussii; the molluscs Hypselodoris infucata, Petaloconchus glomeratus, S. spinosus and Ch. pacifica; the ascidians H. momus and Ph. nigra; and the fish Pempheris vanicolensis. Biocenosis of sandy mud (25-40m depth) is represented by the association *Halophila stipulacea* and *Caulerpa scapel-liformis* with the RA gastropod *Rhinoclavis kochi*.

#### Discussion

Some important changes occur in the Levatine basin, due to the RA and the 'tropicalization' of the Mediterranean (1,2), particularly in the infralittoral zone (0-35m depth), and to a lesser degree in the circalittoral. The marked seasonal changes in the macroalgae cover are noteworthy: in spring and early summer, the phaeophytes dominate the upper strata ( Cystoseira spp., Dictyota fasciola, Dictyopteris polypodioides, Halopteris scoparia, Padina pavonica, Sargassum vulgare, Taonia atomaria); in late summer and autumn, that phaeophyte canopy disappears (also due to the herbivorous pressure?), and the permanent turf of corallinacea ( Amphiroa, Corallina, Jania, Lithophyllum, Neogoniolithon spp.) dominates the photophilic surfaces. Some rocky infralittoral sectors (exposed zones, sheltered boulders, photophilic and sciaphilic surfaces, fouling communities) can be dominated by RA: macroalgae ( C. taylori, C. patentiramea, L. lallemandii, S. schimperi), Cnidaria (L. philippinus), Polychaeta (S. tetraceros, P. kraussii), molluscs (S. persicus, C. scabricum, E. obscura, R. kochi, B. pharaonis, S. spinosus, Ch. pacifica, P. radiata, M. regulus), crustaceans ( Ch. helleri), echinoderms ( S. reciprocans), ascidians ( P. momus, P. nigra, R. turcicum, S. brakenhielmi).

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# SEASONAL VARIABILITY IN ABUNDANCE AND BIOMASS OF TINTINNIDS IN THE KAŠTELA BAY (MIDDLE ADRIATIC SEA)

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## Abstract

Temporal variability in tintinnid abundance and biomass were investigated in the central part of the Kaštela Bay, Croatia. The highest abundance (755 ind.1<sup>-1</sup>) and biomass (3.230  $\mu$ gC 1<sup>-1</sup>) were recorded in February 1998 at the surface, and in September 1998 at 25 m depth, respectively. *Helicostomella subulata, Codonellopsis schabi, Stenosemella nivalis* and *Salpingella rotundata* represented 68% of the total tintinnid number and may have an exceptional importance in the microbial food web of the investigated coastal ecosystem. *Keywords : Adriatic Sea, Biomass, Density, Zooplankton.* 

Ciliated protozoa participate in the transfer of energy and carbon from bacterioplankton and phytoplankton to higher trophic levels through the microbial food web [1, 2]. Also, they can act as a link between classic herbivorous food chain and microbial food web [3]. One approach to studying trophic relations and their role in the cycling of organic matter is to analyse the temporal variability of planktonic components [4]. Therefore, the present study focuses on seasonal changes in abundance and biomass of tintinnids as one important part of ciliated protozoa community [3]. These are the first results for this part of the Bay as well as the first biomass data, which are one of very few available for the whole Adriatic Sea.

Samples were collected at a station located in the middle of Kaštela Bay  $(43^{\circ}31.2^{\circ} \text{ N}; 16^{\circ}22.9^{\circ} \text{ E})$  in the central Adriatic Sea. Sampling was performed on a monthly basis from January 1998 until November 1999, at 5 m depth intervals between the surface and bottom (35 m) with 5 l Niskin bottles. The plankton material was preserved and prepared for microscopic analysis as described in reference [3]. The carbon biomass value of tintinnids was estimated by measuring linear dimensions of the lorica, which were afterwards inserted in appropriate formula [5].

Tintinnids were represented with 45 species, which is about half of the known tintinnid species from the Adriatic Sea. It is commonly known that tintinnid biodiversity is affected by the nearness of land as well as the open sea influence. The influence of both factors at investigated station was almost equal. The highest biodiversity was recorded in October 1999 (17 neritic-estuarine species and 14 open sea species) which points at very intensive exchange of water masses between the Kaštela Bay and the surrounding area.

Temporal variability in abundance of tintinnids was characterised by spring and autumn peaks, with average values of  $132 \pm 169$  ind. $1^{-1}$  in April 1999 and 205  $\pm 77$  ind. $1^{-1}$  in September 1998. The high mean value in winter ( $192 \pm 246$  ind. $1^{-1}$ ) was recorded only in February 1998, with the highest value of 755 ind. $1^{-1}$  at the surface (figure 1). Similar abundances were noticed in the bays of the south Adriatic [6, 7]. Very low abundances during summer could be explained by encystment of tintinnids in unfavourable living conditions, such as high sea temperature and increased light intensity [8].



Fig. 1. Temporal variability in abundance and biomass of tintinnids in the Kaštela Bay

In spite of isothermal conditions in winter, tintinnids were most abundant in the surface layer. In September, they concentrated in the deeper layers. For better understanding of seasonal and vertical distribution of tintinnids it is important to know the taxonomical structure. Quantitatively the most important tintinnids of the Kaštela Bay were *Helicostomella subulata*, *Codonellopsis schabi*, *Stenosemella nivalis* and *Salpingella rotundata*. These species represented 68% of the total tintinnid number and may have an exceptional importance in the microbial food web during the period of their highest abundance. *H. subulata* was most abundant from the end of winter to spring. Favourable environmental conditions and probably the trophic state of the investigated area may be relevant. *C. schabi*, *S. nivalis* and *S. rotundata* are typical autumn-winter species. Very high abundances of *H. subulata* were recorded in the surface layers, while three other species preferred the deeper layers.

Seasonal and vertical distribution of tintinnid biomass was quite similar to oscillations of their abundances (r=0.86, p<0.0001, N=17). The average biomass values ranged between 0.088 ±0.048 and 2.081 ±0.788 µgC l<sup>-1</sup>, recorded in July and September 1998, respectively (figure 1). The highest biomass of 3.230 µgC l<sup>-1</sup> was found in September 1998 at 25 m depth. Similar values were found in the Gulf of Trieste [9]. Differences in the succesion of tintinnid biomass affect the energy flow in the marine food web. Therefore, changes in the abundance or biomass of tintinnid species are important indicators of changes in the microzooplankton community, as a consequence of the changed trophic state of an area.

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# IMPORTANCE OF THE COPEPODITE STAGES IN THE TOTAL NUMBER OF CALANOID COPEPODS IN THE MIDDLE ADRIATIC SEA

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## Abstract

Samples were collected at six stations along Palagruža transect in the Middle Adriatic Sea during four cruises in 2002 and five in 2003. Contribution of juvenile developmental stages of calanoids was pointed out. Their percentages in the total number of calanoids were 41-92%. The highest values were in April, on the station CJ007 from maximal 1333 ind./m<sup>3</sup>, 1117 ind./m<sup>3</sup> copepodites. *Keywords : Adriatic Sea, Copepoda, Zooplankton.* 

## Introduction

The duration of life cycle from egg to adult in calanoid copepods is governed primarily by temperature and food availability. In the past investigations of the calanoid copepods of Adriatic Sea, copepodite stages were insufficiently represented. Because of the method of sampling, big mesh size nets (>200  $\mu$ m) were used, majority of calanoid developmental stages flew through. Many authors counted them with corresponding species.

#### Materials and methods

Planktonic material was investigated along Palagruža transect in the Middle Adriatic Sea during four cruises in 2002 (May, June, August and September) and five in 2003 (April, June, August, October and December). Samples were collected at six stations (CJ007-CJ012) using Nansen net with mesh size 200  $\mu$ m, mouth opening 57 cm and length 255 cm in one or two vertical hauls depending on stations' depth. Organisms were preserved in 2.5% of formaldehyde neutralized with CaCO<sub>3</sub> and later in the laboratory, counted by the means of stereomicroscope Carl Zeiss. All results are presented as the number of individuals per cubic meter (ind/m<sup>3</sup>). Differentiating the last copepodite stage from adults is rather difficult in some groups so they are oftenly counted in adults.

#### Results and discussion

Papers in which the authors refer to copepodite developmental stages as a special quantitative and qualitative category are very scarce. Hure and Scotto di Carlo (1969) investigated open waters of northern Adriatic with 333  $\mu$ m mesh size net (No.3). According to authors, winter samples include minimum copepodites and their number grows up to 40.2% in the total number at the end of the year. Although they noticed quantitative importance they couldn't tell about their real representation in the calanoid populations.

In this investigation contribution of postnaupliar developmental stages in the total number of individuals of calanoids was 41-92% with a median value of 81%. Examining each cruise, percentage of the copepodites ranged from 72 to 85%, except in September 2002 (48%) when the adults prevailed. Some of the calanoid families (e.g. Calanidae, Centropagidae, and Augaptilidae) recorded maximal number of copepodites in late spring and summer, but most of the others were equally presented and durinated during all cruises. Figure 1. shows abundance of the adult and copepodite stages of calanoid copepods in biannual cycle. Although the copepodite values are five times higher that the adult ones, their cycles are nearly equal with the same exception of September 2002.

Lučić i Kršinić (1998) investigated zooplankton in Mali Ston Bay with the Adriatic net equipped with different mesh gauze cylinders, 125 and 250  $\mu$ m. Statistically significant difference (p<0.001) in calanoid copepodite abundance was determined. 250  $\mu$ m mesh sized net kept only 27.7% calanoids i.e. 2.2-8.4% of their copepodite stages comparing to 125  $\mu$ m mesh sized net.

Pronouncedly high concentrations of copepodite stages in the total number of calanoid copepods verify their quantitative importance not only in the Middle Adriatic, but also in general. It would be advisable to perform detailed investigations of the Adriatic Sea and to apply appropriate sampling methods in order to obtain the complete picture about populations of calanoid copepods, their adult individuals but also their copepodites.



Fig. 1. Abundance of the adult and copepodite stages of calanoid copepods in biannual cycle.

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# CAULERPA RACEMOSA (FORSSKAL) INDUCES SHIFTS IN MOLLUSCAN SPECIES COMPOSITION AT POSIDONIA OCEANICA (L.,) DELILE SEAGRASS MEADOWS

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### Abstract

In the Balearic Islands, the *Caulerpa racemosa* is an actual problem because colonize all kind of bottoms between 0-40 meters. The colonization of the dead rhizomes of *P. oceanica* seagrass by the green algae *Caulerpa racemosa* change the molluscan community previously associated with *P. oceanica*. This change is reflected in an increase of molluscan abundances and diversity, higher in *C. racemosa*.

Keywords : Algae, Balear Islands, Mollusca, Coastal Systems.

#### Introduction

*P. oceanica* meadows are characterized by a high molluscan diversity, especially gastropoda species [3]. The substitution of the seagrass *P. oceanica* by *Caulerpa racemosa* macroalgae changes abundances and diversity of molluscan species [1,2]. *C. racemosa* is expanding its presence in the Mediterranean and has been reported in 11 Mediterranean countries [4]. In Balearic Islands *C. racemosa* is frequent growing over dead *P. oceanica* rhizomes near the edge of the meadow.

The aim of this study is to analyze changes in species composition, diversity and abundance in the molluscan fauna associated to *Posidonia oceanica* after the substitution of the seagrass beds by *Caulerpa racemosa* macroalgae.

#### Material and methods

During 2004, bimonthly samples of molluscan fauna were collected in Portals Vells (Balearic Islands) at 5-8 m depth among *Posidonia oceanica* rhizomes colonized by *Caulerpa racemosa*. The control sampling station (*P.* oceanica) without Caulerpa was located in Cala d'Or. Molluscan individuals were collected using a 20x20 cm frame set by scuba-diving in the rhizome bed inserted 5 centimeters into the sediment; both sediment and rhizomes inside the frame were removed, placed in a net-bag of 200  $\mu$ m mesh size and sorted in laboratory.

SIMPER routine (PRIMER 5.0) was used to evaluate main species in each meadow and a CLUSTER (based in Bray- Curtis similarity algorithm) was performed to analyse the grouping of the samples.

#### Results and discussion

A total of 17 gastropoda species and 20 bivalve species were identified in the C. racemosa macroalgae. In C. racemosa samples there was a low similarity value (average similarity 37%, SIMPER). Main species in C. racemosa were Glans trapezia, Ctena decussata, Bittium reticulatum, Limaria hians, Paphia aurea, Rissoina bruguieri, Alvania cimex, Nassarius incrassatus and Arca noae. At seagrass P. oceanica samples a total of 12 gastropoda species and 16 bivalvia were identified. The main contribution to the similarity percentage (average similarity 24%, SIMPER) was due to the bivalves Glans trapezia, Loripes lacteus, Pinna nobilis and Arca noae. The dissimilarity percentage between meadows Caulerpa vs Posidonia was high (average dissimilarity 80,22%) attributed to the differences between the species and abundances between meadows. The cluster analysis clumped all samples from C. racemosa apart from that of P. oceanica showing a clear seasonal pattern in the molluscan species at C. racemosa. In the C. racemosa Margalef diversity maximum values (d= 2,13) and Shannon-Wiever maximum data (H'=2,12) were found in October, and maximum abundance (308 ind/m<sup>2</sup>) was quantified in February. The values at Caulerpa mats were higher than those obtained in the P. oceanica seagrass, where maximum diversity values (d=1,42 and H'=1,9) corresponded to June, and maximum abundance (67 ind/m<sup>2</sup>) to April and June. The substitution of P. oceanica by C. racemosa seems to produce a change in the dominant and most frequent molluscan species of P. oceanica, reflected in an increase in diversity values and abundances quantified at C. racemosa mats.



Fig. 1. CLUSTER representation of the collected samples from *P. oceanica* and *C. racemosa*. PO means *Posidonia oceanica* and CR means *Caulerpa racemosa*.

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# PLANKTONIC OSTRACODS ABUNDANCE IN THE DEEP ADRIATIC SEA

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## Abstract

Planktonic ostracod abundance was investigated in the South Adriatic Sea in the vertical layers at the station 1000 m deep in March 1998 and October 2001. Fifteen species were found, and the dominant ones were *Porroecia spinirostris* and *Archiconchoecia striata*. Maximal abundance of 1084 ind.100 m<sup>-3</sup> was found in 200-300 m layer in March 1998. *Keywords : Adriatic Sea, Biodiversity, Density, Pelagic, Zooplankton*.

Planktonic ostracods are widely distributed in the world seas. Some of dominant species must be amongst the most abundant invertebrates in the world and they still remain almost totally unknown, even amongst oceanic biologists [1]. Nevertheless, little is known about their population structure, reproduction and life-cycle [2]. The investigations in the Adriatic Sea [3, 4] and wider in the Mediterranean [5] are rare. The present investigation shows the species composition and abundance of ostracods in the deep South Adriatic.

Planktonic samples were collected at the 1000 m deep station in the South Adriatic ( $42^{\circ}21.2$ 'N,  $17^{\circ}41.7$ 'E) by r/v Bios in March 1998 and October 2001. Samples were taken by Nansen type net, mesh 200  $\mu$ m, mouth 1/4 m<sup>2</sup>, and 255 cm long, equipped with the closing mechanism. Samplings were performed in the layers of 0-50, 50-100, 100-200, 200-300, 300-400, 400-600 and 600-1000 m. Catch was fixed by 2.5% neutralized formalin and analyzed in laboratory under the stereoscope. The abundance of ostracods was reported as number of individuals per one hundred cubic meters (n ind.100 m<sup>-3</sup>).

Fifteen species of planktonic ostracods from family Halocyprididae were found: *Porroecia spinirostris, Porroecia porrecta, Porroecia porrecta adriatica, Conchoecia magna, Mikroconchoecia curta, Mikroconchoecia echinulata, Proceroecia procera, Proceroecia macroprocera, Proceroecia microprocera, Discoconchoecia elegans, Paraconchoecia spinifera, Paramollicia rhynchena, Loricoecia loricata, Metaconchoecia rotundata and Archiconchoecia striata.* In March 1998 (fig. 1) the abundance increased by the depth down to 200-300 m layer, where the maximum of 1084 ind.100 m<sup>-3</sup>(178 adult ind.100 m<sup>-3</sup>) was recorded.



Fig. 1. Total ostracod abundance in March 1998.

Going deeper the abundance decreased, and in the deepest layer it was slightly higher in comparison to the surface layer. The proportion between juveniles and adults in the surface layer was 2:1, and in the layer of 100-200 m the proportion was 7.6:1.

In October 2001 (fig. 2) the highest total abundance was 50% lower, 544 ind.100 m<sup>-3</sup> (180 adult ind.100 m<sup>-3</sup>), in 100-200 m layer. In the deepest layer the ostracods were less abundant in comparison to the surface abundance.

The dominant species were *Porroecia spinirostris* and *Archiconchoecia striata*. *P. spinirostris* in March 1998 had the highest abundance in the layer of 100-200 m. Above 100 m only females, and beneath 200 m only juveniles were found. In October 2001 the highest abundance was found

in layer 0-200 m. In layer 200-300 m only juveniles were found and deeper in layer 400-600 m only a few females were found.



Fig. 2. Total ostracod abundance in October 2001.

A. striata was noted in both investigations at the depths of 50-300 m, and the highest abundance was recorded in the layer 100-200 m. The results of investigation of planktonic ostracods in the South Adriatic co-incided with former investigations, which also confirmed the ostracods appearance from the surface to 1000 m depth [3, 4]. Angel notes that at temperate latitudes, ostracods are often missing from the surface to 100 m, but otherwise they are usually the second-most abundant group only to the copepods [1].

#### Acknowledgements

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# BIODIVERSITY CHANGES OF THE WATER COLUMN LARGE PELAGIC SPECIES IN THE ALBORAN SEA

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## Abstract

The large pelagic species biodiversity variation of the Alboran Sea (Western Mediterranean) was analysed using data from on board observations in the Spanish longline fisheries. A relationship was found between the estimated H-value (Shannon-Weaver index) and lunar phases, which can be explained by the existence of vertical migrations within the water column in relation to lunar phases. *Keywords : Alboran Sea, Biodiversity, Fisheries, Pelagic.* 

The Alboran Sea (the Western Mediterranean zone connecting with the Atlantic Ocean through the Gibraltar Strait) is an outstanding area for marine biodiversity and constitutes an important corridor for many marine migratory species in the North Atlantic-Mediterranean region [1]. We studied the Spanish surface longline fleet fishing in the north Alboran Sea. This fleet, based in Mediterranean ports, targets Swordfish (*Xiphias gladius*), Bluefin tuna (*Thunnus thynnus*) and Albacore (*T. alalunga*), the latter two species mainly in summer. Surface longline gears targeting large pelagic species are considered the main threat for protected marine vertebrates (mainly marine mammals and turtles) because they are unspecific [2].



Fig. 1. Study area (Alboran Sea).

We assumed homogeneity in the configuration and components of each observed longline set and also that the probability of capture during each fishing operation was the same. Catches should deplete the abundance of vertebrates hooked (target and by-catch species) within the gear deployed area (the water column), particularly for species that have low rates of movement [3]. In this line of reason, if the gears are set in the same fishing area and depths (30 to 40 m), the biodiversity for each set's capture should be a reflection of the large pelagic species abundance/presence within the water column. This paper analysed the large pelagic species biodiversity associated with the surface longline targeted species in the Alboran Sea during the summer of 2004 and its relation with environmental and technical parameters. Environmental parameters included wind intensity and moon phase, satellite measurements of phytoplankton concentration (SeaWiFS), sea surface temperature (AVHRR), and sea surface velocity (altimeter), whereas the technical parameters included bait combination and boat strata. The study area extended from  $36^{\circ}$ -  $37^{\circ}$  N and  $2^{\circ}$ - $5^{\circ}$  W (Figure 1). The Spanish fishery is artisanal and fishes close to the coast, in an area where larger vessels do not operate because of the maritime traffic. During an EU LIFE02NAT Project (E/8610) we observed (onboard) 23 longline sets from 3 boats (15.34 m length and 20.75, register gross tonnage average).

Nine different species were caught during the observed period (27/06/04 to 27/09/04): Blue Shark, *Prionace glauca*, Bluefin tuna, *Thunnus thynnus*, Common dolphinfish, *Coryphaena hippurus*, Common stingray, *Dasyatis pastinaca*, Loggerhead *Caretta caretta*, Ocean sunfish, *Mola mola*, Shortfin mako, *Isurus oxyrinchus*, Swordfish, *Xiphias glaudius*, Thresher shark, *Alopias vulpinus*, and Tope shark, *Galeorhinus galeus*. We calculated the H-value [4] (biodiversity index of Shannon-Weaver) per fishing

#### operation.

Linear multiple forward regressions, Generalized Linear Models, and second-degree polynomial regressions were applied to the captures by species using several technical or ecogeographical numerical factors as predictors, but no significant relationship was found. However when we selected four categorical factors (lunar phases, bait combination, boat strata, and wind) an H-value model was found in relation with Lunar phases (Figure 2). We tested the average of H-value between different moon phases using the Mann-Whitney test, and found significant differences between the H-value from longline set operating during waning Moon and the other longline sets (U= 32; P= 0.036). The higher H-value was obtained during waning Moon and the lower H-value during the New Moon phase. These results could be explained by vertical migrations of species within the water column according to lunar phases.



Fig. 2. The H-values per lunar phase. For each box the average H-value and its confidence interval are shown (individual square point: anomalous point). Key: 1, Full Moon; 2, waning Moon; 3, New Moon; 4, crescent Moon.

The by-catch in pelagic longlines represents an important conservation problem. If these results could be extended all over the Mediterranean Sea, effective management measures could be implemented to preserve threatened pelagic species.

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# WEIGHT-CARAPACE WIDTH RELATIONSHIP OF THE MEDITERRANEAN GREEN CRAB ( CARCINUS AESTUARII, NARDO 1847) IN ÇAKALBURNU LAGOON, IZMIR BAY

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## Abstract

The weight-carapace width relationship of *Carcinus aestuarii* Nardo,1847 (Crustacea, Decapoda, Brachyura, Portunidae) of Çakalburnu Lagoon is given for a sample of 795 specimens. Crabs were collected during 2001-2002. Carapace width, weight and sex of specimens were determined.

Keywords : Crustacea, Decapoda, Lagoons, Aegean Sea.

#### Introduction

Growth is defined as the increase in length, the weight or volume [1]. The Mediterranean green crab, *Carcinus aestuarii* Nardo inhabits in the Mediterranean estuarine and lagoon waters [2], the Black Sea and the Sea of Asov [3]. The aim of this study is to give some information on the seasonal weight- carapace width relationship of the crab population in Çakalburnu Lagoon, Izmir Bay, the Aegean Sea.

#### Material and Methods

The study area, Çakalburnu Lagoon, is a shallow, coastal lagoon, which spreads over 150 h area [4] and is located on the southern coast of the Izmir Bay (Fig.1). The water depth in the lagoon ranges between 0.5-1 m. A total of 795 *C* . *aestuarii* specimens were sampled between 2001 and 2002, using a beam trawl. All sampled crabs were sexed, weighed (wet weight) and measured carapace width (CW, nearest mm). The common allometric equation  $Y = aX^{b}$  has been used to estimate the weight-carapace width relationship, where Y is the wet weight (g), X is the carapace width (mm), respectively. Allometric growth equations that can be linearized by logarithmic transformation, such as log  $Y = \log a + \log X$  [5]. A Student's t-test ( $\alpha$ =0.05) was used to check whether b=3 for the weight-carapace width relationship.



Fig. 1. (A)-(B) Geographical location of Izmir Bay and Çakalburnu Lagoon.

#### Results and Discussion

Data on 384 (48.3%) males and 411 (51.7%) females were analyzed for the relationship between weight-carapace width. The carapace width of the female crabs ranged from 9.06-38.74 mm with a mean value of  $26.54\pm5.37$ mm and males from 5.06-48.41 mm with a mean of  $31.39\pm10.45$ mm. The weight-carapace width relationships are presented seasonally in Table 1.

The males and females of *C. aestuarii* showed negative allometric growth in all seasons, except for the females in spring; their growth was isometric. When the growth of the crabs show positive allometry, this indicates that the weight of the animal increases as it matures [5]. Here, the results denoting negative allometry indicated that the weight of *C.aestuarii* in Çakalburnu lagoon decreased as it matured. The coefficients of determination were high except in summer period. The reason of this difference may be explained by the increased range in the carapace widths of the specimens in this season. Generally, the values of b range between 2.5-3.5 in the weight-length relationship. In this study, the values of b ranged

2.66-2.81 in females and 2.30-2.92 in males. In a study on another portunid crab *Callinectes sapidus*, the estimated b values varied in a similar range (2.19-2.93) just as in this study [6].

Tab. 1. Regression analyses of weight-carapace width seasonal data for *C. aestuarii*.M:males, F:females, N: number of individuals WW: wet weight, CW: carapace width;log: logarithms of base 10. <sup>(1)</sup>Two tailed t-test for H<sub>0</sub>:  $\beta$ =3 in WW/CW relationship, \* *P*<0.05.

| Season | Sex | Sex N <u>logWW=loga+blogCW</u> |                         | 1.2   | t <sup>(1)</sup> level |
|--------|-----|--------------------------------|-------------------------|-------|------------------------|
| Spring | F   | 94                             | logWW=-3.207+2.814logCW | 0.849 | 1.51                   |
|        | М   | 99                             | logWW=-3.342+2.927logCW | 0.975 | 1.09                   |
| Summer | F   | F 168 logWW=-3.223+2.849logCW  | 0.718                   | 7.62* |                        |
|        | M   | 150                            | logWW=-2.440+2.302logCW | 0.768 | 3.24*                  |
| Fall   | F   | 142                            | logWW=-2.975+2.668logCW | 0.964 | 1.52                   |
|        | М   | 85                             | logWW=-3.177+2.824logCW | 0.974 | 6.72*                  |
| Winter | F   | 7                              | logWW=-3.015+2.664logCW | 0.996 | 3.47*                  |
|        | М   | 50                             | logWW=-3.357+2.919logCW | 0.990 | 1.94                   |

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## DEVELOPMENT OF HIGH-RESOLUTION MOLECULAR TECHNOLOGIES TO INVESTIGATE ECOSYSTEM CHANGES IN THE SOUTHERN EUROPEAN SEAS: THE PROTOTYPING OF DNA CHIPS TO IDENTIFY INVERTEBRATE PREY SPECIES IN MARINE FOOD WEBS OF ADRIATIC SEA

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## Abstract

A invertebrate DNA microarray targeting ten species common in the Mediterranean was developed within the framework of the FP6 STREP FISH& CHIPS. Based on sequence variation of the 16S rDNA gene, we designed species-specific probes that were used to construct a DNA chip prototype for the identification of invertebrate (i.e. molluscans and crustaceans) preys of demersal fishes in the Adriatic Sea. The constructed invertebrate DNA chip represents a technological advance towards the wide use of rapid and high-resolution molecular tools to assess structure and changes of marine ecosystems such as the monitoring of invasive species and of re-emerging pathogens in ballast waters.

Keywords : Biotechnologies, Adriatic Sea, Food Webs, Species Introduction, Zoobenthos.

The understanding of trophic interactions among organisms and in the marine ecosystem is crucial for sustainable management of fishery resources and for conservation of marine biotas [1, 2]. Unfortunately, the analysis of gut contents carried out using the traditional analytical approach of morphological identification is time-consuming and requires highly-specific taxonomic expertise. Here, within the framework of the FP6-STREP FISH& CHIPS, we aim to develop a prototype DNA chip targeting invertebrate species (INVCHIP) that are common preys of demersal fish species in the Mediterranean Sea [3].

Ten invertebrate species belonging to molluscans and crustaceans widely distributed in the entire Mediterranean have been sampled in the Adriatic Sea. A 500 bp PCR-amplified 16S rDNA fragment of at least three individuals per species was sequenced using universal or taxon-specific primers. The capture probe design was performed through multiple alignments of DNA sequences using the programmes WinProbe and GeneDoc. Sequences of phylogenetically related species were retrieved from the NCBI nucleotide data bases and used for probe design. Chip configuration, probe immobilisation and hybridisation experiments have been done according to available protocols. Positive and negative controls were added to each microarray.

An INVCHIP-1 was realised including 6 target species (Mollusca: Illex coindetti, Eledone cirrhosa, Crustacea: Meganychtiphanes norvegica, P achigrapsus marmoratus, Liocarcinus depurator, Liocarcinus vernalis). 14 probes were designed and tested with subsequent hybridisation experiments. Capture probes gave different results: four oligonucleotide probes were specific for their target DNA (one for each I. coindetti, E. cirrhosa, P. marmoratus, L. vernalis); one probe hybridised the target species L. depurator but also the closely related species L. vernalis; nine probes did not bind the target DNA., Preliminary experiments carried out under different experimental conditions (i.e. decreased Tm and increased hybridisation time) allowed increasing of specificity and sensitivity for some probes and target species. The realisation of a INVCHIP-2 (including Mollusca: Lentidium mediterraneum, Chamalea gallina; Crustacea: Alpheus glaber, Goneplax rhomboides) is now in progress through probe design and chip configuration steps. Hybridisation experiments are scheduled for the end of 2006.

The developed INVCHIP represents a relevant technological advance towards the wide use of rapid and high-resolution molecular tools to assess structure and changes of marine ecosystems. Beside the investigation of marine food webs, DNA microchips coupled with a metagenomic analytical approach can effectively contribute to the monitoring of invasive species (either as eggs or larval stages) and re-emerging pathogens in ballast waters which are reversed daily in the Southern European Seas [4-6].

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## ABUNDANCE AND SIZE FLUCTUATIONS IN THE DEEP-WATER SHRIMPS ARISTAEOMORPHA FOLIACEA (RISSO, 1827) AND ARISTEUS ANTENNATUS (RISSO, 1819) IN THE NORTH-WESTERN IONIAN SEA (MEDITERRANEAN SEA)

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## Abstract

Fluctuations in abundance and size in *Aristaeomorpha foliacea* and *Aristeus antennatus* were recorded in the North-western Ionian Sea during 1995-2005. Significant increases in both the biomass and density indexes were shown in *A. foliacea* while the abundance changes observed in *A. antennatus* did not show any significant trend. A significant increasing trend in the median value of carapace length was detected for both shrimps. Changes in the abundance of the two shrimps recorded during 2002-2004 seem to be due to delayed transient phenomenon effects.

Keywords : Crustacea, Decapoda, Demersal, Fisheries, Ionian Sea.

The abundance and size of the deep-water shrimps *Aristaeomorpha foliacea* (Risso, 1827) and *Aristeus antennatus* (Risso, 1816) were investigated within the framework of national [1] and international [2] trawl surveys carried out in the North-western Ionian Sea (Mediterranean Sea), from 1995 to 2005, with the aim of assessing the most important economic demersal resources.

Throughout the study period, 21 trawl surveys were carried out, during each spring and autumn, at depths between 300 and 800 m using a commercial vessel with standard equipment for trawling. The percentage of the positive hauls per survey ranged from about 30 to 84% for *A. foliacea* and from about 41 to 82% for *A. antennatus*.

The giant red shrimp *A. foliacea* showed highly variable abundance indexes, both in terms of biomass (BI in kg/km<sup>2</sup>) and density (DI in N/km<sup>2</sup>). The BI values were between 0.62 and 31.09 kg/km<sup>2</sup> and the DI values fluctuated from 46 to 2496 N/km<sup>2</sup>, both showing significant increasing trends evaluated with both parametric and non parametric correlations (p<0.05). In *A. antennatus* the BI values ranged from 4.22 to 25.74 kg/km<sup>2</sup> and the DI values varied between 214 and 1911 N/km<sup>2</sup>. However, the abundance changes observed in this shrimp did not show any significant trend.

During the period 2002-2004 an uncommon increase in abundance of *A. foliacea* together with a decrease in *A. antennatus* were recorded. Moreover, the decrease in *A. foliacea* during the last surveys (2005) coincided with a new increase in *A. antennatus* (Fig. 1).



Fig. 1. Trend of biomass index (kg/km<sup>2</sup>) in *A. foliacea* and *A. antennatus* during 1995-2005 in the North-western Ionian Sea.

For both species, the carapace length (CL in mm) of the specimens varied largely throughout the study period. In fact, the calculated median values varied between 23 and 34 mm CL for *A. foliacea* and between 26 and 42 mm CL in *A. antennatus*. The observed increasing trends were significant in both shrimps (Fig. 2).

The significant increase in *A. foliacea* after 2000 seems to be due both to success in recruitment and to the stability of the fishing effort in the study area. The inverted abundance of the two red shrimps during 2002-2004 could be related to the change in hydrological conditions in the Ionian Sea

derived from the "transient" phenomenon [3]. Such conditions (warm water with high salinity) are considered favourable for *A. foliacea* but not for *A. antennatus* [4, 5]. In relation to the conclusion of the transient effects, *A. antennatus* was again found to be more abundant than *A. foliacea*.



Fig. 2. Trend of median carapace length (CL mm) in *A. foliacea* and *A. antennatus* during 1995-2005 in the North-western Ionian Sea.

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# SURVIVAL OF THE *POSIDONIA OCEANICA* CUTTINGS TRANSPLANTED INTO THE NORTHEASTERN LEVANT SEA

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## Abstract

In the present study *Posidonia oceanica* shoots collected near from Bozyazı- Mersin are transplanted to 3 different sites along the south eastern coasts of Turkey, at 2 of which *Posidonia oceanica* meadows are not present naturally. The survival of transplants was followed from 2004 until recently. The success of the transplantation at the most eastern station, though the high seawater temperature, suggests that there may be combination of environmental reasons for the absence of *Posidonia oceanica* meadows in that area. *Keywords : Posidonia, Levantine Basin, Temperature.* 

## Introduction

The distribution of endemic sea grass species *Posidonia oceanica* L. Delile is limited to the littoral zones of the Mediterranean and Marmara Seas [1]. Nevertheless along the eastern Mediterranean coasts of Turkey there are no *P. oceanica* meadows present and the northeastern boundary of meadows end in the Levant Sea, at  $36^{\circ}$  09' N  $33^{\circ}$  26' E [2]. The possible reason of this absence has been attributed to physical parameters of the seawater in that area such as high temperature [3]. The present study investigated the reason of absence of *P. oceanica* meadows along the northeastern Levant Sea by an experimental transplantation method, which is also being used for acceleration of recovery in damaged *P. oceanica* beds in western Mediterranean Sea.

#### Materials and Methods

*P. oceanica* shoots were collected either by SCUBA or free diving. Additionally some shoots from the by-catch of trawl surveys were used as cuttings to avoid serious impacts on donor *P.oceanica* meadows. Collection was made from 2 stations at various depths: at Turgutlar, where the most eastern boundary of meadows along the southern coasts of Turkey is present; and at Bozyazı, which is located near to the Kizilliman Marine Protected Area with healthy meadows. Afterwards cuttings were attached with nylon cable ties to the iron frames with grids made of nylon rope. Totally 21 frames with different coverage areas ranging from 0,49 to 2,25 m<sup>2</sup> were placed at 3 different stations in winter of 2004, in spring and autumn of 2005 and in spring of 2006. One of the stations was chosen only for control purpose at Bozyazuwhere the shoots were collected. The other two eastern stations, Erdemli and Samandag, were located outside the boundary where the *P. oceanica* meadows are naturally absent [Figure 1.].



Fig. 1. Study area: Site number 1 is the only collection site, the all 3 sites are the transplantation sites.

#### Results

A few weeks after the first transplantation in 2004 at Samandag two frames were found broken on a commercial trawling boat. The cuttings of the next 2 frames transplanted at Erdemli in May 2005 were found dead after two months whereas the leaves of the cuttings on the third frame were alive but overgrazed. The secchi disc measurements at this station during these months ranged from 4 to 10 meters at 20 meter bottom depth. The sixth frame transplanted in August 2005 to the harbour of the Institute for visual observation of potential grazers was also overgrazed. The other 3 frames transplanted parallelly in autumn of 2005 to Bozyazıfor control purpose, Erdemli and Samandag were still alive in May 2006, January 2006 and October 2006, respectively. But leaves of transplanted to Samandag were shortened due to grazing. Last 11 frames, transplanted to Samandag in

May 2006 for increasing the coverage area of the last frame against the reduction by erosion of sediment, were still alive in October 2006.

#### Discussion

The study area is a unique site for P. oceanica transplantation experiments due its geographical position. The eastern Levant Sea is dominated by Levantine surface water mass whose most important features are high salinity and high temperature [4]. The area is also under the effect of pollution due to urbanization and high pressure of fishing by trawlers and purseiners. All of these parameters and activities have negative influence on the health of sea grass ecosystems. Destruction of first 2 grids by trawlers may indicate the significance of heavy trawling pressure on the sea bottom. As was repeatedly observed during visual inspections, grazing by herbivorous organisms seems to be an important factor in the absence of P. oceanica in the region. In addition to the only true herbivorous fish species of the Mediterranean fish fauna Lessepsian Siganids may pose a significant threat to the sea grass. Beside invasive fishes, some herbivorous exotic gastropod species e.g. Conomurex persicus, whose grazing activity may also have potential impacts on native ecosystem [5], have been observed in high concentrations around the frames. The water temperature over the shoots transplanted in Samandag exceeded the upper critical seawater temperature for P. oceanica growth suggested by Celebi et.al. (2006). On the other hand, despite relatively lower temperatures, the first 2 frames transplanted at Erdemli on May 2005 did not survive. The light penetration depth seems to be shallower in Erdemli compared to Samandag. However, the natural meadow in Turgutlar survives under even lower light condition than Erdemli. These three examples may indicate the combined effect of light penetration and temperature that may play synergistic role in the balance between respiration and photosynthesis of the P.oceanica. The long term effects of physical properties of the sea water on growth and production of P. oceanica shoots still need to be observed in following years by lepidochronological analysis of the transplants. Acknowledgements - This study was carried out within the framework of 2 projects CAYDAG 105Y023 and YDABAG 104Y028 by the Turkish Scientific and Technical Research Council. We are indebted to SAT-EKOG of METU and to the crew of R/V Lamas for their efforts during the surveys.

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# PREMIÈRE SIGNALISATION DE *NEROPHIS OPHIDION* (LINNAEUS, 1758) POISSON SYNGNATHIDÉ DANS LA LAGUNE DE TUNIS, TUNISIE

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## Résumé

L'espèce *Nerophis ophidion* (Linnaeus, 1758) est pêchée, pour la première fois, au nord de la Tunisie dans la lagune de Tunis. Les caractères méristiques et morphométriques relevés sur 75 spécimens collectés ont permis de vérifier qu'ils présentent les mêmes caractéristiques que ceux déjà décrits en Méditerranée.

Mots clès : Biodiversity, Fishes, Western Mediterranean.

En Méditerranée, le genre *Nerophis* est représenté par deux espèces, *N. maculatus* et *N. ophidion* [1, 2]. Cette dernière espèce est commune en Méditerranée [1] mais aucun auteur ne rapporte sa capture dans les eaux tunisiennes [3-5].

Des prospections, récemment réalisées dans le Golfe de Tunis, nous ont permis de collecter, pour la première fois, des spécimens de ce syngnathe dans la lagune de Tunis. En effet, les pêches que nous avons effectuées dans la lagune de Tunis au moyen d'engins de pêche spécifiques durant la période allant de Novembre 2004 à Octobre 2005, nous ont permis de capturer un échantillon de 75 spécimens de Nerophis ophidion composé de 40 femelles et de 35 mâles dont la longueur totale est comprise entre 95 et 222 mm. Sur chaque individu, nous avons prélevé le poids total, cinq caractères méristiques (Nombre total des anneaux osseux "NT", nombre des anneaux osseux au niveau du tronc "NTr", nombre des anneaux osseux au niveau de la queue "NQ", nombre des anneaux osseux sous la nageoire dorsale "NSd" et nombre des rayons de la nageoire dorsale "D") et dix neuf caractères morphométriques (longueur totale "LT", largeur maximale du corps "L", hauteur maximale du corps "H", longueur de la nageoire dorsale "Ld", hauteur de la nageoire dorsale "Hd", longueur de la tête "lt", distance anté-dorsale "Da", distance post-dorsale "Dp", distance préanale "Aa", distance post-anale "Ap", largeur de la tête "Lt", hauteur occipitale de la tête "Hoc", hauteur oculaire de la tête "Hcl", longueur du museau "Lm", hauteur du museau "Hm", largeur de la bouche "Lb", distance inter orbitaire "Io", diamètre de l' oeil "O" et distance post-orbitaire "Po").

Les spécimens de *Nerophis ophidion* capturés dans la région de Tunis présentent 81 à 110 anneaux osseux le long du corps, 28 à 31 au niveau du tronc, 59 à 78 au niveau de la queue et 9 à 12 sous la nageoire dorsale. Les rayons de la nageoire dorsale varient entre 33 et 36. Les intervalles de variation de ces caractères sont en concordance avec ceux cités par Dawson [1] et Tortonese [6]. Les données morphométriques des poissons examinés sont consignées dans le tableau 1.

La relation taille-poids observée chez les mâles, les femelles ainsi que chez les deux sexes confondus traduit une allométrie minorante. En grandissant, le poisson devient plus élancé.

Dawson [1] a mentionné la présence de *Nerophis ophidion* sur le littoral méditerranéen. Dans les eaux tunisiennes, aucune capture de cette espèce n'a été rapportée dans la littérature [3-5]. Par conséquent, le présent travail mentionne, pour la première fois, la présence de *N. ophidion* sur les côtes nord de la Tunisie. L'absence de ce syngnathe dans les inventaires ichtyiques précédents serait probablement due à son absence dans les apports de la pêche professionnelle. En effet, en raison de sa petite taille, sa collecte n'est possible qu'avec des engins spécifiques munis de filets à petites mailles.

Notre travail apporte de nouvelles informations sur la distribution et sur la caractérisation morphologique de *N. ophidion*, poisson syngnathidé, en Méditerranée.

Tab. 1. Caractères morphométriques (exprimés en mm) de *Nerophis ophidion* dans la lagune de Tunis. min: minimum; max: maximum; m: moyenne;  $\delta$ : écart type; N: effectif; F: femelles; M: mâles.

| Paramètres | min       | Max       | m         | δ         |
|------------|-----------|-----------|-----------|-----------|
| Variables  |           |           |           |           |
| N          | 40F + 35M | 40F + 35M | 40F + 35M | 40F + 35M |
| L/LT       | 0.009     | 0.013     | 0.016     | 0.002     |
| H/LT       | 0.009     | 0.013     | 0.016     | 0.002     |
| Ld/LT      | 0.014     | 0.096     | 0.114     | 0.015     |
| Hd/LT      | 0.008     | 0.012     | 0.012     | 0.002     |
| lt / LT    | 0.055     | 0.063     | 0.072     | 0.005     |
| Da / LT    | 0.285     | 0.360     | 0.397     | 0.042     |
| Dp / LT    | 0.604     | 0.643     | 0.828     | 0.050     |
| Aa / LT    | 0.242     | 0.365     | 0.423     | 0.058     |
| Ap / LT    | 0.580     | 0.637     | 0.801     | 0.062     |
| Lt/ lt     | 0.183     | 0.211     | 0.248     | 0.015     |
| Hoc / It   | 0.197     | 0.222     | 0.243     | 0.016     |
| Hcl / lt   | 0.178     | 0.203     | 0.229     | 0.019     |
| Lm / lt    | 0.378     | 0.416     | 0.484     | 0.026     |
| Hm / lt    | 0.099     | 0.143     | 0.176     | 0.028     |
| Lb / lt    | 0.066     | 0.091     | 0.109     | 0.012     |
| IO / It    | 0.076     | 0.096     | 0.109     | 0.011     |
| O/lt       | 0.160     | 0.184     | 0.210     | 0.017     |
| Po / lt    | 0.409     | 0.461     | 0.530     | 0.031     |

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# GENETIC STRUCTURE OF THE POLYTYPIC SPECIES IDOTEA BALTHICA (ISOPODA VALVIFERA)

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## Abstract

Allozyme variation among 15 populations belonging to the 4 subspecies, *I .b. basteri*, *I. b. stagnea*, *I b. tricuspidata* and *I. b. balthica* of the polytypic *I. balthica* and collected from the Mediterranean to the Baltic Sea were analysed using polyacrylamide gel electrophoresis. Genetic structural analysis was performed assaying four polymorphic loci. Nei's genetic distance (D) varied from 0 to 0.567 showing low divergence within populations of the same subspecies, except for *I. b. basteri*, while the highest distance was recorded between the Nordic and the Mediterranean groups. Fst and gene flow were estimated and revealed a gene flow restriction between the geographical groups. *Keywords : Crustacea, Enzymes.* 

#### Introduction

The sublittoral Isopod *Idotea balthica*, occurred in the Baltic Sea, on the Atlantic coast, on the and on the Mediterranean coasts and lagoons, is relatively widely distributed. Based on the interbreeding tests and the morphological features in parents and hybrids, [1] considered this species as a polytypic species composed of four subspecies: *Idotea b. balthica* from the Baltic Sea, *Idotea b. tricuspidata* from the European Atlantic coasts, *Idotea b. basteri* from the Mediterranean Sea and *Idotea b. stagnea* from some Mediterranean French lagoons.

In the present paper, we report the allozyme variation analysis based only on the polymorphic loci of natural populations of the polytypic species *Idotea balthica*: 1) to analyse the genetic variability within populations, 2) to estimate the gene flow between these populations 3) to calculate the genetic distance and the level of genetic divergence among populations and subspecies, 4) to reconstruct the evolutionary history of this species.

The analysis was conducted on 15 populations of the polytypic species *Idotea balthica* from different geographical areas: *I. b. balthica* from Baltic Sea, *I. b. tricuspidata* from the European Atlantic coasts, *I. b. basteri* from the Western Mediterranean basin and Adriatic Sea and *I. b. stagnea*, from some Mediterranean French lagoons.

#### Materials and Methods

The enzymatic polymorphism was performed on polyacrylamide gels. More than 30 enzyme assays were tried; ten yielded scorable results and only the four polymorphic loci (Amy-2, Est-2, Ldh-1 and Pgi-1) were considered.

For each population, mean sample size per locus, average number of alleles per locus, mean heterozygosity observed and mean heterozygosity expected under Hardy-Weinberg equilibrium were calculated using Biosys-1 program of [2]. The genetic structure within and among populations was evaluated using F-statistics (Fit, Fis and Fst).

#### Results and Discussion

The mean number of alleles ranged from  $1.7\pm0.2$  to  $3.2\pm0.7$ . Mean direct count heterozygosity gene (Ho) varied from  $0.071\pm0.059$  to  $0.201\pm0.090$  and the expected average heterozygosity from  $0.081\pm0.052$  to  $0.286\pm0.125$ . Considering the subspecies, the highest level of genetic variability was observed in *I. b. stagnea* (Ho=0.171), followed by *I. b. tricuspidata* (Ho=0.144), *I. b. basteri* (Ho=0.131), whereas the lowest belonged to *I. b. balthica* (Ho=0.088). The Fis values ranged from 0.0140 for Ldh to 0.898 for Pgi. The average value was high (0.280) showing that the populations were not in Hardy-Weinberg equilibrium.

Fst varied from 0.045 to 0.861 with an average of 0.433 and the amylase-3 locus exhibited most gene flow restriction. Among the fixation indices, Fit shows the highest value (0.590) indicating a high differentiation between populations.

Genetic distance values were low 0 < D < 0.024 within populations of the same subspecies except from *I. b. basteri* populations where D rose to 0.217. D ranged from 0.084 to 0.164 between *I. b. balthica* and *I. b. tricuspidata* with the average value  $D_m=0.120$ , and from 0.010 to 0.118 between *I. b. basteri* and *I. b. stagnea* ( $D_m=0.063$ ). The average genetic distance values among *I. balthica* subspecies showed a higher mean value among Nordic subspecies than Mediterranean ones. However, an average high value ( $D_m=0.137$ ) within *I. b. basteri* was observed when comparing Adriatic and western Mediterranean populations and a lower value between *I. b. stagnea* and *I. b. basteri* ( $D_m=0.063$ ).

The clustering pattern using the UPGMA and the NJ methods, respec-

tively requiring or not requiring, equal rates of evolution, showed two main groups, the Nordic and the Mediterranean ones. In the first group, the two subspecies can be clearly separated confirming morphological features. In contrast, within the Mediterranean group more than two subspecies could be distinguished; the Adriatic populations seem to be genetically different.

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# SURROGATE MEASURES OF BIODIVERSITY IN MACROBENTHIC COMMUNITIES IN THERMAIKOS GULF, GREECE

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## Abstract

The use of higher-taxon richness as surrogate for species was investigated in a study of macrobenthic communities in Thermaikos Gulf, north Greece. The correlation of genera and families to species richness showed that they can both be effective surrogates of biodiversity, while the use of an indicator group (Polychaeta) was sufficient, but it should be applied with caution and when the group is dominant in the area.

Keywords : Aegean Sea, Biodiversity, Zoobenthos.

#### Introduction

Most analyses of macrobenthic communities are based on the identification of species [1]. However, the use of higher-taxon richness as surrogate for species can also produce a reliable distribution pattern of macrobenthic fauna [1-3]. Other surrogates can be the abundance of species of certain indicator groups [4-5]. Analyses based on higher-taxon richness is often more convenient than the time-consuming and costly species identification [4-6]. The present study considered the genera and families of organisms and of polychaeta as indicator group, as regards their suitability as surrogates for species in investigations of macrobenthic fauna in Thermaikos Gulf, north Greece.

#### Materials and methods

The sampling period lasted three years (2003-2006). Three vertical transects along the NE coasts of Thermaikos Gulf were selected in the area around the construction site of the new air lane of Thessaloniki Airport. Six stations - two at each transect - were established for benthic macrofauna sampling with corer samplers at depths between 3 and 10 m (ST1-ST6). In total, 16,650 species were collected, classified in 181 species. Polychaeta were the dominant group in terms of presence and abundance in most of the stations. The Spearman rank correlation coefficient was employed to determine whether there was a statistically significant correlation (r values) between the species richness and the genera (Sp-Gen) and families (Sp-Fam) richness. The same was applied for Polychaeta (Sp-Pol.Sp. and Sp-Pol.Gen.), in order to investigate the suitability of an indicator group as surrogate.

### Results and Discussion

Figures 1 and 2 show that genera and families richness (r=0.98 and r=0.89, respectively) is a truly effective surrogate and the use of species and genera richness of Polychaeta also provides sufficient surrogacy (r=0.75 each).





There were a couple of exceptions in the latter pattern, namely St1 and St4 where Sp-Pol.Sp  $\kappa\alpha\iota$  Sp-Pol.Gen. correlations are not significant (Figure 2).In a number of studies in areas with severe organic pollution [1, 3, 7] the use of families or species and families of polychaetes are often in accordance with the biocoenotic patterns that originate from the nor-

mal use of species richness. Natural selection premises that each higher taxon contains species that can only cope with small scale environmental changes. Therefore, in areas where anthropogenic impact is large, higher taxa are represented by a small number of species and their use as surrogate for species is more reliable there than in non-disturbed areas [6]. In polluted areas, more specifically, the Polychaeta can be of great advantage as a surrogate group. Their great variety of feeding guilds and reproductive strategies enable them to be abundant in a large number of habitats, disturbed or not. Our study, however, showed that the surrogacy should be applied with caution, because there are cases like St.1 and St.2, neighbouring sites with similar substrate structure, where the same surrogate (number of species of polychaetes) was not similarly distributed and, thus, not equally effective.



Fig. 2. Correlation between the number of species and the number of genera, families, polychaeta species and polychaets genera at each sampling station.

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# ICHTHYOPLANKTON DISTRIBUTION OF IZMIR INNER BAY BETWEEN 2000 AND 2005

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## Abstract

The Izmir Bay, which is located on the western coast of Turkey, became one of the conspicuous areas in the Mediterranean Sea with its high domestic and industrial pollution level by the end of 1990s. However, starting from 2000, as a result of terminating the pollution sources and beginning of water treatment system, positive changes have been observed in the habitat. This is reflected in all living groups in the marine ecosystem. By evaluation of the seasonal surface plankton sampling between the years of 2000 and 2005, it was determined that spawning fish populations in the Izmir Inner Bay consisted of *Engraulis encrasicholus, Arnoglossus* spp , *Buglossidium luteum, Callionymus pusillus, Solea* spp. These species are considered as resistant to the pollution. *Engraulis encrasicholus* forms 98% of eggs and 60% of larvae. Other important larval species are *Gobius niger* (14%) , *Parablennius gattorugine* (10%) and *Salaria pavo* (8%) in the Inner Bay.

Keywords : Ichthyoplankton, Pollution.

#### Introduction

The pollution process in the Izmir Inner Bay had accelerated due to domestic and industrial effects from 1960. Because of this, after 1970s the priority in scientific studies was especially given to observation of pollution effects. The pollution had reached the highest level in the Inner Bay in 2000, when the water treatment system began to work. Pollution sources of the Inner Bay were reported as; hydrocarbon, heavy metal, pathogenic organisms caused from domestic and industrial waters (organic materials) (50%), precipitations (15%), brooks and streams (10%), agricultural sources (10%), sea transportation-harbour (4%) and other sources (11%)[1]. After caving Rag ip Paşa Lagoon's walls, which is located in the Inner Bay, deep and surface flows have become more effective, and significant improvement has been observed in the Bay by completing the Great Channel Project. Eutrophication has regressed largely in the Inner Bay and light transmission has increased. The pollution effects in last 30 years as; beginning of pollution, the most polluted and termination period of pollution sources, have importantly affected certain species composition in the marine ecosystem of the Inner Bay. Related to recovery of the Bay, positive effects have been observed on the organism groups (phytoplankton, zooplankton, macrobentic organism, fish) [2]. Ichthyoplankton organisms are the most importantly affected group among the mentioned organism groups. In this study, changings in distribution of ichthyoplankton in the pelagic region during recovery period of the Bay were discussed.

Tab. 1. Fish species of which eggs and larvae were determined in the Inner Bay between 2000 and 2005.

| Fish species                               | Eggs | Larvae |
|--------------------------------------------|------|--------|
| Sardina pilchardus (European Pikhard)      |      | +      |
| Engraulis encrasichalus (European Anchovy) | +    | +      |
| Brisopterus luscus capelanus (Poor Cod)    |      | +      |
| Diplodus annularis (Annular Sea Bream)     | +    |        |
| Godius niger (Black goby)                  |      | +      |
| Pomato schistus microps (Common goby)      |      | +      |
| Zosterizessor ophiocephalus (Grass goby)   |      | +      |
| Califonymus lyra (Dragonet)                |      | +      |
| Calionymus pusillus (Dragon)               | +    | +      |
| Blennius ocellaris (Butterf ly blenny)     |      | +      |
| Salaria pavo (Pescock blenny)              |      | +      |
| Parablernius gattorugine (Tombot blenny)   |      | +      |
| Parablennius sanguinolentus (Blenny)       |      | +      |
| Parablennius tentacularis (Blenny)         |      | +      |
| Blennius spp.                              |      | +      |
| Amoglossus spp.                            | +    | +      |
| Solea spp.                                 | +    |        |
| Buglossidium luteum (Solenette)            |      | +      |

Material and Method

Sampling studies were carried out with R/V K. Piri Reis between 2000 and 2005, by horizontal (25 times) hauling with 250 m mesh size WP-2 type plankton net lasting in 10 minutes. Hauling was achieved in 5 stations located in the Izmir Inner Bay; inshore, central part (around) and exit way

to the Middle Bay. Depth in the region is maximally around 23 m. Hauling include seasonal periods as 2000 (January), 2001 (January, April, August, December), 2002 (August), 2004 (March, August, November) and 2005 (April, February). Samples were preserved in 4% formaldehyde solution and examined in laboratory with SZ-60 type 10x6 binocular microscope.

#### Result

In the study fish eggs (Clupeidae, Engraulidae, Gadidae, Callionymidae, Bothidae and Soleidae families) and larvae (Engraulidae Sparidae, Gobiidae, Callionymidae, Blenniidae and Soleidae families) were determined to belong to 18 species from 9 family. Species diversity of ichthyoplankton was observed to increase through east-west direction of the Middle Bay, except in south and south-east inshore parts of the Inner Bay.

Anchovy eggs composed 98% of the total eggs in the Inner Bay and dominated the egg composition during 2000-2005. Other species consisting of 2 % are; Callionymus pusillus, Arnoglossus spp., Solea spp., Sardina pilchardus, Buglossidium luteum and dead eggs. European anchovy (60 %) composed the highest level in larval distribution in the Inner Bay. Black goby (14 %) was in the second place. Two species from Blennidae family , Tombot blenny (10 %), Peacock blenny (8 %) were the important species. Other Blennidae and Gobiidae species distributed in 1-2 % levels. In 1 % part; Annular Sea Bream, Solenette, Common goby species had equal distribution values. According to distribution percentage of species in stations at the Inner Bay, the highest distribution rates belong to; European anchovy (64 %) and Black goby (45-47 %) species. B. ocellaris (Butterfly blenny), P. sanguinolentus (Blenny) species found in 18-27% values in central part of Inner Bay. Common goby, Dragon , P. tentacularis (Blenny), Blennius spp., and Solenette larvae were represented with the lowest levels (1-9 %) in some stations. No larvae was found around the port. In study area it was observed that egg percentage distributed irregular and larva distribution increased through out of the Inner Bay. In spite of the improvement in water quality, dominancy of anchovy known as resistant to pollution is in point issue. The Inner Bay composes one of the most important areas for anchovy to spawn in all around the Bay. On the other hand larvae of goby species (G.niger) were obtained dominantly in Inner Bay as done in past periods. Dominancy of mentioned species eggs- larvae evaluated as the indicator that the environment has not been recovered completely.

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# MODELLING MARINE FOOD WEBS FOR AN ECOSYSTEM APPROACH IN THE MEDITERRANEAN SEA

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## Abstract

This contribution aims at reviewing main applications of mass-balance and trophodynamic models for representing marine food webs in the Mediterranean Sea. This review allows evidencing the potential of these tools for an ecosystem approach to several human impacts and provides insights on future directions of research.

Keywords : Food Webs, Macroelements.

Mass-balance and trophodynamic models are used worldwide for describing marine food webs and studying ecosystem structure and functioning. In particular, Ecopath with Ecosim (EwE) enables to integrate large body of data and information in a coherent description of marine food webs and allows the study of direct and indirect anthopogenic impacts on ecosystems [1]. Therefore, although developed for understanding impacts of fishing activities, EwE represents a valuable tool for the theoretical analysis of food webs and for applying an ecosystem approach to different anthropogenic impacts [2]. Accordingly, several EwE applications have been developed in the Mediterranean Sea.

Mass-balance Ecopath models have been largely used to explore the trophic structure and apply network analysis at different scale on coastal and shelf areas. In the Venice Lagoon (Italy), Ecopath models were used to describe the trophic structure [3], to compare food webs of two habitats thus providing evidence of the high maturity of seagrass meadows [4] and to compare the same system through time evidencing the stress induced by a new fishery [5]. In the Orbetello Lagoon (Italy), the key role of cormorants and the decrease of eutrophication level were assessed by comparing mass-balance models for two different years [6]. Food web models for the Adriatic Sea [7] and the South Catalan Sea [8] allowed to evidence ecosystem effects induced by fishing through analysis of synthetic indices and cross-system comparison of standardized models enabled to examine differences between ecosystems [9-10] and ecosystem effects of protection [10]. An EwE model was also developed for the Gulf of Calvi [11] to place fishing within the ecosystem context and examine indirect effects of fishing and, analogously, a dynamic application to the Black Sea allowed exploring trophic cascade driven by fishing [12]. A mass balance model explored the energy flow controls of the Miramare Marine Protected Area [13] and a spatial one assessed the effectiveness of MPAs of different sizes in the North Adriatic Sea [14].

Few cases explore the effects of environmental forcings on ecosystem dynamics [8, 11, 14, 15] because of the general lack of time series of biological data long enough for the validation of time-dynamic simulations. Nevertheless, mass-balance Ecopath models proved to be a good basis for linking structure to dynamics and for identifying keystone species within food webs [16]. These models also gave basis for defining a new measure of ecosystem effects of fishing that has been applied extensively to landings data and models output in the Mediterranean Sea [17-18]. Moreover, trophic flows estimated by Ecopath permitted the direct coupling with ecotoxicological information thus providing a realistic representation of the bioaccumulation of organic pollutants in the food web, as in the Venice Lagoon case study [19].

Future research would benefit from the generalization of this methodology to the Mediterranean basin, through the development of new case studies (especially in the eastern part) and the standardized comparison of existing models. Moreover, fitting models to time series of data for their validation should be a priority, as well as the application of spatio-temporal dynamics for capturing ecosystem features and patterns. Finally, the assessment of uncertainty of model inputs and propagation of errors to results should be considered of overwhelming importance.

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## INVERTEBRATE DISCARDS FROM TRAWLERS IN THERMAIKOS GULF (AEGEAN SEA, GREECE)

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## Abstract

The present study aims at giving the first results of the composition of invertebrate fauna discarded by trawls in Thermaikos Gulf, north Aegean Sea. Sampling followed conditions of commercial fishery and resulted in collecting 64 discarded invertebrate species. The most abundant of them was the crab *Liocarcinus depurator*, while crustaceans were prominent in all samples. *Keywords : Aegean Sea, Trawl Surveys.* 

#### Introduction

The study of discards of trawl fisheries is of great interest since they consist almost a quarter (27%) of the global catch [1]. The present study is the first to focus on the invertebrates that are discarded by trawls in the Thermaikos Gulf, north Aegean Sea, during a fishing season. The aim is to present preliminary results on the composition of the discarded invertebrate fauna.

#### Methods and Material

Sampling took place in Thermaikos Gulf between October 2005 and April 2006, which is the period of allowed trawl activity in the Gulf. A total of 21 hauls, corresponding to 21 stations, took place in real conditions of commercial fishery. The duration of each haul ranged from 2 to 6 hours and their depth varied from 32 to 96 m. The average speed of the trawlers was 3.3 knots. The mesh size of the net was 40 mm in the cod-end. The average volume of each catch was 0.226 m<sup>3</sup> and samples of 0.08 m<sup>3</sup> were collected at random. Specimens were transferred to the laboratory, identified to species level and preserved in formalin solution.

#### Results

The total number of collected invertebrates was 3,789, classified to 64 species. Table 1 shows the species whose frequency in the samples exceeds 50%. The most widely represented class was Malacostraca, which constituted 87% of the total abundance of the taxa. The species with presence in every station were the anthozoan *Alcyonium palmatum*, the cephalopod *Sepia elegans* and the crustaceans *Parapenaeus longirostris, Liocarcinus depurator, Medorippe lanata, Goneplax rhomboides* and *Squilla mantis.* In terms of abundance, it is obvious that the crab *L. depurator* was the most abundant species in all surveys, making up 47.16% of the invertebrate discards, followed by *P. longirostris* and *S. mantis* (Figure 1). In general, the results show that the composition of discarded invertebrates in the Thermaikos Gulf is similar to that of other Mediterrenean regions, like Spain or the Ligurian Sea [2, 3].

Tab. 1. List of the most frequent invertebrates (F>0.5) discarded by trawls in Thermaikos Gulf (F=frequency, mL=mean length, sd=standard deviation, A=abundance, %=percentage)

| -  | Scientific name                                                                     | class         | F    | ml+sd        | Α    | %     |
|----|-------------------------------------------------------------------------------------|---------------|------|--------------|------|-------|
| 1  | Alcyonium palmatum (Pallas, 1766)                                                   | Anthozoa      | 1,00 | 51,83±17,30  | 111  | 2,93  |
| 2  | Calliactis parasitica (Couch, 1838)                                                 | Anthozoa      | 0,52 | 15,15±7,45   | 69   | 1,82  |
| 3  | Pennatula rubra (Ellis, 1761)                                                       | Anthozoa      | 0,95 | 133,99±22,46 | 69   | 1,82  |
| 4  | Melicertus kerathurus (Forskal, 1775)                                               | Malacostraca  | 1,00 | 115,41±15,67 | 28   | 0,74  |
| 5  | Parapenaeus longirostris (Lucas, 1846)                                              | Malacostraca  | 1,00 | 116,92±15,08 | 651  | 17,18 |
| 6  | Liocarcinus depurator (Linnaeus, 1758)                                              | Malacostraca  | 1,00 | 30,72±4,95   | 1787 | 47,16 |
| 7  | Medorippe lanata (Linnaeus, 1767)                                                   | Malacostraca  | 1,00 | 21.05±4.46   | 97   | 2,56  |
| 8  | Goneplax rhomboides (Linnaeus, 1758)                                                | Malacostraca  | 1,00 | 15,45±2,44   | 107  | 2,82  |
| 9  | Squilla mantis                                                                      | Malacostraca  | 1,00 | 103,18±19,39 | 662  | 17,47 |
| 10 | Sepia elegans (Blainville, 1827)                                                    | Cephalopoda   | 0,86 | 41,29±8,52   | 86   | 2,27  |
| 11 | Galeodea echinophora (Linnaeus, 1758)                                               | Gastropoda    | 0,95 | 64 76±3 59   | 15   | 0,40  |
| 12 | Atrina pectinata (Linnaeus, 1767)                                                   | Bivalvia      | 0,81 | 290,64±76,26 | 23   | 0,61  |
| 15 | Acanthocardia echinata (Linnaeus, 1758)                                             | Bivalvia      | 0,67 | 53,15±9,56   | 14   | 0,37  |
| 16 | Parastichopus regalis (Ĉuvier, 1817)<br>Astropectep irregularis pentacanthus (Delle | Holothuroidea | 0,67 | 200,2±41,4   | 35   | 0,92  |
| 17 | Chiele 1827)                                                                        | Asternidea    | 0.52 | 86 93+32 19  | 35   | 0.92  |



Fig. 1. Prevalence of the most frequent discarded invertebrates in the total of samples.

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# EFFECTS OF SEASONAL CLOSURES ON BENTHIC COMMUNITIES FROM TWO MEDITERRANEAN TRAWLING GROUNDS

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## Abstract

Seasonal closures in trawling grounds are generally considered a useful management tool, but there is a lack of knowledge on their benefits for benthic communities. Two trawling grounds located in the Catalan and Adriatic seas, which are regulated by a two-month fishing closure, were surveyed to monitor changes in the benthos during the trawling cessation. Results suggest that closures are too short to detect a response of benthic communities.

Keywords : Adriatic Sea, Biodiversity, Fisheries, Western Mediterranean.

#### Introduction

The establishment of temporal closures in trawling grounds is one of the most effective measures to reduce fishing effort. Several authors have evidenced an increase in commercial catches after the closure [1]; however, the effects on benthic communities have been poorly investigated. Numerous studies have demonstrated that commercial trawling chronically modifies benthic communities [2]. Consequently, it is necessary to implement adequate management actions to improve the effectiveness of marine ecosystems protection.

#### Methods

Two trawling grounds located in the Catalan and Adriatic Seas, and regulated by a two-month seasonal closure, were selected to study the response of benthic communities to this management measure. Two study sites were delimited within each fishing ground: a fished site, regularly exploited by the local trawling fleet, and an un-fished site as a reference. In order to analyse changes in the community structure, epifaunal and infaunal samples were collected at both sites during six experimental cruises performed before, during and after the fishing closure. Total abundance, biomass and diversity, based on Shannon index, were recorded, and a two-way ANOVA was developed to identify any effects of site or cruise on these variables. Multivariate analyses, based on the Bray-Curtis similarity index and subsequent MDS ordination plot, were conducted to study changes in the community structure.



Fig. 1. Epifaunal diversity at fished and reference sites from the Catalan Sea. B, before the closure; C, during the closure; A, after the closure. \* p>0.001.

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Fig. 2. MDS plot of epifaunal abundance from the Adriatic Sea. Triangles: fished site, circles:reference site. B: before closure; C1: at the beginning, and C2: at the end of the closure; A1: one month after, and A2: two months after the closure.

#### Results

An overall of 96 epifaunal species and 153 infaunal taxa were collected in the Catalan Sea study area, and 68 epifaunal species and 217 infaunal taxa in the Adriatic Sea sites. Variations in total abundance and biomass of infauna and epifauna did not reflect a closure effect. Epifaunal diversity significantly decreased immediately after the closure at the fished site from the Catalan Sea, when the fishing effort in the area is high (Fig 1). This pattern was not observed in the Adriatic Sea, where the fishing effort after the closure is low. Multivariate analysis of epifaunal data detected changes in the community structure during the closure in both study areas. Although this analysis differentiated samples from fished and reference sites, similarity between sites was slightly higher during the closure (Adriatic: 67% and Catalan: 66% similarity) (Fig. 2). Differences emerged when comparing the infaunal community from fished and reference sites, however no response to the closure was highlighted.

#### Discussion

Overall these results suggest that a two-month closure is too short to benefit benthic communities. Nevertheless, despise the brevity of this period, the epifaunal community showed a positive response suggested by the increase of similarity between the fished and un-disturbed communities during the closure. Moreover, the reduction of epifaunal diversity in the Catalan Sea fished area after the closure highlights that a high level of fishing activity has an immediate negative effect on the community.

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# SMALL-SCALE FISHERIES IN THE NORTHERN ADRIATIC SEA

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## Abstract

Sampling of small-scale fishery landings at four harbours of the northern Adriatic Sea was carried out from 1999 to 2005 to study fishing capacity, fishing effort and quali-quantitative composition of retained catches. Landing data evidenced a strong seasonality of five fishing gears (sole gillnet, gillnet, trammel net, basket trap for gastropods and trap for cuttlefish) used on the basis of the target species' ecoethology. The landings of both types of traps included only few species and were dominated by the target one in biomass. In contrast, the retained catches of set nets consisted of a wide pool of species, but the highest yields were obtained only for the target species and a few kept by-catch ones.

Keywords : Adriatic Sea, Coastal Management, Fisheries.

#### Introduction

In Italy set gear fisheries play an important role at the social level, although they do not compete with trawling in economical terms. The small-scale fishery uses many different gears on the basis of the area, period of the year and target species, and vessels are usually spread out in several small mooring places, so making difficult to draw a complete picture of the actual situation in terms of catch composition, fishing effort and fishing activity. In order to increase the knowledge on this fishing sector, data on technical features of gears, fishing areas, landings, fishing effort, fishing yields and qualitative composition of landings were collected over 7 years at four harbours of the northern Adriatic Sea.

#### Materials and Methods

During 1999-2005 the small-scale fleets of Senigallia, Ancona, Portonovo and Numana harbours consited of 77 operating vessels having the following features: 0.57-8.57 GRT, 5.44-298 HP and 3.88-13.01 m Loa. The daily landings of randomly chosen vessels were analysed for a total of 587 sampling days and 1,494 census. At each time the following parameters were recorded: technical parameters of the employed vessels and gears, fishing areas, fishing time, and quali-quantitative composition of landings.

#### Results and Discussion

During the study period the number of active vessels fluctuated seasonally from 35 (winter 2003) to 73 (spring 2002), usually reaching the highest values in spring (Fig. 1). Five types of set gear were observed: basket trap for gastropods, sole gillnet, gillnet targeting grey mullets and sparids, trap for cuttlefish and trammel net (Fig. 1) [1]. Basket traps were used to catch Nassarius mutabilis from fall to spring on the coastal sandy and muddy bottoms. From 200 to 500 traps per vessel were lowered at sea at the beginning of the fishing season and hauled at 1-2 day intervals to collect the catch. At each time the traps were baited with dead fish. Landings mainly consisted of the target species accounting for 99% in biomass, while kept by-catch included only 4 species. Sole gillnet was employed all year-round on the coastal soft bottoms within 3 nm offshore following a seasonal trend with the highest values in summer and the lowest ones in winter. This net was characterised by a low height (1.6-2.5 m) and buoyancy of floats allowing it to lay partially on the seabed thus favouring the capture of benthic fish. The most commonly used mesh sizes were 64 and 68 mm (stretched) [2]. Landings included 59 taxa, but were dominated by Solea solea, Squilla mantis and Chelidonichthys lucernus, which made up 37%, 38% and 11% of the total biomass, respectively. The gillnet used for nekto-benthic and pelagic fish had a larger mesh size (80-100 mm stretched) and a higher net panel (3-5 m) with respect to the sole gillnet. This gear was mainly employed in fall and winter on the rocky bottoms close to the shore. Landings included 48 species, but Liza ramado (63%) and Lithognathus mormyrus (18%) were the most important ones in terms of biomass. Traps for cuttlefish were represented by fyke nets and pots baited with laurel branches acting as spawning substrate for Sepia officinalis. This fishing activity was carried out mainly in spring in correspondence with the reproductive season of the target species on the sandy and muddy bottoms of the coastal zone. Each vessel set 200-500 traps in late winter and collected the catch at 2-3 day intervals. Only 8 species were observed in landings and cuttlefish made up 99% of the total catch. Trammel nets were characterised by a wide variety of technical parameters: panel colour (transparent, white, brown, red, black), line type (poliamide monofilament, twisted poliamide) and diameter, height and mesh sizes of inner and outer panels. They were generally used to catch cuttlefish (60% in weight) in spring on the coastal rocky bottoms close to the shore and *L. mormyrus* (9% in weight) in winter inside the coastal area. The most important by-catch species was *S. mantis*, accounting for 11% of the total catch. A total of 41 species were observed in the landings but, beyond the three above-mentioned species, only *L. ramado* gave an appreciable contribution to the total landed biomass (8%).

The study evidenced the great dynamism of the investigated small-scale fisheries, due to their capacity of changing gear according to the target species' eco-ethology. The used gears were characterised by a high species selectivity, although sometimes kept by-catch made up a discrete portion in biomass contributing to the fishermen' overall income. The information gathered from this study may used for the management of the fishing activities in the coastal area.



Fig. 1. Seasonal number of vessels belonging to the Senigallia, Ancona, Portonovo and Numana small-scale fisheries subdivided into fishing activities. BT = basket trap; SG = sole gillnet; GI = gillnet; TR = traps; TN = trammel net; 1 = winter; 2 = spring; 3 = summer; 4 = fall.

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## CETACEAN OBSERVATIONS IN THE MARMARA AND AEGEAN SEA IN SPRING SEASON 2005

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### Abstract

In the Aegean Sea, according to standard distance sampling procedure, 1800 km (972 nm) and 139 hrs effort of observation carried out during 20.04-20.05.2005 for determining the size and distribution of dolphin population. During the study, totally 19 sightings of three species (*Delphinus delphis, Tursiops truncatus* and *Stenella coeruleoalba*) were recorded. The sighting data were analysed by the Distance 5.0

Keywords : Cetacea, Aegean Sea, Sea Of Marmara.

#### Introduction

In the Aegean Sea, nine cetacean species are known to occur [1,2,3]. These are; D. delphis, T. truncatus, S. coeruleoalba, Globicephala melas, Grampus griseus, Pseudorca crassidens, Ziphius cavirostris, Physeter macrocephalus and Balaenoptera physalus. The situation of Phocoena phocoena that are widely distributed in the North Atlantic coasts and Black Sea and rare in the Marmara Sea is not certain in the Aegean and Mediterranean Sea [4]. Therefore it is important to understand dolphin movements between the Black Sea and Aegean Sea via the Marmara Sea and Straits. A few studies have been conducted on cetacean fauna in the Turkish Aegean coasts. Researches on determining species composition, population and distribution of Cetacea are urgently needed. Such studies conducted in the Aegean Sea, especially in the northern part are very important due to its close position to the Turkish Straits System (TSS) which is known as a migration route for dolphins [5]. Studies conducted in the Turkish coasts of the Aegean Sea and Mediterranean Sea carried out by sampling of strandings or by caught species in fishing gears. Between 1990-1997, in the Turkish coasts of the Aegean Sea and Mediterranean Sea, totally 23 cetacean; 9 T. truncatus, 7 S. coeruleoalba, 3 Z. cavirostris, 2 D. delphis, 1 P. macrocephalus, 1 P. crassidens were found as stranded animals [6]. Besides, between 1999-2000 in the Turkish coasts of the Aegean Sea during swordfish fishery, (7 S. coeruleoalba, 2 T. truncatus, 1 G. griseus) in year 1999 and (6 S. coeruleoalba, 2 T. truncatus, 1 G. griseus) in year 2000 totally; 19 cetacean bycatches were recorded by [7].



Fig. 1. Survey trackline and sighting locations.

#### Material and Method

Cetacean sighting data were collected on a research cruise carried out in spring season (20.04-20.05.2005) in the TSS and the Aegean Sea coasts of Turkey between Istanbul and Marmaris vice versa (Figure 1). This research cruise was conducted with a 16 m. sailing boat NAUTICA and followed standard line transect protocols. During the cruise, three experienced observers were placed in helm, port and starboard side. with 7x50 binoculars and naked eye, port and starboard observers, scan areas covering 0-90 and 90-180 degree and helm observer scan entire 180 degree in the front of the vessel. Dolphin species identified with lowest taxonomic level and group size estimates were recorded by observers. Estimation of dolphin density, group size and encounter rate (n/L) where (n) is the number of observed animals and (L) is the total length of transect line was

based on distance sampling [9]. Thus, Distance 5.0 beta was used for the analyses of sighting data and resolution of estimates given at global level. Average speed of the sailing vessel was 7 nautical miles/h.

#### Results and Discussion

During the survey, totally 1800 km was covered and 139 hour of effort was made. Totally 97 dolphins which belong to three species of family Delphinidae were recorded in 19 sightings; these are 56 T. truncatus in 13, 37 D. delphis in five and three S. coeruleoalba in one observation. Consequently, T. truncatus observed most frequently, although the D. delphis has a bigger group size. Besides, P. Phocoena was not observed and S. coeruleoalba observed only one point near Aegean-Mediterranean border suggest that need more effort to increase the level of encounter or these species are not common in the Aegean Sea. Distance results show hat the density of dolphins 0.27 (SE: 0.68, 95%CI; 0.17-0.45), encounter rate (n/L) 0.11 (SE: 0.01, 95%CI: 0.83- 0.14) and average cluster size 5.2 (SE: 0.5, 95%CI: 4.1-6.6). These cetacean species are under the protection by national and international (eg. Barcelona and Bern Conventions) laws. Besides, the Mediterranean common dolphins status has been declared as "endangered" [8]. Studies on cetacean species in the Aegean coasts provide an important contribution to diversty and determining conservation strategies for protection of biological richness. This is the preliminary study for understanding dolphin populations in the Turkish coasts. Therefore, more detailed studies are necessary for this purpose.

#### Acknowledgements

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# BANQUETTE FAUNAL ASSEMBLAGES FROM GROOMED AND UNGROOMED BEACHES ON THE MALTESE ISLANDS

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## Abstract

The macrofauna associated with beached seagrass wrack on three regularly cleaned (groomed) Maltese beaches and three that are not cleaned (ungroomed) was sampled over a two year period by taking cores and by using pitfall traps. Overall, 40 species were collected from both types of beaches. Coleoptera had the highest species richness (20 species) but the most abundant individual species were the gastropod *Truncatella subcylindrica* and the amphipod *Orchestia stephenseni*. Species richness and individual abundance were highest in the winter months for all beaches. The ungroomed beaches had more species (34) than the groomed ones (9) as well as a higher Shannon-Wiener diversity index, Pielou's evenness, and individual abundance for all species collectively. Thick and long-standing wrack accumulations support higher species richness and abundance and a more taxonomically and trophically diverse biota than thin, freshly deposited layers of wrack.

Keywords : Beach, Biodiversity, Coastal Systems, Posidonia.

#### Introduction

Extensive meadows of *Posidonia oceanica* together with some *Cymodocea nodosa* occur adjacent to the gently sloping north-eastern coastline of the Maltese Islands [1,2]. Most beaches along this coast receive substantial annual inputs of seagrass debris during the autumn and winter months [3]. However, this wrack is regularly cleared away in the summer months from beaches of importance to the tourism industry and it is only on a few relatively inaccessible beaches that this debris is left undisturbed. On such beaches, 'banquettes' [4] of beached dried seagrass (wrack), as high as 2m, can accumulate over a number of years.

### Material and Methods

The beaches at Salina, Xatt l-Ahmar and Selmun (ungroomed beaches), and those at White Tower Bay, Fomm ir-Rih, and Qarraba Bay (groomed beaches) were sampled in winter and summer of 2002 and 2003 by collecting wrack from a 20cm x 20cm quadrat until a 1 litre container was filled (in effect collecting a 0.001m<sup>3</sup> core sample), and repeating the procedure at 10cm depth intervals until the bottom of the wrack accumulation was reached. The material was then washed over a 1mm-mesh and sorted for macrofauna. Nocturnally active motile macrofauna were sampled with pitfall traps laid in the wrack at the surface and left overnight using a standardised protocol for all beaches.

#### Results and Discussion

On the ungroomed beaches, the volume of wrack on the beaches ranged from 120m<sup>3</sup> (Xatt 1-Ahmar, winter) to 15m<sup>3</sup> (Selmun, summer), whislt on the groomed beaches, the volume of wrack ranged from 273m<sup>3</sup> (White Tower Bay, winter) to 6m<sup>3</sup> (White Tower Bay, summer). On all the beaches, the longest decomposing Posidonia leaves were at the surface of the banquette, and leaf length became progressively shorter deeper down in the accumulation suggesting more trituration of leaf material in the thicker and more aged banquettes relative to freshly deposited ones. Considering all beaches collectively, 36 species were recorded from the quadrats and 29 species from the pitfall traps; 14 and 6 species were collected exclusively from the quadrats and pitfall traps respectively, therefore, the total species richness for both collecting techniques together was 40 species. A total of 15 species from quadrats and 8 species from pitfall traps were collected on the ungroomed beaches only, whilst a total of 9 species from quadrats and 3 species from pitfall traps were collected on the groomed beaches only. For the pitfall trap collections, Arachnida was the most species-rich taxon (6 species), whilst for quadrats, Isopoda and Arachnida were the most species-rich (3 species each). As estimated from the quadrat samples, Gastropoda had the highest individual abundance (73,646 individuals/m<sup>3</sup>), whilst the most abundant individual species were the gastropod Truncatella subcylindrica and the amphipod Orchestia stephenseni, which reached maximum densities of 68,070 individuals/m<sup>3</sup> at Salini and 708 individuals/m<sup>3</sup> at Selmun (winter 2003 for both species), respectively. Interestingly, whilst in the quadrat samples a mean density of 6,384 individuals/m<sup>3</sup> was recorded for *T. subcylindrica* from the three ungroomed beaches, no individuals of this gastropod were recorded from the quadrat samples from the three groomed beaches. Considering the quadrat samples only, for all the beaches sampled, the 0-10cm wrack layer was the most species-rich, whilst the lowermost layers (30-40cm and 40-50cm, where the wrack accumulated to these thicknesses) had the least number of species. Species richness (quadrat and pitfall samples together) and individual abundance (quadrat samples only) were highest in the winter months for all beaches, including the ungroomed ones. Multivariate classification (group average linkage hierarchical cluster analysis and nonmetric multidimensional scaling ordination) of the species-abundance data for the quadrat samples only (absolute densities cannot be estimated from pitfall trap data and fauna collected by pitfall traps is not necessarily resident in the wrack) showed the assemblages from Xatt l-Ahmar and Salini as distinct from those of the other beaches. This may be related to Xatt l-Ahmar being the most isolated beach of those studied and Salini to being the only one with a muddy substratum beneath the beached wrack. SIM-PER analysis showed Truncatella subcylindrica and the endemic isopod Spelaeoniscus vallettai to account for 71.6% of the observed dissimilarity between the ungroomed beach at Xatt l-Ahmar (to which both species were exclusive) and the groomed beach at White Tower Bay. Overall, the wrack assemblages from the different beaches were relatively distinct, suggesting compartmentalisation of the fauna. Considering both sampling techniques together, a higher macrofaunal species diversity (34 species compared to just 9 species from groomed beaches) was recorded from the ungroomed beaches. Considering the quadrat data alone, a higher individual abundance (a total of 317,200 individuals/m<sup>3</sup> from ungroomed beaches compared to 84,400 individuals/m<sup>3</sup> from the groomed beaches, all species considered together), the highest Shannon-Wiener diversity index value (1.475 in 2002 and 2.100 in 2003, from Selmun in both cases) and the highest Pielou's evenness value (0.823 in 2002 and 0.818 in 2003, from Selmun in both cases) were recorded for the ungroomed beaches. In addition, Arachnida and Staphylinidae were only recorded from aged wrack from the ungroomed beaches of Xatt l-Ahmar, Selmun and Salina. Thick and long-standing wrack accumulations support higher individual abundances, higher species richness, and a more taxonomically and trophically diverse biota than thin, freshly deposited layers of wrack, while breakdown of seagrass litter is more complete in the former than in the latter. These results suggest that ungroomed beaches with thick banquettes contribute more to beach biodiversity and to carbon cycling that groomed beaches.

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# EFFECTS OF A TWO-MONTH CLOSURE ON TWO TRAWL FISHING GROUNDS IN THE NW MEDITERRANEAN

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## Abstract

Changes in the commercial catches in two trawling grounds located in Sant Carles de la Ràpita (Catalan Coast, NW Mediterranean), were monitored in order to analyse the effects of a two-month seasonal closure. Catch data per unit effort (CPUE) of the three most representative commercial species in each of the two fishing grounds were selected for the study. Results conclude that in both trawling grounds the CPUE increases after the fishing closure.

Keywords : Fisheries, Demersal, Western Mediterranean.

### Introduction

The trawling fleet of Sant Carles de la Ràpita (SCR) corresponds to 50% of the total fleet, and is the largest (16.81%) of the Catalan Coast (NW Mediterranean). The fishing fleet activity is developed from Monday to Friday on a daily basis, operating at the two selected trawling grounds: inshore (<70m) and offshore (>70m). The trawling fleet is regulated by a two months fishing closure every year: July and August (1).

#### Material and Methods

Daily landings by vessel, indicating the specific composition, were obtained from January 2002 to June 2004 from the SCR Fisherman's Association. The fishing effort in each fishing ground was estimated as hours per month and vessel (2).

The three most representative exploited species from each fishing ground were selected to analyse the effects of the seasonal closure. In the offshore fishing ground catches of *Merluccius merluccius*, *Lophius* spp and *Nephrops norvegicus* represent the 21% of the total demersal catches, whereas in the inshore fishing ground catches of *Squilla mantis*, *Mullus* spp and *Loligo vulgaris* represent 34% of the total demersal catches. The catch data was standardized to kg per fishing hour (CPUE)

The fishing activity at both fishing grounds has seasonal fishing effort variability. From March to June the inshore fishing ground shows a low fishing activity and from September to February shows a high level of effort. The fishing activity at the offshore fishing ground is developed in the opposite way.

#### Results and Discussion

To monitor trawl catches variability in both studied fishing grounds, both CPUE (Kg/h) and catches (Kg) of the three inshore and offshore species were compared before and after the seasonal closure (Fig.1 and Fig.2).



Fig. 1. Catches from the two trawling grounds from January 2002 to June 2004.



Fig. 2. CPUE from the two trawling grounds from January 2002 to June 2004.

Results showed different patterns when catches or CPUE were analysed. Regarding the catches, an evident decrease is observed in the offshore fishing ground after the closure in 2002. Nevertheless, in 2003 catches after the closure don't show clear changes. On the contrary, catches increased spectacularly in the inshore fishing ground after the closure. In relation to CPUE, an evident increase appears after the two months of closure in the two studied years at both fishing grounds.

The analysis of the effect of a two month cessation of trawl fishing activity in two fishing grounds highlighted an increase of CPUE in both trawling grounds after the fishing closure.

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# SUMMER ICHTYOPLANKTON DATA IN THE SEA OF MARMARA

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## Abstract

Eggs and larvae belonging to 10 species were identified in July 1997 and to 19 species in August 2000 in the Marmara Sea. Erdek Bay, Marmara Island and surrounding areas and Tekirdag-Sarkoy region are especially important spawning areas in the Sea of Marmara. *Keywords : Ichthyoplankton, Sea Of Marmara, Spawning.* 

The Sea of Marmara is an enclosed basin where Atlanto-Mediterranean originated commercial pelagic fishes spawn while migrating from the Mediterranean and the Aegean Sea to the Black Sea [1]. Organic and microbiological pollution increased in recent years in the eastern part of the Sea of Marmara especially Izmit Bay [2]. The Sea of Marmara receives large amounts of water from the northwestern Black Sea via the Strait of Istanbul and became eutrophic [3]. Ichthyoplankton research enables a good evaluation of ecosystem changes via fluctuations in species diversity and stocks [4]. The present study identifies important spawning areas in the Sea of Marmara based on summer ichthyoplankton data.

Ichthyoplankton was sampled at 63 stations with Nansen closing nets (mouth diameter 57 cm, mesh size 500  $\mu$ m) vertically in July 1997 and August 2000.

The average upper layer water temperature was 23.8  $^{\circ}$ C in July 1997 and 24.1  $^{\circ}$ C in August 2000. Eggs and larvae belonging to 10 species were identified in July 1995 and to 19 species in August 2000 (Table 1).

Tab. 1. Presence-absence data of the identified species.

| Emosion                                  | July | 1997   | Augu  | ist 2000 |
|------------------------------------------|------|--------|-------|----------|
| Species                                  | Egg  | Larvae | Egg   | Larvae   |
| Arnoglossus sp.                          |      |        | +     |          |
| Blennius sp.                             |      |        |       | +        |
| Buglossidium luteum (Risso 1810)         |      |        | +     |          |
| Callionymus sp.                          | +    |        |       |          |
| Coris julis (Linnaeus, 1758)             |      |        | +     |          |
| Diplodus annularis (Linnaeus, 1758)      | +    |        | +     | +        |
| Diplodus sp.                             |      | +      |       | +        |
| Engraulis encrasicholus (Linnaeus, 1758) | +    | +      | $\pm$ | +        |
| Gobius sp.                               |      |        |       | +        |
| Liza saliens (Risso 1810)                | +    |        |       | +        |
| Liza sp.                                 |      |        | +     |          |
| Maurolicus muelleri (Gmelin, 1789)       | +    |        | +     |          |
| Merlangius merlangus (Linnaeus, 1758)    |      |        | +     |          |
| Microchirus variegatus (Donovan, 1808)   |      |        | +     |          |
| Mullus barbatus Linnaeus, 1758           | +    |        | +     |          |
| Sardina pilchardus (Walbaum, 1792)       |      |        | +     | +        |
| Scomber japonicus Houttuyn, 1782         | +    |        | +     |          |
| Scorpaena porcus Linnaeus, 1758          | +    |        | +     |          |
| Serranus hepatus (Linnaeus, 1758)        | +    |        | +     |          |
| Solea sp.                                |      |        | +     |          |
| Trachurus trachurus (Linnaeus, 1758)     | +    |        | +     | +        |
| Trigla sp.                               | +    |        | +     |          |

The mean egg abundance per unit area was 336 ind.m<sup>-2</sup> in July 1997 and 634 ind.m<sup>-2</sup> in August 2000. The distribution of eggs was higher generally in the north and west part of the Sea of Marmara in July 1997. The abundance and species number were higher especially in the northwest part (Tekirdag-Sarkoy shores). On the contrary, only 7 larvae were found in July 1997. Higher egg abundances were found in the west part among Tekirdag, Marmara Island and Erdek Bay in August 2000. Species numbers were also high in Tekirdag and Gebze coasts (southeast). Similar to egg distribution, larval distribution was high in the northwest and west parts of the Sea of Marmara. Highest abundance value was 1097 ind.m<sup>-2</sup> at Murefte coast (Figure 1).



Fig. 1. Distribution and abundance of eggs-larvae and number of species.

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# CYCLE SEXUEL DU CORB SCIAENA UMBRA (SCIAENIDAE) DU LITTORAL D'ANNABA (ALGERIE EST)

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## Résumé

Le cycle sexuel et la fécondité sont étudiés chez le corb *Sciaena umbra* du littoral d'Annaba. La population échantillonnée est composée essentiellement d'individus immatures et de femelles (S.R = 39,23%). Les mâles et les femelles se reproduisent une seule fois au cours de l'année entre mars et août, à partir d'une taille de 26,5 cm. Les femelles mesurant respectivement entre 33,7 et 44 cm de longueur totale pondent entre 76140 et 404593 oeufs. La fécondité relative moyenne est estimée à 279 oeufs.g<sup>-1</sup>. Elle a tendance à chuter à partir d'une longueur totale de 43,6 cm.

Mots clès : Algerian Basin, Fishes, Teleostei, Reproduction.

#### Introduction

*Sciaena umbra* (L, 1758) est un poisson téléostéen qui est devenu vulnérable à la pression de la chasse sous-marine et les populations de la Méditerranée nord occidentale ont été réduites d'une manière considérable, aussi bien en zone ouverte chassée qu'au niveau des réserves marines [1, 2]. D'ailleurs, les données de biologie concernant cette espèce proviennent surtout des populations, relativement abondantes du Sud du bassin occidental de la Méditerranée [3, 4, 5]. Sur le littoral d'Annaba, les informations sur le corb ne concernent que son écologie *in situ* [6] et son alimentation en milieu naturel [7]. Le travail présenté ici fournit des données nouvelles sur son cycle sexuel: sex-ratio, période de reproduction, taille à la première maturité sexuelle et fécondité.

#### Matériel et méthodes

La période de reproduction est déterminée à partir de l'évolution du rapport gonado-somatique, entre mars 2001 et mars 2002. La taille à la première maturité est celle pour laquelle 50 % des individus sont mûrs et présentent des gonades bien développées. Le sex-ratio est exprimé par la relation suivante: SR = (nombre de mâles / nombre total) x 100. La fécondité est étudiée chez des femelles au stade IV de maturité sexuelle [8].

Tab. 1. Fécondités absolue  $(F_a)$  et relative  $(F_r)$  des femelles de *S. umbra* du littoral de Annaba (L<sub>t</sub>: longueur totale, P<sub>t</sub>: poids total, P<sub>e</sub>: poids éviscéré, P<sub>g</sub>: poids des gonades).

| L <sub>i</sub> (cm) | $P_{i}(g)$ | $P_{e}(g)$ | P <sub>g</sub> (g) | F <sub>o</sub> (oeufs) | F, (oeufs.g <sup>-1</sup> ) |
|---------------------|------------|------------|--------------------|------------------------|-----------------------------|
| 33,7                | 458        | 424        | 1594               | 76140                  | 166,2                       |
| 36,3                | 636        | 564        | 30,59              | 173343                 | 272,5                       |
| 37                  | 535        | 464        | 62,14              | 207050                 | 387                         |
| 42                  | 1038       | 907        | 80,32              | 294453                 | 283,6                       |
| 43,6                | 1116       | 980        | 83                 | 404593                 | 363,4                       |
| 43,7                | 1059       | 930        | 70                 | 36000                  | 317,2                       |
| 44                  | 1106       | 1033       | 43,29              | 181818                 | 164,39                      |

#### Résultats

La population de *S. umbra* est composée essentiellement d'individus immatures (N = 82) puis de femelles (N = 79) et de mâles (N = 51). Avec une valeur moyenne de 39,23%, le sex-ratio est en faveur des femelles (khi-deux = 6,03; P  $\leq$  0,05), notamment en autome (khi-deux = 9,84; P  $\leq$  0,01). La reproduction débute en mars et s'achève en août. Le corb est gonochorique et se reproduit à partir d'une longueur de 26,5 cm. La fécondité absolue est comprise entre 76140 et 404593 oeufs pour des femelles mesurant respectivement 33,7 cm (Pt = 458 g) et 43,6 cm (Pt = 1116 g) (Tab. 1). La fécondité relative moyenne est estimée à 279 oeufs.g<sup>-1</sup>. Sa valeur maximale est de 387 oeufs.g<sup>1</sup> pour une femelle mesurant 37 cm et pesant 535 g. L'équation exprimant la fécondité absolue en fonction de la longueur totale des poissons examinés est: F<sub>a</sub> = 5,18 L<sub>t</sub> - 2,96 (r = 0,774; P  $\leq$  0,05). Au cours de la phase de maturation ovocytaire, les ovocytes mesurent 540  $\mu$ m de diamètre et 873  $\mu$ m lors de la phase d'hydratation juste avant leur émission.

#### Discussion

La prédominance numérique des femelles, en particulier en période de repos génital (automne), résulterait de l'action de deux facteurs agissant seuls ou ensemble: l'action sélective de l'engin de pêche ou la dispersion des mâles au niveau des aires de fraie. La période de reproduction débute au printemps et s'achève en été, comme sur les cotes tunisiennes [4, 5]. Toutefois, ils se reproduisent plus précocèment (Ls = 18,8 cm) comparés à la population tunisienne dont la taille standard à la première maturité sexuelle est estimée respectivement à 20 et 22 cm chez les mâles et les femelles, alors que [3] la situe plus tardivement, à 30 cm de longueur totale. La précocité de la taille de première maturité sexuelle chez les femelles de S. umbra de l'Est algérien, comparée à celle de la population tunisienne, s'expliquerait par les différences de température des eaux et aussi par la disponibilité des ressources alimentaires ayant pour effet de réduire la taille de maturité sexuelle. Sur le littoral maltais, le corb atteint sa maturité sexuelle tardivement, à l'âge de 5 ans [9]. La valeur élevée de "b" (5,18) pourrait se traduire par une longévité assez importante de cette espèce qui atteindrait 15 années dans l'Est algérien et 21 ans sur les côtes tunisiennes [3].

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# DISTRIBUTION AND ABUNDANCE OF THE HOLOTHURIAN OCNUS PLANCI (BRANDT, 1835) IN THE NORTHERN AND CENTRAL ADRIATIC SEA

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## Abstract

Data on the distribution and abundance of the holothurian *Ocnus planci* in the northern and central Adriatic Sea were collected by bottom trawl during 11 cruises of the Pipeta Expedition from 1985 to 1994. A total of 518 bottom trawl hauls were performed. The species was collected at depths from 20 to 174 m. The highest mean abundance was recorded on sand-silt-clay sediment (185,97 $\pm$ 565,69 N h<sup>-1</sup>) at depth stratum from 25 to 50 m.

Keywords : Echinodermata, Adriatic Sea.

### Introduction

The holothurian *Ocnus planci* (Brandt, 1835) is distributed in the Eastern Atlantic from the North Sea to West Africa and throughout the Mediterranean Sea on different types of substratum at depths from 5 to 250 m [1, 2]. It is common species in trawl by-catches from the continental shelf in the Adriatic Sea [3]. In this paper we present the distribution and abundance of *O. planci* on the continental shelf of the northern and central Adriatic Sea.

#### Material and methods

Samples were collected using the standard Italian bottom trawl [4] during 11 cruises of the Pipeta Expedition (7<sup>th</sup> - 17<sup>th</sup> cruises) in the Adriatic Sea from 1985 to 1994. The expedition sampled approximately 59000 km<sup>2</sup> of the Adriatic continental shelf at predetermined, permanent stations along ten transects (A - L) over different sediment types at depths of 10 to 430 m (Fig. 1). Total of 518 hauls were performed. The abundance (catch rate) of the species is expressed as the number of specimens per trawling hour (N h<sup>-1</sup>). To calculate mean catch values at different substrata and depth strata only hauls from the area of species distribution were used, i.e., stations where the species was caught at least once. ANOVA and Tukey's test were performed.



Fig. 1. Mean abundance (number of specimens per trawling hour, N  $h^{-1}$ ) of *Ocnus planci* along transects in the Adriatic Sea during the Pipeta Expedition (1985-1994).

## Results and discussion

Holothurian *Ocnus planci* was recorded in 35.5% bottom trawl hauls along all investigated transects in the northern and central Adriatic and is one of the most common species of the mobile bottoms (Fig. 1). The highest mean abundance was recorded at stations in the northernmost part of the northern Adriatic. The species was collected from a shallowest depth of 20 m and a deepest of 174 m, which presents the deepest record of *O. planci* in the Adriatic. The highest mean catch rates were obtained at depth strata up to 50 m. *Ocnus planci* inhabits all types of mobile bottoms investigated during the expedition. The highest mean abundance was recorded at stations on sand-silt-clay sediment ( $185,97\pm565,69 \text{ N h}^{-1}$ ) at depth stratum from 25 to 50 m (Tab. 1). Additionally, high catch rates were recorded on relict sand, clayey relict sand and silty sand and sandy silt up to 50 m. Very small presence of *O. planci* was recorded on clayey silt and silty clay sediment (Tab. 1). The high standard deviation values of means (Tab. 1) denote the uneven species distribution in the area. ANOVA results and Tukey's test results show that the differences between catch rates on each sediment type are statistically significant (*P* <0.001).

Tab. 1. Abundance (number of specimens per trawling hour, N  $h^{-1}$ ) of *Ocnus planci* at different sediment types and depth strata during the Pipeta Expedition (1985-1994) in the Adriatic Sea. n - number of the trawl hauls, n+ - number of positive trawl hauls.

|                                                                                                                                       |           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                        | Abundanc                | Abundance (N h <sup>-1</sup> )                                                                                                                                                                                                                                                                                     |  |  |  |
|---------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|
| Sediment                                                                                                                              | Depth (m) | n                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | n+                                                     | $\overline{\mathbf{x}}$ | SD                                                                                                                                                                                                                                                                                                                 |  |  |  |
|                                                                                                                                       | total     | 86                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 49                                                     | 92.39                   | 249.64                                                                                                                                                                                                                                                                                                             |  |  |  |
|                                                                                                                                       | 10 - 25   | 17                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 16                                                     | 139.34                  | 75.16                                                                                                                                                                                                                                                                                                              |  |  |  |
| "relict" cand                                                                                                                         | 25 - 50   | 36                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 27                                                     | 151.33                  | 369.51                                                                                                                                                                                                                                                                                                             |  |  |  |
| Tenet sand                                                                                                                            | 50 - 100  | 22                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 4                                                      | 5.58                    | 18.01                                                                                                                                                                                                                                                                                                              |  |  |  |
|                                                                                                                                       | 100 - 150 | 11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | $\begin{array}{c c c c c c c c c c c c c c c c c c c $ | 0.60                    | 1.34                                                                                                                                                                                                                                                                                                               |  |  |  |
|                                                                                                                                       | total     | 93                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 48                                                     | 50.16                   | 186.69                                                                                                                                                                                                                                                                                                             |  |  |  |
|                                                                                                                                       | 25 - 50   | 32                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 27                                                     | 143.68                  | 299.43                                                                                                                                                                                                                                                                                                             |  |  |  |
| clavey                                                                                                                                | 50 - 100  | 33                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 15                                                     | 1.78                    | 3.26                                                                                                                                                                                                                                                                                                               |  |  |  |
| clayey<br>"relict" sand<br>sand-silt-<br>clay                                                                                         | 100 - 150 | 19                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 5                                                      | 0.37                    | 0.75                                                                                                                                                                                                                                                                                                               |  |  |  |
|                                                                                                                                       | 150 - 200 | 8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1                                                      | 0.09                    | 0.24                                                                                                                                                                                                                                                                                                               |  |  |  |
|                                                                                                                                       | > 200     | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0                                                      | 0.00                    | See (N h <sup>-1</sup> )           SD           249.64           75.16           369.51           186.69           299.43           3.26           0.75           0.24           0.00           565.69           7.57           5.94           7.73           11.17           2.52           0.89           113.26 |  |  |  |
| sand-silt-                                                                                                                            | total     | n         n           86         5         17           0         36         00         22           50         11         93         0         32           00         32         00         33         50         19           00         8         1         30         0         30           0         30         164         5         31         0         42           00         43         50         39         00         9         3         3           30         3         3         3         3         3         3 | 18                                                     | 185.97                  | 565.69                                                                                                                                                                                                                                                                                                             |  |  |  |
| clay                                                                                                                                  | 25 - 50   | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 18                                                     | 185.97                  | 565.69                                                                                                                                                                                                                                                                                                             |  |  |  |
| -                                                                                                                                     | total     | 164                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 66                                                     | 2.85                    | 7.57                                                                                                                                                                                                                                                                                                               |  |  |  |
| 1                                                                                                                                     | 10 - 25   | $\begin{array}{c ccccccccccccccccccccccccccccccccccc$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 10                                                     | 2.06                    | 5.94                                                                                                                                                                                                                                                                                                               |  |  |  |
| clayey silt                                                                                                                           | 25 - 50   | 42                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 24                                                     | 4.22                    | 7.73                                                                                                                                                                                                                                                                                                               |  |  |  |
| silty clay                                                                                                                            | 50 - 100  | 43                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 18                                                     | 4.19                    | 11.17                                                                                                                                                                                                                                                                                                              |  |  |  |
| Sincy only                                                                                                                            | 100 - 150 | 39                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 12                                                     | 1.09                    | 2.52                                                                                                                                                                                                                                                                                                               |  |  |  |
| "relict" sand<br>clayey<br>"relict" sand<br>sand-silt-<br>clay<br>clayey silt<br>and<br>silty clay<br>silty sand<br>and<br>sandy silt | 150 - 200 | 9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2                                                      | 0.36                    | 0.89                                                                                                                                                                                                                                                                                                               |  |  |  |
| silty sand                                                                                                                            | total     | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 3                                                      | 135.93                  | 113.26                                                                                                                                                                                                                                                                                                             |  |  |  |
| and<br>sandy silt                                                                                                                     | < 25      | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 3                                                      | 135.93                  | 113.26                                                                                                                                                                                                                                                                                                             |  |  |  |

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## ESTIMATION, PAR OTOLITHOMETRIE, DES PARAMETRES DE CROISSANCE DE POMATOMUS SALTATRIX (TELEOSTEI, POMATOMIDAE), DANS LE GOLFE DE GABÈS, TUNISIE

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## Abstract

La lecture des otolithes de 675 individus de Tassergal, Pomatomus saltatrix, du golfe de Gabès (Tunisie), a permis de déterminer les paramètres de croissance en longueur de cette espèce. Ces paramètres, pour les deux sexes combinés, sont les suivants : LT = 490,4 mm, k = 0,266 et  $t_0 = -0,352$ .

Keywords : Growth, Teleostei, Gulf Of Gabes.

#### Introduction

Le Tassergal, Pomatomus saltatrix (L. 1766), est exploité dans le golfe de Gabès par tous les engins de pêche en usage et particulièrement par les métiers côtiers, les sennes tournantes et les chaluts. Le potentiel offert par le stock et la fraction qui en est extraite demeurent indéterminés jusqu'à présent. Pour les estimer au moyen d'un modèle analytique, il a fallu déterminer certains paramètres, entre autres ceux de la croissance qui seront présentés dans cette note.

#### Matériel et méthodes

L'étude a porté sur 675 individus ayant chacun une longueur totale (LT) comprise entre 58 et 446 mm, provenant, en majorité, des débarquements commerciaux. Après incision au niveau de l'oreille interne, les otolithes ont été prélevés, nettoyés à l'eau et conservés à sec dans de petites pochettes. Pour révéler les anneaux d'arrêt de croissance, ces otolithes ont été trempés dans une solution d'acide acétique pendant deux minutes puis colorés au bleu de toluidine pendant 30 secondes. L'excès de colorant a été enlevé par l'alcool absolu. Une loupe binoculaire munie d'un micromètre oculaire a servi à l'observation de ces pièces, immergées, in toto, dans un bain éclaircissant de glycérine, sur un fond noir. Le rayon total (R) a été mesuré, sur la face concave, du primordium au bord postérieur de l'otolithe suivant le prolongement du sillon: sulcus acusticus. Les rayons des anneaux d'arrêt de croissance ont été mesurés sur ce même axe. Les divisions micrométriques ont été, ensuite, converties en millimètres.

La relation (LT =  $aR^b$ ) qui lie la taille de chaque individu examiné au rayon de son otolithe a été établie pour décrire l'allométrie entre les deux variables. La valeur de la constante b (proche de 1) a été testée par le test t de Student  $(t_c)$ .

Pour situer la période de l'arrêt de croissance, nous avons analysé les variations mensuelles de l'allongement marginal (AM) des otolithes.

 $AM = (R - R_n)X100/(R_n - R_{n-1}),$ 

où R = rayon total de l'otolithe,  $R_n$  = rayon du dernier anneau et  $R_{n-1}$  = rayon de l'avant dernier anneau.

Pour attribuer un âge approximatif à un individu donné, nous avons pris en compte, en plus du nombre d'anneaux que montrent ses otolithes, trois évènements essentiels : la date de naissance qui correspond à la période de ponte de l'espèce (fin octobre - début novembre), la date de capture et la période d'arrêt de croissance.

Pour déterminer les paramètres théoriques de croissance, nous avons lié, pour chaque individu examiné, sa longueur totale mesurée en mm à son âge estimé en ans. Ensuite, une longueur totale moyenne a été calculée pour un groupe d'âge moyen. Les longueurs -aux âges- ont été utilisées pour l'ajustement de la courbe de croissance de Von Bertalanffy dont l'équation est :

 $\mathbf{L}_t = \mathbf{L} \infty \left( 1 - \mathbf{e}^{-k(t-t0)} \right)$ 

où  $L_t$  = longueur totale du poisson au temps t,  $L\infty$  = longueur maximale théorique que le poisson pourrait atteindre, to= temps théorique correspondant à L = 0 et k = constante de la vitesse de croissance.

#### Résultats

Les deux otolithes du Tassergal, du golfe de Gabès, sont oblongs. Chacun d'eux présente une face convexe (interne), une face concave (externe) et un rostre ventral. C'est la face concave qui se prête à l'observation et à la détection des anneaux. En lumière réfléchie, les otolithes présentent, particulièrement chez les individus âgés de plus d'un an, une alternance de zones opaques de couleur blanche et de zones translucides (hyalines) de couleur sombre. Ces dernières sont toujours les moins larges et correspondent à une croissance très ralentie. Une quinzaine d'individus dont l'âge

était approximativement connu (de 5 à 7 mois) ont été très utiles pour le décryptage du premier anneau. Les otolithes de ces individus présentaient des anneaux bien clairs qui seraient pris pour des anneaux annuels, alors qu'ils n'étaient que les marques du premier hiver (environ 3 mois).

Les relations LT = f(R) sont les suivantes : - pour les femelles : LT = 66,863 R<sup>1,0774</sup> ; R<sup>2</sup> = 0,8958 ; N = 320 ; t<sub>c</sub> = 10,12; p<0,001;

- pour les mâles : LT = 60,361 R<sup>1,1574</sup> ; R<sup>2</sup> = 0,9382 ; N = 339 ; t<sub>c</sub> = 32,46; p<0,001;

Ces relations montrent que la taille du Tassergal a une croissance positive par rapport à celle de ses otolithes (b>1, t<sub>c</sub>>1,96, p<0,001) et que la corrélation entre les deux variables est très significative.

L'analyse des variations mensuelles de l'allongement marginal des otolithes a permis de situer l'arrêt de croissance au mois de janvier (le mois le plus froid en Tunisie). Mais si la plus faible valeur moyenne de ce rapport (AM) a été observée à ce mois, cela ne voudrait pas dire que tous les individus ont forcément formé leurs anneaux à la même époque.

L'ajustement de l'équation de Von Bertalanffy aux longueurs - aux - âges estimées a permis de déterminer les paramètres de croissance du Tassergal du golfe de Gabès qui sont les suivants:

- pour les femelles: LT $\infty$  = 472,3 mm  $\pm$  81,5 mm ; k = 0,292  $\pm$  0,110 et  $t_0 = -0,304 \pm 0,255$ ;

- pour les mâles:  $LT\infty = 512,6 \text{ mm} \pm 76,1 \text{ mm}$ ; k = 0,254  $\pm$  0,076 et t<sub>0</sub>  $= -0,333 \pm 0,200;$ 

- pour les deux sexes combinés (N= 675):  $LT\infty$  = 490,4 mm ± 68,8 mm ; k = 0,266  $\pm$  0,079 et t<sub>0</sub> = - 0,352  $\pm$  0,221.

Tab. 1. Tailles-âges et tailles maximales de P. saltatrix dans différentes régions.

| Lion/Antour             |     |     | Cla | isse d | 'âge |     |     |                   |
|-------------------------|-----|-----|-----|--------|------|-----|-----|-------------------|
| Lieu/Auteur             | 1   | 2   | 3   | 4      | 5    | 6   | 7   | $L_{\infty}$ (mm) |
| Mer noire [2]           | 322 | 409 | 562 | 615    | 663  |     |     | LT: 1080          |
| Longue Islande, USA [3] | 230 | 400 | 490 | 580    | 640  | 690 | 710 | LF: 795           |
| Mexico [4]              | 308 | 413 | 509 | 576    | 627  | 675 | 715 | LF: 944           |
| Afrique du Sud [5]      | 165 | 279 | 369 | 437    | 480  |     |     | LT:840            |
| Sud du Brésil [6]       | 196 | 356 | 438 | 506    | 562  | 600 | 618 | LT : 662          |
| Sud du Brésil [7]       | 214 | 351 | 451 | 506    | 554  | 615 | 647 | LT : 754          |
| Présent travail         | 148 | 228 | 289 | 336    | 372  | 400 | 421 | LT: 490           |

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## DEMERSAL ASSEMBLAGES ON DEEP WATER TRAWLING GROUNDS OFF THE MALTESE ISLANDS: MANAGEMENT IMPLICATIONS

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## Abstract

Data from three consecutive years of trawl surveys were used to characterise the demersal assemblages present on trawling grounds around the Maltese Islands, (Central Mediterranean) in water ranging from 85 to 800 m depth. Five different assemblages were present which seemed related to depth zones that do not coincide with those sampled in existing stock assessment programmes. It is therefore clear that the depth strata sampled in such programmes need to be revised to make them more biologically relevant and to achieve a better sampling representation of each assemblage type.

Keywords : Demersal, Deep Waters, Fisheries, Stock Assessment, Trawl Surveys.

#### Introduction

The modern trend in the management of fish stocks is 'ecosystem-based fisheries management', where fish stocks are no longer considered in isolation but as one component of an integrated ecosystem [1]. In turn, such an approach requires a good knowledge of the constituents of the system. Bottom trawling is an important component of many Mediterranean fisheries, being responsible for a high share of total catches and, in many cases, yielding the highest earnings among all the fishing sub-sectors. In the Mediterranean, bottoms are trawled for commercial fishing at depths ranging from 50 to 800 m [2]. We studied the spatial distribution of demersal resources on muddy bottoms in the depth range from 80 to 800 m within the General Fisheries Commission for the Mediterranean (GFCM) geographical sub-unit 15, and assessed management implications of our results.

#### Methods

Samples were collected from trawling grounds off the Maltese islands within the GFCM geographical sub-unit 15 as part of the ongoing MED-ITS trawl survey programme. Otter trawl samples were collected in June-July of 2003, 2004 and 2005 from 45 stations located at different depths between 80 and 800 m. Each haul lasted for ca 45 minutes, depending on the depth and substratum type, and trawl speed was ca 3 knots; the gear used was IFREMER GOC 73 [3] and consisted of a 40 m long and 22 m wide trawl net with a 1-2 m vertical opening and a cod end stretched mesh size of 20 mm. The entire faunal component from each haul was sorted, identified, weighed and counted. The data for each station were standardised per square kilometre, and were analysed using classification and ordination techniques. Species whose percentage biomass was less than 0.01% were removed from these analyses. Agglomerative hierarchical clustering followed by non-metric multidimensional scaling (nMDS) ordination was then applied on a similarity matrix constructed from the fourth-root transformed data using the Bray-Curtis similarity measure, using the PRIMER 6 software [4]. Since the biomass data yielded more detailed and clearer results than abundance data, the former is presented in this paper.

#### Results and discussion

A total of 552,963 live individuals (22,887 kg) comprising 189 different species (26 elasmobranchs, 111 teleosts, 26 decapods and 26 molluscs) were identified, of which teleosts were the largest component in terms of both abundance and biomass.Cluster analysis and nMDS ordination of the species biomass data resulted in five main clusters at a similarity of 46% (Fig.1). These clusters correspond to two sets of outer continental shelf stations, those from the continental shelf slope (140 - 273 m), those from the shelf break (240 - 440 m) and those from the deep slope (466 - 701 m) stations.

In general, the difference in assemblage structure increases with depth, with the transition from one assemblage to the next being more gradual at shallower depths and sharper as the depth increases. The differences between the continental shelf assemblages (Outer shelf A, Outer shelf B, Shelf break) were mainly quantitative, but were both quantitative and qualitative between the outer and shelf break assemblages and the upper slope assemblages, and between the upper slope assemblages and those of the deep slope.



Fig. 1. Non-metric multidimensional scaling (nMDS) plot for the sampling stations for all the three years, based on biomass. The ovals enclose the groups generated by cluster analysis. OSA - Outer shelf A; OSB -Outer shelf B; SS - Shelf break; SL - Shallow slope; DS - Deep slope.

Based on these results the fishery resources of Maltese trawling grounds are stratified in four main depth ranges: 80-160 m (outer continental shelf: two subgroups), 160-270 m (shelf break), 270-440 m (upper slope), and 440-800 m (deep slope). These strata do not coincide with those sampled in existing stock assessment programmes, which were set up without reference to benthic/demersal assemblage structure and its relation to depth. It is therefore clear that the depth strata sampled in such programmes need revision to make them more biologically relevant and in order to have a better sampling representation of each assemblage structure to detect the impact of various fishing practices on the benthic/demersal assemblages both spatially and temporally, and if any changes found are related to the spatial and temporal effort of the fishing fleet.

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## ROLE OF ENVIRONMENTAL VARIABLES IN STRUCTURING DEMERSAL ASSEMBLAGES ON TRAWLED BOTTOMS ON THE MALTESE CONTINENTAL SHELF

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## Abstract

Demersal assemblages from trawl surveys made at depths of 45-800 m in trawled areas within the 25NM Fisheries Management Zone round the Maltese Islands were related to environmental characteristics on the seabed. Depth, temperature, and mean grain size all affected the structure of the demersal assemblages but depth and temperature gradient were overall the most important in that order; while mean grain size seemed more important for relatively shallow bottoms (<80 m) than for deep ones. *Keywords : Demersal, Fisheries, Sediments, Temperature, Trawl Surveys.* 

Introduction

Prior to joining the European Union, Malta managed a 25 nautical mile Exclusive Fishing Zone. Post-EU membership, Malta was allowed to retain this zone, which covers an area of 10,700 km<sup>2</sup>, as a Fisheries Management Zone (FMZ) as there are indications that demersal fishery stocks within the zone are distinct from those outside [1]. For shallow shelf resources (<200 m) within the FMZ, adult populations of demersal fish are believed to be isolated to some degree from adjacent populations and exchange of adult individuals between these populations may be limited. At present, there is little information on the distribution of biological assemblages in relation to environmental variables within the Maltese FMZ, even if such information is essential for the management of living resources. A programme of research to address this is being implemented.

#### Methods

Otter trawl samples were collected from stations at depths between 45 and 800 m distributed within the Malta 25NM FMZ in the summer of 2003, 2004 and 2005 as part of the ongoing MEDITS trawl survey programme. Samples were collected with a semipelagic experimental trawl net (IFRE-MER GOC 73) and each haul lasted for ca 45 minutes, depending on the depth and substratum type; trawl speed was ca 3 knots. Bottom temperature was measured with a temperature probe attached to the net. The entire catch from each haul was sorted, and the fauna were identified and counted. Samples for sediment analyses were collected in 2004 and 2005 from a limited number of stations using a 0.0625 mÅš box corer. Sediment granulometry was determined according to the procedures described by Buchanan [2].

The macrofaunal data were analysed by first constructing a similarity matrix from the root-root transformed biomass data using the Bray-Curtis similarity measure and then applying non-metric multidimensional scaling (nMDS) ordination [3]. Relationships between measured abiotic characteristics (depth, temperature, mean grain size) and demersal assemblages were determined using the BIOENV procedure and by superimposing scaled individual variables onto the sample locations on the two-dimensional nMDS ordination plots. All the analyses were made using the PRIMER 6 statistical software package [3].

#### Results and Discussion

The visual correlations between the environmental variables and the groups generated by the nMDS ordination indicate that all three physical parameters seemed to play a role in structuring the demersal assemblages. The BIOENV correlation analyses gave relatively high values of Spearman's coefficient for depth, temperature, and to a lesser extent, for mean grain size. (Figs. 1 and 2).

The most important environmental variable responsible for the observed patterns of change in community structure was depth. Depth has also been shown to be the main factor determining the distribution of marine fauna in other areas of the Mediterranean [4]. Temperature was second in importance, while the correlation coefficient for mean grain size was relatively low when compared to the coefficients for depth and temperature. While mean grain size explained well the distribution of the relatively shallow water stations (46-82 m), it was not as important in structuring the deeper water assemblages. In summary, the depth and temperature gradients, with their accompanying environmental and biological changes, are the main factors responsible for the patterns in community structure observed.



Fig. 1. Non-metric multidimensional scaling (nMDS) plot for the sampling stations from 2004 and 2005, based on biomass with superimposed scaled values of mean grain size ( $\mu$ m). The numbers on each station position give the mean depth for that station.



Fig. 2. nMDS plot with superimposed scaled values of temperature ( $^{o}$ C) for all three years (2003, 2004 and 2005).

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# IMPACTS OF CAGE FARMING ON THE DISTRIBUTION ON THE MOLLUSCAN FAUNA IN THE AEGEAN SEA

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## Abstract

The impacts of the cage culture on the Molluscan fauna in the vicinity of fish farms were studied seasonally at 2 stations in the Aegean Sea. A total of 1064 individuals belonging to 129 species were encountered. Relatively low diversity and evenness index values under the cages were determined.

Keywords : Mollusca, Aegean Sea, Aquaculture.

#### Introduction

Over the last two decades, aquaculture activities have rapidly expanded in the coastal marine areas and resulted in decreasing at qualities of sea water and bottom sediment. Similarly, those activities have a continuous conflict with tourism activities. The effects of fish farming on the benthic fauna in the vicinity of fish cages have been reported from several parts of the world as in the Mediterranean [1, 2].

The present study attempts to determine the effects of the fish farming activities on the mollusc fauna inhabiting under and around of the cages of two fish farms.

## Material and Methods

Samplings were performed seasonally at two stations in the Aegean Sea between September 2002 and June 2003 at station 1 and October 2001 and August 2002 at station 2. At each station three samples were taken with dredge; one under the cages, one at the vicinity of the cages and one from reference point where it is far enough from the stress of the organic enrichment. The samples were washed through 0,5 mm mesh size sieve fixed with 10 % formalin and preserved in 70 % ethanol. Data concerning stations and the fish farm are given in Table 1. Diversity, evenness and similarities were determined by means of PRIMER software.

Tab. 1. Data concerning stations and the fish farms. A: under the cages; B: at the vicinity of the cages; C: at a reference site; M: Mud; Ms: Muddy sand; P: *Posidonia oceanica* Delile; Sa: Sand.

| Station | Sample         | Depth<br>(m) | Biotop | Distance<br>from the<br>cages (m) | Sampling<br>date | Instal.<br>date          | Annual<br>production<br>(ton) | Breeding<br>species |  |
|---------|----------------|--------------|--------|-----------------------------------|------------------|--------------------------|-------------------------------|---------------------|--|
|         | А              | 47           | Ms     | 0                                 |                  |                          |                               | Tuna<br>fish        |  |
| 1       | В              | 45           | Sa     | 100                               | 09/02-<br>06/03  | 09/02-<br>06/03 2002 500 | 500                           |                     |  |
|         | С              | 20           | P+Sa   | 400                               |                  |                          |                               |                     |  |
|         | Α              | 25           | М      | 0                                 |                  |                          |                               | Sea                 |  |
| 2       | В              | 9            | P+Sa   | 1200                              | 10/01-<br>08/02  | 1997                     | 500                           | bass &<br>Sea       |  |
|         | C 14 P+Sa 6000 |              |        |                                   |                  | bream                    |                               |                     |  |

#### Result and Discussion

In the 24 samples analyzed, a total of 1064 individuals were identified belonging to 129 species. *Bittium latreillii* sampled mainly from the *Posidonia oceanica* meadows was the most abundant species (15,6 %) followed by *Dentalium inequicostatum* (7,99 %) occurred mostly on the muddy bottom of the station 2. *Tellina distorta* considered as a species of semi polluted zone [3] was another abundant species (5,17 %) encountered under the cages having muddy bottom at station 2. *Corbula gibba* considered as tolerant species that can inhabit in semi-polluted or polluted zones where they may form dense populations [4] was sampled relatively less in number under and the vicinity of the cages situated on muddy-sand and sandy bottoms of station 1.

The number of species and the species diversity (H) were lower in the samples collected under the cages while the evenness (J) was relatively constant between the sampling points of the stations. The lowest number of species (27) and diversity value (3,18) were determined under the cages at station 2, whereas the reference point of station 1 was represented with the highest number of species (68) and diversity value (5,37). The maximum numbers of individuals were encountered in the reference points of both stations as 248 at station 1 and 246 at station 2. The lowest number

of individuals (93) was determined at the vicinity of the cages at station 2, and under the cages of station 1 (104).

According to the Bray-Curtis similarity, two stations were linked together with a similarity of 19 % and higher similarity values (49 %, 55 %) were seen in the sub-regions of these two stations (Fig. 1) presumably due to similar bottom structure.



Fig. 1. Bray-Curtis similarity between samples.

The mollusc fauna under the cages especially in station 2 seems to be affected by the earlier installation date of the cages, relatively limited current conditions and shallower depth.

As a result, in order to decrease unfavorable effects of the fish farming activities on the marine ecosystem, the cages should be installed in the locations having appropriate conditions such as depths and strong currents. Beside, certain effects of fish farming on benthic communities can be revealed by more detailed studies including all benthic groups.

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# MISE EN EVIDENCE DE LA PRESENCE DES TINTINNIDES DANS LE GOLFE DE GABES (SUD-EST TUNISIEN)

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## Résumé

L'étude spatiale du zooplancton dans le golfe de Gabès pendant une campagne estivale en Juillet 2005, a montré qu'à côté des copépodes qui sont dominants et représentant 86% du zooplancton total, les ciliés composés essentiellement par les tintinnides des eaux côtières marines sont peu abondants et constituant 1% du zooplancton total. Ces tintinnides de grande taille sont représentés essentiellement par 7 espèces. Leurs densités peuvent atteindre dans certaines stations  $8.8 \cdot 10^4$  ind.m<sup>-3</sup>. Une relation trophique manifestée par un broutage du phytoplancton par les tintinnides pourrait exister dans le golfe de Gabès pendant la saison estivale. *Mots clès : Gulf Of Gabes, Zooplankton, Copepoda, Phytoplankton.* 

#### Introduction

Les tintinnides sont des Oligotriches planctoniques de 20 à 200  $\mu$ m qui constituent un lien trophique entre le compartiment microbien et métazoaire [1]. Ce sont des importants brouteurs et jouent un rôle fonctionnel dans la chaîne trophique marine [2]. Ils constituent le majeur composé du microzooplancton dans les environnements marins [3]. A fin de dégager la relation trophique entre les tintinnides avec d'autres communautés planc-toniques, nous avons étudié la répartition spatiale du phytoplancton et des copépodes des tintinnides.

#### Matériel & Méthodes

Durant une campagne estivale (Juillet 2005), 33 stations côtières et néritiques ont été prospectées au niveau du golfe de Gabès (Figure 1A) afin d'étudier le peuplement zooplanctonique et phytoplanctonique. La récolte du zooplancton a été effectuée à l'aide d'un bongo de 100  $\mu$ m de porosité et le comptage a été fait à l'aide d'une cuve de Dollfus sous une loupe binoculaire. La récolte du phytoplancton a été réalisée par un dispositif de CTD. La composition phytoplanctonique a été estimée par microscope inversé [4].





#### Résultats & discussion

L'étude qualitative et quantitative du zooplancton dans les différentes stations du golfe de Gabès, a montré que les copépodes constituent le groupe le plus dominant avec une moyenne de 86%. Les tintinnides (1%du zooplancton total) sont composés par 7 espèces à savoir Codonellopsis morchella, Tintinnopsis sp1, Tintinnopsis sp2, Tintinnidium sp, Brandtiella palliata, Laackmanniella naviculaefera et Rhabdonella sp. Ces espèces se caractérisent par une taille variant entre 131 et 405  $\mu$ m et une abondance pouvant atteindre  $8.8 \cdot 10^4$  ind.m<sup>-3</sup>. La répartition spatiale des tintinnides a montré la présence de 3 foyers de concentrations dont 2 sont situés au niveau de l'isobathe de 50 m et le troisième à l'intérieur du golfe (<50 m) (Figure 1B). Les tintinnides peuvent consommées les diatomées et les dinoflagellés [5]. La fluctuation relative de l'abondance des tintinnides est liée à la densité du phytoplancton [6]. En effet, le maximum d'abondance des tintinnides coïncide avec le maximum de concentrations du phytoplancton [7]. Les tintinnides constituent une nourriture importante pour les crustacés tels que les copépodes [8]. Une corrélation positive a été détectée entre l'abondance des copépodes totaux et des tintinnides ( $r^2 = 0.563$ , p < 0.005) qui est due probablement au broutage des tintinnides par les copépodes [9]. L'étude de la répartition spatiale, a montré que les fortes densités de copépodes correspondent à de faibles abondances des tintinnides.

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# INVESTIGATION OF CYCLIC CHANGES OF ZOOPLANKTON COUNTS AND SOME ENVIRONMENTAL FACTORS USING FOURIER ANALYSIS IN THE EASTERN HARBOR OF ALEXANDRIA EGYPT

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## Abstract

Time series data of monthly counts of zooplankton, groups and species, and some environmental factors (water temperature, salinity and chlorophyll) were collected, in the Eastern harbor of Alexandria Egypt, in the period from October 1999 to November 2003. The biological investigation of these data has been dealt with in another publication [1]. In this paper 27 time series, each of length 36 months, for 3 environmental factors, 5 zooplankton groups and 19 zooplankton species, are analyzed using the Fourier analysis to find out the amplitudes and phase angles at the different cycles with periods between 2 and 36 months. The results show the periods of the relevant cycles affecting the movement of the time-series for each of the used variables including the groups, the species and the environmental factors, detected by the peaks of the periodogram (Frequency - amplitude chart).

Keywords : Time Series, Zooplankton.

#### Introduction

The study area is the Eastern harbor of Alexandria that lies at  $(31.2-31.214^{\circ} \text{ N}, 29.880 - 29.908^{\circ} \text{ E})$ . It is a semi-circular basin bounded at the open sea side by an artificial break water to protect the inner part of the harbor from the direct wave action especially in winter time. There are two outlets at the sea, eastern and western outlets. The depths lies between 1 and 9 meters with an average 5 meters and the largest depths are near the outlets. This area is important as a fishing harbor as well as a tourist site.

#### Data and methods of analysis

Time series analysis was applied on biological data [2]. The Fourier analysis is one of the important tools used in the investigation of the of any time series. It aims to fit the equally spaced time series by the summation of sine and cosine functions so that the variable value can be estimated. The main arguments in the equation are the amplitudes and phase angles relative to time series starting.

Tab. 1. Harmonic analysis peaks frequencies for zooplankton groups and environmental factors in the eastern harbor (1999-2003) indicated by sign (x).

|                   |     |                |                          | VARIA | BL  | E |   |   |   |   |   |   |
|-------------------|-----|----------------|--------------------------|-------|-----|---|---|---|---|---|---|---|
| VARIABLE          | NO. | Period (month) | freq(cycles/36<br>month) | 1     | 2   | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| salinity          | 1   | 36             | 1                        | Х     |     |   | X |   |   | Х | Х | X |
| chlorophyll       | 2   | 18             | 2                        | Х     |     |   | 1 |   | Х |   |   |   |
| temp              | 3   | 12             | 3                        |       | Х   | X |   | X |   | Х | X |   |
| totalzoo          | 4   | 9              | 4                        | X     |     |   | X | X |   |   |   | X |
| Ciiripede<br>lar. | 5   | 7.2            | 5                        |       |     |   |   |   | × |   |   |   |
| Polychaetes       | 6   | 6              | 6                        |       | Х   |   |   |   | Х | Х |   |   |
| Copepods          | 7   | 5.143          | 7                        |       |     |   |   | X |   |   |   | X |
| Rotifers          | 8   | 4.5            | 8                        | X     |     |   | X |   | Х |   |   |   |
| Titinnids         | 9   | 4              | 9                        |       | 21  |   |   |   |   |   |   | X |
|                   |     | 3.6            | 10                       |       |     |   |   |   |   | Х |   |   |
|                   |     | 3.273          | 11                       |       |     |   | X | X | Х |   |   | Х |
|                   |     | 3              | 12                       | _     | Х   |   |   |   |   |   |   | 1 |
|                   |     | 2.769          | 13                       |       | 1 9 |   | X | X |   |   |   |   |
|                   |     | 2.571          | 14                       |       |     |   |   |   |   |   | X |   |
|                   |     | 2.4            | 15                       | Х     | Х   |   |   | X |   |   |   |   |
|                   |     | 2.25           | 16                       |       |     |   | Х |   | X |   |   |   |
|                   |     | 2.118          | 17                       |       |     |   |   |   |   |   |   |   |

The spectra represented as the relation between amplitude as y- axis and frequency as x- axis and the important peaks are corresponding to the main controlling cycles in the time series. The phase angles of the different variables enable to determine the time delay at a given frequency or given period between the occurrences of the maxima in the original time series of any two variables.

In the full text the results are presented as follows:

1- The time series of the three environmental factors and the five zooplankton groups are presented graphically.

2- The amplitudes of the above variables are presented graphically against the frequency.

3- The relevant frequencies in the environmental variables as well as zooplankton groups and species have been tabulated to deduce the common frequencies among the different variables (table 1).

4- For a given frequency (or period) the delay time of occurrence of the

maxima in original time series (blooming times) of any two variables was calculated (tables 2). The negative sign indicates raw variable peak comes first, and positive sign indicates that the column variable peak comes first (table 2).

Tab. 2. Matrix of delay in months (from phase of raw var. - phase of column var.) for the cycle of zooplankton groups and some environmental variables at the periodic time of 12 months from Fourier analysis (- sign indicates raw variable peak comes first, and + sign column variable peak comes first.

| variable          | No. |             | 1      | 2     | 3      | 4      | 5     | 6      | 7      | 8      | 9      |
|-------------------|-----|-------------|--------|-------|--------|--------|-------|--------|--------|--------|--------|
|                   |     | Phase Angle | 193.92 | 6.92  | 271.79 | 296.39 | 10.31 | 264.20 | 265.31 | 180.37 | 304.15 |
| temp              | 1   | 193.92      | 0.00   | -6.23 | 2.60   | 3.42   | -6.12 | 2.34   | 2.38   | -0.45  | 3.67   |
| salinity          | 2   | 6.92        | 6.23   | 0.00  | 8.83   | 9.65   | 0.11  | 8.58   | 8.61   | 5.78   | 9.91   |
| chlorophyll       | З   | 271.79      | -2.60  | -8.83 | 0.00   | 0.82   | -8.72 | -0.25  | -0.22  | -3.05  | 1.08   |
| totalzoo          | 4   | 296.39      | -3.42  | -9.65 | -0.82  | 0.00   | -9.54 | -1.07  | -1.04  | -3.87  | 0.26   |
| Ciiripede<br>Iar. | 5   | 10.31       | 6.12   | -0.11 | 8.72   | 9.54   | 0.00  | 8.46   | 8.50   | 5.67   | 9.79   |
| Polychaetes       | 6   | 264.20      | -2.34  | -8.58 | 0.25   | 1.07   | -8.46 | 0.00   | 0.04   | -2.79  | 1.33   |
| Copepods          | 7   | 265.31      | -2.38  | -8.61 | 0.22   | 1.04   | -8.50 | -0.04  | 0.00   | -2.83  | 1.29   |
| Rotifers          | 8   | 180.37      | 0.45   | -5.78 | 3.05   | 3.87   | -5.67 | 2.79   | 2.83   | 0.00   | 4.13   |
| Titinnids         | 9   | 304.15      | -3.67  | -9.91 | -1.08  | -0.26  | -9.79 | -1.33  | -1.29  | -4.13  | 0.00   |

#### Conclusions

The most common periods for the different variables are 36, 12, 9 and 6 months. The 12 months is corresponding to seasonal changes, the 36 months may be related to inter-annual climate changes and periods less than 12 months are due to local changes depending on the hydrological exchange between the Eastern harbor and the open Mediterranean coastal waters in-front of the study area. The time lags of the occurrence of the maxima for each variable (groups and environmental factors) relative to the other variables at the important cycles with periods 36, 12, 9 and 6 months are calculated to expresses the response time of the different groups blooming. The cluster and correlation analyses of the different variables have also be done to show the significantly correlated ones.

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# THE BIOMASS OF DEMERSAL FISHERIES RESOURCES IN THE EASTERN AEGEAN SEA

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## Abstract

Bottom-trawl catch data collected from the Eastern Aegean Sea between July 1991 and August 1995 were analysed. The Eastern Aegean Sea is divided to five main regions according to their ecological properties, and trawl samples were grouped by these subregions. Total biomass values (t/km<sup>2</sup>) for each subregion were calculated. Although the total biomass estimates according to subregions were highly variable, ranging from 0.22 to 8.75 t/km<sup>2</sup>, in general similar biomass distribution patterns were observed. *Keywords : Biomass, Aegean Sea, Trawl Surveys, Demersal.* 

### Introduction

Biomass and/or abundance data are of great importance to fisheries science, because they provide fishery independent indices to assess the demersal fisheries resources. From this perspective, the aim of this work is to evaluate the catch data collected during the "JICA and TUBITAK"trawl survey programs in 1991-1993 and 1993-1995, respectively.

#### Material and Methods

Data were collected by R/V K. Piri Reis during the bottom-trawl surveys conducted between July 1991 and August 1995 from the Eastern Aegean Sea along the Turkish Coastal and Internatial Area. A total of 11 trawl surveys were carried out, and a total of 525 trawls were hauled between depths of 20 to 700 m. The biomass of demersal organisms was estimated using the "Swept Area Method"[1]. For a more accurate calculation of the area swept by the gear the "SCANMAR-Net Sounder system" was used to determine the width between wing nets during the trawling operation. In order to evaluate whether there is a spatial variation in the biomass estimations, the Eastern Aegean Sea was divided into five main regions according to their ecological properties (Fig 1). Trawl samples were grouped by these subregions and the total biomass of demersal organisms were calculated in terms of t/km<sup>2</sup> for each subregion.



Fig. 1. Sampling subregions.

Results and Discussion

A total of 191 species belonging to 62 families were sampled. From

these, 132 species were teleosteans, 42 elasmobranchs, 19 cephalopods and 9 decapod crustaceans. However, the large majority of the cathes was dominated by a small number of taxa. *Mullus barbatus and Merluccius merluccius* were *the* dominant commercial species in most samplings. Some of the other abundant species were *Pagellus acarne*, *Pagellus erythrinus*, *Diplodus annularis*, *Dentex macrophthalmus*, *Lophius piscatorius*, *Chelidonichthys lastoviza*, *Lepidotrigla cavillone*, *Upeneus moluccensis*, *Scyliorhinus canicula*, *Parapeneus longirostris*, *Nephrops norvegicus*, *Octopus vulgaris*, and *Loligo vulgaris*. The occurrence and percentage contributions of the species to the catch composition svaried by subregions, seasons or depths. The number and composition of species observed in this study were similar to those reported by from the North Aegean Sea [2], and from the southern Aegean Sea [3].

Although the total biomass estimates according to sub regions were highly variable ranging from 0.22 to 8.75 t/km<sup>2</sup>, in general similar biomass distribution patterns were observed (Fig 2). The total biomass estimates for the subregions I, II and III were rather similar. While the highest estimated total mean biomass was found in subregion V, the lowest estimate was estimated for subregion IV. Both subregions belong to the Southern part of the Aegean Sea. The reason for discrepancy is probably due to the fact that subregion IV is under the influence of heavy fishing pressure from commercial fishery while subregion V is mostly closed for trawl fishery.



Fig. 2. Total biomass ( $t/km^2$ ) distribution per subregion. An ANOVA showed no significant variation among the sub regions ( $F_{4,109}$ =1.52, p>0.25)

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# FEEDING HABITS OF RHINOBATOS RHINOBATOS IN THE GULF OF GABES

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## Abstract

The stomach contents of 498 common guitarfishes, *Rhinobatos rhinobatos*, from the gulf of Gabès were examined. The number of empty stomachs was higher in juvenile than in adults (97.05% and 80.64%). Crustaceans and Teleostei were the most important prey groups (IRI% were respectively 51.44% and 47.46%) in the diet of adults. Crustaceans were the main prey for juveniles (IRI% = 83.43%). *Keywords : Fishes, Gulf Of Gabes, Fish Behaviour.* 

#### Introduction

*Rhinobatos rhinobatos* is a benthic fish inhabiting soft bottoms, generally in shallow water. Data on its feeding of are scarce, concerning few specimens collected in the lagoon of ElBibans (Southern Tunisia) [1]. The present study provides data on its feeding habits in the Gulf of Gabès.

#### Materials and methods

A total of 498 *R. rhinobatos* landed by bottom trawl in the gulf of Gabès were examined. Specimens were divided in two categories: Juveniles (total length less than 600 mm) and adult (over than 600 mm).

Stomachs were removed, the diet composition was identified to the lowest possible taxon, and each prey was weighted to the nearest 0.1 g. The specimens with empty stomach were recorded (RI%).

To assess the relative importance of each prey item in the diet three indices were used: the numerical index (N%), the gravimetric index (M%) and the relative importance index (standardized; IRI%) [3]. The classification of prey was based on Cortes' methods [2].

We calculated also the overlap index [4] to determine the prey overlap between the two sizes class. The values of this index range from 0 to 1, with values exceeding 0.6 showing 'biologically significant' overlap in resource use [5].

#### Results and discusion

The RI % was relatively hight: 97.05 and 70.64%, respectively, for juveniles and adults.

*R. rhinobatos* consumed a wide range of macrobenthic organism. Prey included shrimps (*Sicyonia carinata, Trachypenaeus curvirostris*), crabs (*Dorippe lanata, Ehtusa sp.*), fishes (represented by *Diplodus annularis, Serranus hepatus, Pagellus erythrinus, Engraulis encrasicolus, Sardina pilchardus*). Sepia officinalis, Loligo vulgaris and Sepiola sp. were the most abundant Mollusca.

Crustacean were the main important prey for juveniles (Table 1). For adults crustacean and teleostei were the main prey (Table 1). The diet overlap index was high, 0.9.

Tab. 1. N %, M % and IRI% for each food item for juvenile and adult of *Rhinobatos rhinobatos*.

| <b>T</b> .                                                                                                      | N                                                                    | %                                                                 | М                                                                     | %                                                                      | IRI %                                                                |                                                                        |  |
|-----------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------------------|----------------------------------------------------------------------|------------------------------------------------------------------------|--|
| Items                                                                                                           | juveniles                                                            | adults                                                            | juveniles                                                             | adults                                                                 | juveniles                                                            | adults                                                                 |  |
| Crustacean:                                                                                                     | 94,7                                                                 | 73,53                                                             | 46,05                                                                 | 22,34                                                                  | 83,43                                                                | 47,46                                                                  |  |
| I sopods<br>Amphipods<br>Brachyurans<br>Macroura<br>Others                                                      | 3,51<br>12,58<br>48,9<br>25,1<br>2,61                                | 7,1<br>9,9<br>21,4<br>29,9<br>5,23                                | 1,9<br>3,5<br>26,1<br>12,9<br>1,65                                    | 2,8<br>1,43<br>9,09<br>8,1<br>0,92                                     | 7,9<br>9,1<br>41,9<br>21,81<br>2,72                                  | 4,9<br>5,71<br>17,7<br>16,97<br>2,18                                   |  |
| Teleostei:                                                                                                      | 3,05                                                                 | 21,11                                                             | 47,16                                                                 | 71,83                                                                  | 15,63                                                                | 51,44                                                                  |  |
| Sparidae<br>Gobiidae<br>Serranidae<br>Carangidae<br>Cepolidae<br>Mullidae<br>Clupeidae<br>Engraulidae<br>Others | 1,21<br>0,62<br>0,09<br>0,02<br>0,17<br>0,12<br>0,05<br>0,09<br>0,68 | 7,91<br>5,47<br>2,01<br>0,9<br>1,18<br>1,9<br>1,07<br>0,2<br>0,47 | 15,48<br>9,91<br>6,92<br>2,38<br>0,74<br>2,91<br>1,83<br>2,01<br>4,98 | 29,61<br>10,19<br>7,41<br>5,28<br>4,18<br>3,29<br>4,89<br>2,51<br>4,47 | 6,01<br>3,97<br>1,68<br>0,74<br>1,01<br>0,12<br>0,05<br>0,04<br>2,01 | 18,14<br>12,14<br>6,29<br>3,05<br>2,91<br>3,19<br>1,07<br>2,21<br>2,44 |  |
| Mollusca                                                                                                        | 1,15                                                                 | 2,12                                                              | 4,83                                                                  | 4,81                                                                   | 0,62                                                                 | 0,54                                                                   |  |
| Others                                                                                                          | 1,1                                                                  | 3,22                                                              | 1,96                                                                  | 1,02                                                                   | 0,31                                                                 | 0,54                                                                   |  |
|                                                                                                                 |                                                                      |                                                                   |                                                                       |                                                                        |                                                                      |                                                                        |  |

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# DIRECT GRADIENT ANALYSIS OF THE MOLLUSCAN COMMUNITY AT THE MARINE-LAGOONAL ENVIRONMENTAL TRANSITION AT KALLONI SOLAR SALTWORKS (NE AEGEAN SEA, GREECE)

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# Abstract

A direct gradient analysis technique (CCA) was employed for the investigation of (a) the spatial organisation of the molluscan community and (b) the environmental factors structuring the molluscan community, at the part of Kalloni solar saltworks that is in the immediate vicinity of the sea (Kalloni Gulf, NE Aegean Sea). The molluscan community and environmental parameters were sampled at four sites, on a seasonal basis during 2004. The strong environmental gradient that exists across space between the gulf and pond2 site, structures the molluscan community in the study area. Species composition spatial variations imply a marine-lagoonal environmental transition, typicaly observed in coastal lagoons. Sediment type, organic matter % and chloroplastic pigments concentration were found to be among the key components of the environmental gradient in the study area, as has also been observed in natural coastal lagoons. *Keywords : Mollusca, Biodiversity, Lagoons, Aegean Sea.* 

## Introduction

Solar saltworks comprise man-made systems, where a salinity gradient is maintained along a sequence of interconnected ponds for the production of salt by solar evaporation. On the other hand, the ecosystems of solar saltworks are extremely heterogeneous and consequently of great ecological importance and scientific interest [1]. However, solar saltworks ecosystems, in particular the benthic subsystem, have not been sufficiently studied. The aim of this paper is to employ a direct gradient analysis technique [2] for the investigation of the spatial organisation of the molluscan community as well as the evaluation of the environmental factors structuring the molluscan community at the part a solar saltworks that is in the immediate vicinity of the sea.

# Materials and methods

The study area is Kalloni solar saltworks (Kalloni Gulf, Lesvos Island, NE Aegean Sea, Greece). The molluscan community was sampled at four sites, on a seasonal basis during 2004. Environmental variables [water column salinity and temperature, sediment type (measured as sand %), water column and sediment chloroplastic pigments concentration, sediment organic matter %] were also measured. Canonical correspondence analysis [3] was applied to assess the statistical associations between the molluscan abundance data (response variables) and the space aspect of the sampling design, coded as dummy variables (explanatory variables). Environmental variables were projected *post hoc* into the ordination plot (supplementary variables).

## Results

Canonical correspondence analysis (CCA) ordination of the biotic data of all seasons (Fig. 1), performed with explanatory variables representing the spatial aspect of the sampling design, revealed that the differences between sites explained a large part of the total inertia of the biotic data (total inertia=2.292, sum of all canonical eigenvalues=0.821, p=0.001). Two different groups of abundant species (>1 ind.  $m^{-2}$ ) can be distinguished: one group of marine and marine/estuarine species that are associated with the gulf site and, to a lesser extent, with the channel site and a second group of marine/estuarine and typical lagoonal species that are associated with the pond sites. The first axis of the ordination diagram corresponds to a strong spatial gradient that exists between the gulf site and the pond2 site (eigenvalue=0.589, explained 25.7% of total inertia or 71.8% of the total explainable inertia, p=0.001). The second axis corresponds to a comparatively weaker spatial gradient that exists between the gulf site and the channel site (eigenvalue=0.186, explained 8.1% of total inertia or 22.8% of the total explainable inertia). The environmental variables that were best correlated with the primary spatial gradient are the sediment type and organic matter %, whereas sediment chloroplastic pigments concentration correlated best with the secondary spatial gradient.

#### Discussion

The strong environmental gradient that exists across space between the gulf and pond2 site, structures the molluscan community in the study area. Species composition spatial variations imply a marine-lagoonal environmental transition, typically observed in coastal lagoons [4]. Sediment type, organic matter % and chloroplastic pigments concentration were found to be among the key components of the environmental gradient in the study

area, as has also been observed in natural coastal lagoons [5].



Fig. 1. CCA ordination of the biotic data of all seasons, performed with explanatory variables representing the spatial aspect of the sampling design, with environmental variables projected post hoc into the ordination plot as supplementary variables. The explanatory variables (GULF, CHANNEL, POND1 & POND2 sites) are indicated by open circles, whereas the supplementary variables [water column (WCPE) and sediment (SCPE) chloroplastic pigments, sediment type (SAND%) and organic matter (OM), water column salinity (SAL) and temperature (TEMP)] are indicated by arrows. Molluscan species are indicated by open triangles. Only the most abundant species are shown (*Abra segmentum, Bittium reticulatum, Cerastoderma glaucum, Cyclope neritea, Donacilla cornea, Hydrobia acuta, Loripes lacteus, Pirenella conica, Pusillina radiata, Rissoa variabilis, Rissoa ventricosa, Tellina tenuis, Tricolia pullus).* 

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# AGE ET CROISSANCE D' ELEDONE MOSCHATA (CEPHALOPODA, OCTOPODA) DES EAUX TUNISIENNES

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# Résumé

Le présent travail est une contribution à la biologie de croissance du poulpe musqué *Eledone moschata* des côtes tunisiennes. Il est basé sur un échantillonnage de la pêche au chalut et de la pêche artisanale durant 3 années consécutives (1996-1998). L'évolution des fréquences de taille de la population Nord et Sud-Est (méthode de Battacharya) a permis d'estimer les paramètres de l'équation de von Bertalanffy et d'établir les clés âge-longueur. Selon les résultats, le poulpe musqué atteint une taille maximale estimée à 15 cm dans la zone Nord et à 16 cm dans la région Sud-Est pour une longévité correspondante d'environ 1,5 an et un accroissement notablement plus important dans la première année de vie. Ces résultats attribuent à l'espèce une croissance très rapide et une longévité courte caractéristique des Céphalopodes.

Mots clès : Cephalopods, Growth, Mediterranean Ridge.

## Introduction

L'exploitation du poulpe musqué *Eledone moschata* s'est accrue suite à la surpêche du poulpe commun, *Octopus v ulgaris*, céphalopode de première importance économique nationale. Exception faite aux travaux parus sur la population de la mer catalane [1-3] et sur la reproduction de la population sud-tunisienne [4], peu de données étaient jusqu'alors disponibles sur l'espèce. L'intérêt orienté vers ce produit de substitution a donc suscité son étude biologique et dynamique, accomplie durant la période 1996-1998 sur les côtes tunisiennes.

Dans ce travail, nous avons présenté les résultats obtenus sur les paramètres de croissance d' *Eledone moschata* par classe de taille estimés à partir de deux populations exploitées le long des côtes tunisiennes.

#### Matériel et méthodes

L'étude est basée sur les échantillonnages métriques des débarquements commerciaux des chalutiers et de moindre importance des embarcations de la pêche artisanale exerçant dans la région Nord (de Tabarka à Kélibia, Méditerranée occidentale) et dans la zone Sud-Est (de Kélibia à Zarzis, Méditerranée centrale). Au total, 11241 individus ont été échantillonnés, répartis respectivement entre 4831 dans le Nord et 6410 dans le Sud-Est ; la longueur standard considérée étant la longueur dorsale du manteau délimitée entre la partie postérieure du manteau et le milieu des yeux.

Nous avons adopté le logiciel FISAT [5] pour la décomposition modale mensuelle des fréquences en taille selon la méthode de Battacharya et pour l'estimation des paramètres de l'équation de croissance de Von Bertalanffy.

## Résultats

Analyse de l'unicité du stock des zones Nord et Sud-Est

Avant d'entamer l'étude de la croissance, nous avons tenté de délimiter la population exploitée dans la région Nord, Est et Sud des côtes tunisiennes. Le suivi chronologique des fréquences de taille n'a pas décelé de différence nette dans la structure démographique des populations des 3 zones. Par contre, l'évolution annuelle de la production des pêches de l'élédone par région sur une série d'années (de 1995 à 2000), a permis d'obtenir pour la région Sud et Est deux courbes similaires mais différentes de celle relative à la région Nord. Compte tenu de ces résultats et faute de données sur les prises par unité d'effort respectives qui pourraient trancher sur l'unicité des populations respectives, deux populations d'élédone ont été donc considérées comme étant exploitées par la flotte tunisienne. Il s'agit de la population Nord et la population Sud-Est que nous avons étudiées séparément sans distinction des sexes.

Paramètres de croissance

Les paramètres de l'équation de von Bertalanffy définie par la relation suivante:

sont estimés à partir du logiciel FISAT ; les résultats obtenus sont comme suit:

Pour la Région Nord : L $\infty$ = 16.17cm ; K=1.753 ; t<sub>0</sub>=0.002

Pour la région Sud-Est: L $\infty = 15.0 \text{cm}$  ; K=0.712 ; t\_0=-0.022

D'après la figure ci-dessous, les courbes de croissance des deux populations présentent une allure similaire avec une phase ascendante durant la première année de vie, suivie par un ralentissement de la croissance vers la taille de 11cm pour la population Sud et 14.5cm pour la population Nord, qui correspondent biologiquement à la taille de maturité sexuelle respective d' *Eledone moschata* [4]. Le processus de reproduction sexuelle serait donc un facteur physiologique précurseur du retard de la croissance survenant à la fin de la vie de l'animal.

Comparées aux populations du bassin occidental de la Méditerranée [2], celle des eaux tunisiennes, qu'elle soit du Nord ou du Sud-Est paraît avoir une croissance plus rapide, alors que la taille maximale atteinte est inférieure à celle du poulpe musqué de la mer catalane [2]. Ce décalage dans le rythme de croissance serait en relation avec les facteurs climatiques ambiants, en particulier le paramètre température [2].

Les plus petits individus capturés par chalutage expérimental mesuraient 3 cm de longueur du manteau, ils sont récoltés à partir du mois de juillet de chaque année. Connaissant la période de reproduction de la population des côtes tunisiennes principalement entre mars et juin [4], et la durée d'incubation d'environ 2 à 3 mois, ces petits animaux recrutés dans la pêcherie, auraient donc l'âge de 1 à 2 mois. A partir de l'équation de croissance établie, nous avons estimé la longévité des deux populations ; elle est de l'ordre de 2,5 ans, toutefois les plus grands individus récoltés du milieu naturel ne dépassent pas 1.5an.



Fig. 1. Courbe de croissance de deux populations d' *Eledone moschata* de la région Nord (A) et Sud-Est (B) des côtes tunisiennes

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# ENVIRONMENTAL IMPACT OF GAS PLATFORMS IN THE NORTHERN ADRIATIC SEA: A CASE STUDY

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# Abstract

The potential impact induced by the installation of the off-shore gas platform PCMS-1 (Northern Adriatic Sea) on the surrounding sediments and benthic community, as well as bio-accumulation in mussels settled on the submerged part of the rig, was studied for 2 years. A few sediment anomalies were observed in the first survey, but they decreased in the following periods. The only change in zoobenthos occurred after one year from installation, when mussel mounds developed close to the rig. Differences in hydrocarbon and organic matter content between the platform mussels and those collected at a control site were detected only in the first survey year. *Keywords : Adriatic Sea, Bio-accumulation, Monitoring, Sediments, Zoobenthos.* 

## Introduction

In spite of the large number of gas platforms existing in the Adriatic Sea (about 90), only a few studies focusing on the impact of these structures have been carried out. To cover this gap, starting from 1998 multidisciplinary studies have been performed by CNR-ISMAR of Ancona, in co-operation with ENI S.p.A. [1]. We report an example of these studies. Materials and Methods

The one-leg platform PCMS-1 was placed in July 2001 about 20 km far from Ravenna (Northern Adriatic Sea), at 24.5 m depth (clay-silt bottom). In 2002-03 two surveys in winter and two in summer were carried out to evaluate the impact induced by PCMS-1 construction on the surrounding environment. Sediments and benthic communities were sampled along a transect (7 sampling sites at increasing distances from the rig) intersecting the rig and directed from NW to SE, following the main Adriatic currents. Three control sites having the same geo-morphological features of the study area were also sampled. Sediments and benthic community (4 replicates) were collected by box corer and Van Veen grab (sampling surface = 0.11 m<sup>2</sup>) respectively. Polycyclic aromatic (PAH) and aliphatic (AH) hydrocarbons as well as organic matter (OM) contents were measured on the soft parts of mussels ( Mytilus galloprovincialis) taken from the platform leg, both close (CA) and far (FA) from sacrificial anodes and at a control site (C). The multivariate analysis was carried out by MultiDimensional Scaling on 3 data sets: on particle size and content of OM, heavy metals and PAH for the sediments, on density and biomass of species groups for the zoobenthos and on PAH. AH and OM contents for bio-accumulation. Similarity was based on the Bray-Curtis index.

#### Results

In the MDS plot on sediment data set the sample points are arranged according to a seasonal gradient, especially clear during 2002 (Fig.1). In winter, anomalies in Cd, Pb and MO content were observed in PCMS site. They disappeared in the following surveys, hence this station increased its similarity to the others. MDS based on biotic data did not discriminate the PCMS site from the others in winter 2002 (8 months after the rig installation; Fig. 1). Soft-bottom species dominated everywhere, with a prevalence of polychaetes and molluscs. From summer 2002 onward, mussel mounds were recorded close to the rig. They were inhabited by a mixed community, with soft- and hard-bottom species. Such modification also occurred within 30 m from the rig, but only in that season. AH, PAH and MO contents showed similar seasonal variations in CA, FA and C mussels, but no quantitative differences were evidenced among the three sites. The only exception occurred in summer 2002, when AH and PAH contents were higher in C organisms (Fig. 1).

#### Conclusions

PCMS-1 installation did not cause a consistent impact on the surrounding sediments and benthic communities. This was likely due to its small dimensions and its location in an area characterized by a high density of productive platforms, where sediments are frequently remixed. The only evident change was the mussel mound development close to the platform after one year from construction, as already observed at other rigs located at the same depth [1]. No bio-accumulation processes were detected in the mussels settled on the submerged part of PCMS-1, being the hydrocarbons and OM contents similar to those observed in other Adriatic areas [2].



Fig. 1. MDS applied to sediments, zoobenthos and bio-accumulation data.

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# TROPHIC RELATIONSHIPS OF TWO MACROURIDS FROM THE BALEARIC BASIN (WESTERN MEDITERRANEAN): TEMPORAL CHANGES IN DIETS AND IN TROPHIC LEVELS

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# Abstract

Seasonal changes in dietary habits and resource partitioning of *Hymenocephalus italicus* and *Nezumia aequalis*, two dominant macrourids co-existing at mid-slope depths (between 550 and 750 m) off Cabrera Archipelago (Balearic Basin, Western Mediterranean), were analysed. *H. italicus* and *N. aequalis* prey mainly on mobile prey (suprabenthos), with a dominance of polychaetes and infaunal amphipods in its diet. Dietary overlap was very low (0,28). Changes in  $\delta^{15}$ N signature also occurred with the highest values observed in spring. *N. aequalis* occupied a higher trophic level (4,4) than *H. italicus* (3,8).

Keywords : Deep Sea Ecology, Fishes, Trophic Relations, Western Mediterranean.

## Introduction

Macrourids are a widely diversified family of deep-sea fish, distributed worldwide, and dominant at bathyal and abyssal depths [5]. Because several macrourids coexist at similar habitats and depths, these *taxa* have been the object of different comparative multi-specific studies: some studies regard resource partitioning among these coexisting species [4, 1] but only few investigations aimed to temporal variations in diets [3]. In this context feeding habits of *H. italicus* and *N aequalis* from Cabrera archipelago were analyzed at a temporal scale, focusing on changes of  $\delta^{15}$ N signatures.

# Materials and Methods

224 specimens of H. italicus and 258 of N. aequalis were collected off Cabrera archipelago (Western Mediterranean), within the framework of the project IDEA. Samples were caught during six trawl survey carried out from August 2003 to June 2004, at middle-slope depths (580-750 m). All the specimens were measured, weighted and dissected for stomach contents analysis. From three specimens of each species per month, a portion of white dorsal muscle was collected, dried to constant weight at 60°C, and ground to a fine powder to be processed for stable isotopes analysis [6]. Prey in the stomachs were identified to the lowest taxonomic level, then analysed by means of trophic indices (e.g. %W; %N and %IRI) [2], univariate and multivariate techniques. Month variation of fullness, mean prey weight and mean prey number of each species was tested by oneway ANOVA. In order to detect spatio-temporal changes in diet, nMDS analysis were performed for each species separately; a PERMANOVA design was created on two factors (month fixed 6 levels; depth random 3 levels, nested in month). Secondarily both nMDS and PERMANOVA techniques were used in order to examine the overlap pattern within the two macrourids. In addition the overlap degree within species was calculated by Schoener index [8]. Temporal differences in stable isotopes signature were tested by one-way ANOVA. The trophic level (TL) of macrourids was estimated based on their  $\delta^{15}$ N data and using copepods as reference material.  $\delta^{15}$ N values were converted to trophic level gone upon the assumption that there was a fractionation of 3 permil per trophic level [6] and that the base material (copepods) had a trophic level of 2. All the univariate and multivariate analyses were performed using STATISTICA and PRIMER 6 plus PERMANOVA packages.

## Results and discussion

From 162 stomachs of *H. italicus* containing food, 52 categories of prey items were identified. Mysids were dominant throughout the year, particularly in August (80,98% IRI) and February (66,39% IRI), whereas isopods were dominant in February and April (28,71 and 18,44 % IRI respectively). Changes in diet were observed in September-November and February-April. Symmetrical PERMANOVA provided evidence for significant differences among months ( $F_{5,156}=1,53$ ; p=0,023) and mainly for the interaction between months and depth ( $F_{5,156}=1,49$ ; p=0,004). A total of 185 stomachs of N. aequalis were analyzed for diet composition and 75 prey items were identified. Poychaetes and amphipods were the main prey items ingested in all seasons; however the ingestion of polychaetes increased gradually from August to February and dominated the species' diet. Isopods were abundant throughout the year but mainly in April. Mysids were consumed mainly in April and June (30 and 40% IRI respectively). NMDS analysis delineated a partial seasonal trend (stress: 0,23): April seemed to be period of change in trophic habits, also evidenced by the low value of overlap of Schoener index between February and April. Symmetrical PERMANOVA provided evidence for significant difference both for factor month ( $F_{5,120}=1,86$ ; p=0,01) and depth ( $F_{5,120}=1,58$ ; p=0,004).

Overall, dietary overlap based on Schoener index revealed a very low dietary affinities (0,28), nMDS evidenced a good separation between the diets of the two macrourids (stress: 0,16).

In *H. italicus* the most enriched  $\delta^{15}$ N value was observed in April and the most depleted in September (*F*: 3,85; *p*: 0,026). Differences of  $\delta^{15}$ N values were not significant in *N. aequalis*, though there was a progressive increase from September to June. The estimated trophic levels were 4.47 in *N. aequalis* and 3.85 in *H. italicus*.

The two macrourids inhabiting mid-bathyal depths in the Balearic basin showed very diverse diets, based mainly on suprabenthic prey and infauna. According to [4] *H. italicus* preyed mainly on fauna inhabiting the Benthic Boundary Layer (BBL) than on mesopelagic resources (i.e. copepods and euphausiids). Low levels of dietary overlap was observed in this study, implying high resource partitioning and probably low levels of competition between coexisting species. The patterns of variability in <sup>15</sup>N signatures, with highest values in spring-summer and lower in autumn-winter agreed with other findings [7] according to which temporal changes were found between October and May in a bathyal community off Ibiza (Balearic islands), with highest values in May.

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# THE SPATIAL ZOOPLANKTON DISTRIBUTION IN THE NORTH BALEAR FRONT (WESTERN MEDITERRANEAN): EARLY SPRING, 2005

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# Abstract

During the early spring, 2005, the micro and mesozooplankton have been analyzed in northern waters off the Balearic islands and related to the main physico-chemical properties of the sea surface water (EFLUBIO cruise). A frontal structure separating the Atlantic from the Mediterranean waters was clearly observed all along the northern part of the Mallorca and Menorca islands (North Balearic Front) which strongly affected the distribution of the main zooplankton groups. Acting those surface water masses as a boundary for the zooplankton structure. Into the mesozooplankton, the copepods were the most abundant group (86%) followed by the appendicularians (9%) and the nauplii into the microzooplankton (77%). A higher abundance of micro and mesozooplankton was observed in the northern area in relation to the higher salinity and enrichment of nutrients, meanwhile the larger organisms exhibited their higher abundance in the southern area. The most pronounced differences were observed for the group of the copepods. To understand the Balearic Sea productivity the impact of the frontal system on the distribution on zooplankton communities is analyzed. *Keywords : Balear Sea, Copepoda, Fronts, Western Mediterranean, Zooplankton*.

## Introduction

The Balearic islands are a geographical barrier into the Western Mediterranean that keeps two sub-basins apart, the Gulf of Lions and the Algerian basin, where different waters masses of northern and southern origin meet. Therefore, the Balearic sea form a hydrographic boundary influenced by all these different waters in the surface [4,5]. The channels between the islands are strategic areas where the different waters masses all flow through. The physical-biological interactions have been studied in other forward areas but little information exits on this relationship in the western Mediterranean [2]. The maximum zooplankton abundance occurs in spring in the Balearic sea [3]. The main goal of this study was to examine the relationship of the frontal system on zooplankton community, spatial distribution and composition.

#### Material and Methods

From March 16th to 30th, 2005 a large survey of 77 stations (EFLU-BIO project\*) was carried out in the surface waters of the Balearic Sea. We present here the main results of the zooplankton community (micro and mesozooplankton) in relation to the hydrographic conditions around the frontal system found in the area. Satellite images were taken every day for temperature and chlorophyll a, only when the weather allowed it. CTD (SBE 911 plus profiles were taken previously each zooplankton haul. Mesozooplankton was sampled by a triple WP2 net, 200  $\mu$ m mesh and the microzooplankton by a double Calvet net 53  $\mu$ m, by means of vertical hauls from 100 m depth to the surface. and the data shown as abundance (ind m-3 and %). Hydrographic samples for oxygen, nutrients and chlorophyll data were collected by a Rosetta with 10 L Niskin bottles at depths of 0, 25, 50, 75, 100 and 200 m depth.

## Results and Discussion

Physical environment- Compared with the last 20 years surface temperature data showed an extremely cool late winter with no spatial gradient and values below  $13.5^{\circ}$ C in the 100 m upper layer. Salinity, however, exhibited a clear gradient between the Atlantic waters (AW <38.0 PSU), just flowing up close to the north Balearic islands (limited by 40°15N; and  $4^{\circ}30^{\circ}E)$  and the further northern Mediterranean surface waters (MSW >38.2 PSU). Moreover, the dynamic topography confirmed the frontal boundary and the current direction. According to the salinity data, an obvious frontal system was observed in the area (NW-SE) and further northeast of Menorca island a filament southward of cool northern waters. The front produces a convergence between the two water masses with a sinking of the denser northern waters where the convective movement was intense. In the southern part of the front the overlapping of more oxygenated and less dense Atlantic Waters produced a vertical density gradient which made the mixing difficult. In the eastern part, the northern filament performed a divergence zone. The highest nutrient concentrations and less oxygen Mediterranean waters were related to the upwelling generated by the previous polar event (March, 2006) in the area and the later relaxed wind forcing which favored the inflow of Atlantic waters in the area. In relation to that nutrients and oxygen concentrations also depicted the frontal system in the upper 100 m layer.

The chlorophyll *a* also showed an intense gradient between both water masses regardless of whether small (<20  $\mu$ m) or large phytoplankton cells

were analyzed [1]. According to such late winter situation in the Mediterranean Sea, very unusual high values (>2  $\mu$ g l-1) for the studied area were found in the northern part of the front. In contrast, very poor but more oxygenated waters were found in the southern part which were influenced by the recent Atlantic waters (<1  $\mu$ g l-1).

Zooplankton - The zooplankton distribution was related to the hydrographic features and both, micro and mesozooplankton, depicted the frontal system. The microzooplankton was 3 times more abundant than the mesozooplankton but accounted for only 10% total biomass. Copepod nauplii and small copepods were the most abundant (75%) into the microzooplankton and both of them were separated by the highest salinity gradient with higher amount of nauplii in the northern part of the front. Copepodites and others, however, were more abundant in the south. In the mesozooplankton the copepods (86%) were the most important group in all the area. The larger size groups but less abundant such as, appendicularians (8%), siphonophors (2%), chaetognaths and doliolids (2%) were more abundant closer to the islands, in those waters less saline and where the convective movements were less important .

More than 50 copepod species were identified in the upper layer of the North Balearic front (0-100 m) and the 25 most abundant species indicated their preference for different properties of the water masses. *Oithona* and *Clausocalanus* were the most abundant copepods (50%). The smaller *Clausocalanus spp.* were the most important species (22%), followed by *Ctenocalanus vanus, Calocalanus styliremis, C. arcuicornis, Paracalanus parvus* and *Centropages typicus* (>1%). Besides the previously mentioned groups, the copepods such as *Nannocalanus minor, Ctenocalanus vanus, Mecynocera clausi, Farranula rostrata* were more abundant in the warmer AW. Meanwhile on the other hand, the smaller copepod nauplii and the bulk of larger Copepods, such as *Calanus helgolandicus, C entropages typicus, Euchirella rostrata* and *Paracalanus parvus*, showed their higher preference for the most saline waters.

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# ABUNDANCE AND SIZE STRUCTURE OF OIKOPLEURA DIOICA SOULTH EASTERN

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# Abstract

*Oikopleura dioica* is a unique species of Apendicularia living in the Black Sea. Seasonal size distribution of *O. dioica* in the southeastern Black Sea was studied between February and September, 2004. Total length of the specimens ranges between 0.15 mm and 2.85 mm, maximal size was observed in late spring.

Keywords : Black Sea, Plankton, Tunicata.

# Introduction

Appendicularias are small pelagic and suspension feeders found in high numbers in the world ocean [1]. The only species living in the Black Sea is *Oikopleura dioica*, and being a filter feeding is extremely important in its food web [2]. *O. dioica* constructs a mucous shell but occasionally is observed "naked" [3]. It is an hermaphrodite, and its well developed ovary occupies the entire apical region of the body [4]. The grazing rate of *O. dioica* in the field can equal or surpass those of copepods [2]. The present study shows that body size is one of the most important factors affecting the clearance rate of *O. dioica* [1]. The aim of this study was to investigate seasonal size structure of *O. dioica* in southeast Black Sea.

### Materials and Methods

Plankton samples were taken by R/V KTU DENAR during February-September 2004 off Trabzon, on the southeastern coast of the Black Sea, using Hensen type closing net with 75 Îijm mesh size, 70 cm mount diameter, and 220 cm long net. The plankton nets were towed vertically from 150 m depth to surface. The volumes of the sea water filtered were calculated by digital flowmeter (Hydro-bios Kiel, No 439115). The samples were preserved in borate-buffered 4% formaldehyde-seawater solution until laboratory analysis [5]. *O. dioica* were removed from the solution and counted Total body length ( $\mu$ m), tail length ( $\mu$ m), trunk length ( $\mu$ m), and trunk height ( $\mu$ m), were measured under the stereomicroscope. Population structure of *O. dioica* was compared by one-way ANOVA. When significant differences were found (p<0.05) comparison among means were made with a Tukey test [6].

#### Result and discussion

Seasonal anomalies were not observed in sea water temperature: minimum and maximum temperature were 9.3 °C (February) and 26.7 °C (August), respectively. Relationship between tail length- total length, total length-trunk length and trunk length- trunk height are shown in figure 1A, figure 1B and figure 1C, respectively. Linear positive relationship was observed between tail length and total lengths. Total length (included tail) of the *O. dioka* ranges between 0.15 mm and 2.85 mm. Small size organisms were observed in February, when average mean length of *O. dioica* was 0.25  $\pm$  0.11 mm. Mean total length was high at April (1.85  $\pm$  0,57 mm) . 11 April 2004 sampling period was statistically different than others months. Although 98% of the *O. dioica* size ranged between 0.2 and 0.8 mm and maximum length (exclude tail) of the organism was 1 mm in the North Black Sea [2], in the present study 99% of the organism size ranged between 0.1 and 0.7 mm and max length was 0.76 mm.



Fig. 1. Figure 1 A. Relationship between tail length and total length; B. Relationship between total length and trunk length; C Relationship between trunk length and trunk height;

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# STATUT DE PATELLA FERRUGINEA (MOLLUSQUE: GASTÉROPODE) SUR LE LITTORAL NORD ET EST DE LA TUNISIE

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# Résumé

L'étude écobilogique de *Patella ferruginea* sur les côtes tunisiennes a révélé la présence d'importantes populations dans le Golfe de Tunis (4.5 ind/mlc à Korbous) et sur la pointe du Cap Bon à El Haouaria et Kelibia. Cette espèce partage le substrat rocheux avec d'autres espèces de patelles et l'ensemble obéit à une distribution verticale assez prononcée. *Mots clès : Density, Gastropods, Mollusca, Mediolittoral, Mediterranean Ridge.* 

Patella ferruginea, Gmelin, 1791 est endémique de la Méditerranée occidentale, elle est inféodée à l'horizon moyen du médiolittoral des côtes rocheuses en mode battu [1]. Son aire de distribution s'est fortement réduite à tel point qu'elle ne subsiste qu'en Corse, en Sardaigne, dans le sud-est de l'Espagne et en Afrique du nord. Sur le littoral tunisien, les recherches sur cette espèce sont rares et se limitent aux prospections de Boudouresque effectuées à l'île de Zembra [2]. Pour cela, nous avons en trepris une étude écobiologique sur la patelle géante, au niveau du littoral nord et est de la Tunisie, portant sur sa distribution et l'estimation de ses effectifs ainsi que sur son emplacement au niveau du substrat vertical par comparaison à ceux des autres Patellidés.

Au total 19 stations du littoral rocheux nord et est du pays ont été prospectées durant la période allant de décembre 2005 à août 2006. Ces stations sont reparties dans les 5 sites suivants: le littoral de Tabarka (les Aiguilles, l'île de Tabarka et la plage d'Ettrouche), le littoral de Bizerte (les Grottes, le Canal et Cap Zebib), le golfe de Tunis (Sidi Ali-El-Mekki, Cap Gammart, Sidi Bou-Said, la Goulette, Korbous et Port Prince), la pointe du Cap Bon (El Haouaria et Kelibia), le littoral de Sousse (Hergla, El Kantaoui) et le littoral de Monastir. L'estimation de la densité de P. ferruginea a été effectuée au moyen d'un transect horizontal parallèle à la ligne du rivage de 20 m de long. Ainsi les individus de cette espèce ont été dénombrés et la densité a été déterminée par mètre linéaire de côte rocheuse (ind/mlc). En parallèle, nous avons procédé à l'identification des autres patelles associées à P. ferruginea et à la connaissance de leur répartition verticale, au niveau des stations où P. ferruginea est abondante (Korbous, Kelibia et El Haouaria), par un transect vertical, de 1m de largeur, placé entre le niveau zéro et l'horizon supérieur du médiolittoral.

Selon nos prospections, 5 stations ont révélé la présence de P. f erruginea, à savoir Sidi Bou Said, Korbous et port prince dans le golfe de Tunis et El Haouaria et Kelibia sur la pointe du Cap Bon. A Sidi Bou Said, nous n'avons trouvé que 5 individus dispersés sur la digue du port, ce qui correspond à une faible densité de l'ordre 0.025 ind/mlc. La densité est également faible à Port Prince (0.09 ind/mlc) où nous n'avons recensé que 9 individus clairsemés et fixés sur les rochers. Les massifs rocheux de la région de Korbous, disposés au pied d'une falaise, abritent une importante population de P. ferruginea avec une densité relativement élevée de l'ordre de 4.5 ind/mlc. Les plus grands spécimens ont été rencontrés à ce niveau. P. ferruginea abonde également à la station de El Haouaria (3.4 ind/mlc), qui se situe à l'extrémité occidentale de la pointe du Cap Bon et dont les côtes rocheuses sont fréquemment exposées aux fortes houles. Cette population est dominée par les individus de petite taille. Quant à la station de Kelibia, en dépit de sa situation géographique à proximité du port et de son accès facile, elle présente une densité relativement assez élevée de l'ordre de 2.5 ind/mlc.

Ces résultats semblent indiquer que la répartition de *P. ferruginea* dans les différents sites étudiés n'est pas homogène. Les fortes densités ont été enregistrées à Korbous et El Haouaria dans des biotopes caractérisés par un accès difficile ainsi que par une relative préservation vis-à -vis des apports terrigènes des oueds de la zone et des apports polluants des agglomérations. Ces localités sont brassées par les vents violents du nord-ouest en hiver et les vents d'été assurant ainsi un mouvement des eaux qui se traduit par un élargissement de l'étage médiolittoral.Ceci semble favoriser l'installation et la prospérité d'importantes populations de patelles. En outre, la faible densité, notée à Sidi Bou-Said, pourrait être due à la turbidité des eaux des secteurs nord et nord-ouest du golfe de Tunis. Notons que les valeurs de densité obtenues dans le cadre de ce travail sont plus importantes que celles signalées par Boudouresque à Zembra en Tunisie (0.7ind/mlc) et Laborel-Deguen en Corse (0.79 ind/mlc). Cependant, la densité trouvée à Korbous est égale à celle enregistrée par Boumaza [3] aux îles Habibas à l'ouest Algérien (4.5 ind/mlc) et inférieure à celle estimée par Guerra-Garcia [4] à Ceuta au Maroc (6.7 ind/mlc).



Fig. 1. Variation spatiale de la densité de Patella ferruginea.

Comme il a été signalé par Laborel Deguen (1990) en Corse et Espinoza et al. à Ceuta (2005), nous avons constaté, au niveau des stations assez peuplées (Kourbous, El Haouaria et Kelibia), que P. ferruginea partage le littoral rocheux battu par lesvagues avec d'autres patelles possédant des caractéristiques écologiques et morphologiques bien différentes. A la station de Kourbous, ces espèces suivent une stratification verticale assez remarquable et se répartissent commesuit : P. rustica Linné, 1758 occupe le supralittoral avec une densité pouvant atteindre 35 ind./m<sup>2</sup>. L'horizon supérieur et moyen du médiolittoral est colonisé par P. caerulea Linné, 1758 qui est abondante (12 ind./m<sup>2</sup>) et l'espèce Siphonaria pectinata, Linné, 1758, qui appartient à la sous-classe des pulmonés et qui est présente en très faible densité (0.15 ind./m<sup>2</sup>). Quant à P. ulyssiponensis, Gmelin 1791, elles'installe au niveau du médiolittoral inférieur et apparaît fréquemment couverte d'algues épiphytes avec une densité relativement faible, de l'ordre de 4 ind./mlc. Au niveau des stations de Kelibia et d'El Haouaria, nous avons rencontré, suivant la même répartition verticale, les mêmes espèces mais avec des effectifs moindres que ceux de la station de Korbous.

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# THE DRIFTFISH, *CUBICEPS GRACILIS* (LOWE, 1843) (PISCES, NOMEIDAE): A NEW RECORD FOR THE AEGEAN SEA

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## Abstract

Eight specimens of very rare species *Cubiceps gracilis* (LOWE, 1843) (Pisces, Nomeidae) were caught from the Sigacik Bay (Aegean Sea). A recent record of the species was confined to Antalya Bay (eastern Mediterranean coast of Turkey). By this record, its distribution range at Turkish seas has extended to the Aegean Sea.

Keywords : Aegean Sea, Biogeography, Eastern Mediterranean, Fishes.

# Introduction

*Cubiceps gracilis* is an oceanic fish distributed in the eastern Atlantic, western Mediterranean [1] and western Pacific [2]. Also, it was well known in Adriatic Sea [3]. A previous record was given from the Turkish coasts of Mediterranean (Antalya Bay) [4]. Therefore, the present report constitutes the first record of this species in the Aegean Sea.

#### Material and methods

On  $11^{st}$  September 2005, eight specimens of *Cubiceps gracilis* (Fig. 1) were sampled by a commercial trawl (F/V Hapuloglu, 23 m length and 550 HP), in Sigacik Bay (from  $38^{\circ}08'$  N,  $26^{\circ}42'$  E to  $37^{\circ}55'$  N,  $26^{\circ}44'$  E). Depth range of the fishing ground was 150-473 m. The specimens were captured during day time (08.00-11.30 a.m.).



Fig. 1. General vew of *Cubiceps gracilis* captured from Sigacik Bay, Aegean Sea.

The specimens were identified according to [5], fixed by 40% formalin and stored in the Ege University Faculty of Fisheries, Turkey. Morphometric measurements were taken to the nearest 0.1 cm (Table 1).

Tab. 1. Meristic and morphometric characters recorde in examined specimens of *C. gracilis* in the Aegean Sea (Sp. specimen; minimum and maximum value are given in parenthesis).

|                       | Sp. 1 | Sp. 2 | Sp. 3 | Sp. 4 | Sp. 5 | Sp. 6 | Sp. 7 | Sp. 8 | % SL<br>(minmax.)           |
|-----------------------|-------|-------|-------|-------|-------|-------|-------|-------|-----------------------------|
| Total Length (TL)     | 17.2  | 16.7  | 16.5  | 17.4  | 17.5  | 18.0  | 17.3  | 16.1  | -                           |
| Fork Length (FL)      | 15.0  | 14.8  | 14.7  | 15.5  | 15.5  | 15.9  | 15.7  | 14.3  | -                           |
| Standard Length (SL)  | 14.2  | 14.0  | 14.0  | 14.5  | 14.6  | 14.8  | 14.5  | 13.4  | -                           |
| Snout to eye          | 1.1   | 1.0   | 0.8   | 1.0   | 1.0   | 1.0   | 1.0   | 0.8   | 6.74±0.44<br>(5.71–7.75)    |
| first dorsal fin      | 5.0   | 4.8   | 4.6   | 5.0   | 5.0   | 4.9   | 4.8   | 4.8   | 34.14±0.74<br>(32.86–35.82) |
| second dorsal fin     | 7.2   | 6.9   | 7.0   | 7.2   | 7.6   | 7.4   | 7.1   | 6.7   | 50.08±0.66<br>(48.97-52.05) |
| Pectoral fin          | 4.5   | 4.1   | 3.8   | 4.3   | 4.3   | 4.5   | 4.4   | 3.9   | 29.64±0.91<br>(27.14-31.69) |
| Pelvic fin            | 5.6   | 5.4   | 4.8   | 5.3   | 5.3   | 5.4   | 5.3   | 4.9   | 36.84±1.08<br>(34.29-39.44) |
| Anal fin              | 8.4   | 7.9   | 7.7   | 8.4   | 8.4   | 8.5   | 8.4   | 7.9   | 57.55±0.93<br>(55.00-59.15) |
| Maxilla length        | 0.8   | 0.9   | 1.0   | 1.0   | 1.0   | 1.0   | 1.0   | 0.9   | 6.67±0.32<br>(5.63-7.14)    |
| Eye diameter          | 0.8   | 0.9   | 1.0   | 1.0   | 1.0   | 1.0   | 1.0   | 0.9   | 6.67±0.32<br>(5.63-7.14)    |
| Head length           | 4.2   | 4.1   | 4.1   | 4.1   | 4.1   | 4.1   | 4.1   | 4.0   | 28.79±0.55<br>(27.70-29.85) |
| Body height           | 3.5   | 3.5   | 3.7   | 3.7   | 3.7   | 3.9   | 3.9   | 3.5   | 25.79±0.54<br>(24.65-26.90) |
| Pectoral fin leght    | 4.6   | 4.6   | 4.7   | 4.4   | 4.4   | 4.6   | 4.6   | 4.6   | 32.05±1.04<br>(30.14-34.33) |
| Interorbital distance | 1.1   | 1.2   | 1.3   | 1.2   | 1.2   | 1.2   | 1.3   | 1.3   | 8.61±0.46<br>(7.75-9.70)    |
| First dorsal fin      | XI    | XI    | XI    | XI    | XI    | XI    | XI    | XI    |                             |
| Second dorsal fin     | 1+22  | 1+22  | 1+22  | 1+22  | 1+22  | 1+22  | 1+22  | I+22  |                             |
| Anal fin              | 11+22 | II+22 | 11+22 | 11+22 | II+22 | 11+22 | 11+22 | 11+22 |                             |

### Diagnosis

Body elongated and compressed. Head large (27.70-29.85), predorsal (32.86-35.82), preanal (55.00-59.15); snout short, round (5.71-7.75), eye large (5.63-7.14) and interorbital distance wide (7.75-9.70); all percentage of standard length (SL). Small mouth reaching back to the vertical of the anterior of the eye. A single row of small conical teeth in both jaws. Small granular teeth in broad patches on the tongue and roof of the mouth. Upper gill arch with nine rakers and lower with 16, the raker below the angle is the largest, sub-equal to the longest gill filament. Two dorsal fins, first with 11 spines, the last four spines and 22 rays. Base of pectoral fin at  $45^{\circ}$  angle to body axis. Pelvic fin with a single spine and five rays, its origin on the vertical of the posterior edge of the pectoral fin base. Scales on the head reach almost to the posterior nostril.

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# BENTHIC INDICES ON COMPARISON IN THE NORTHERN ADRIATIC SEA

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# Abstract

In order to meet the requirements of the European Water Framework Directive, a new benthic index, named Daphne, has been recently developed for the Northern Adriatic Sea and it is here compared to other benthic indices used along European coasts: AZTI Marine Biotic Index (AMBI), Bentix and Benthic Quality Index (BQI). The results obtained by Daphne are consistent with the environmental characteristics of the study area and with the application of the AMBI index. Some critical points are discussed. *Keywords : Adriatic Sea, Bio-indicators, Coastal Waters, Monitoring, Zoobenthos.* 

## Introduction

In coastal waters, benthic invertebrate fauna is one of the biological elements indicated by the European Water Framework Directive for the classification of the ecological quality status. To this aim several benthic indices have been developed and applied along European coasts: the AMBI (AZTI Marine Biotic Index) [1], the Bentix [2], and the BQI (Benthic Quality Index) [3].

In this work we compare the results obtained by the application on soft bottom benthic fauna, collected along the Emilia Romagna coast (Northern Italy), of all the indices mentioned above and of a new one recently proposed for the Northern Adriatic Sea [4].

AMBI and Bentix indices require the identification of all organisms to species level and the assignment, often controversial, of each species to different ecological groups (EG) on the basis of their sensitivity to pollution. The BQI tries to overcome the problem of species assignment to EG by calculating the species tolerance value by means of an objective analysis.

The new index does not consider the sensibility of each species, but it is based on six characteristics of the benthic community, which do not require in depth taxonomic expertise.

#### Materials and methods

Soft bottom macrobenthos was sampled in May, July and October 2004, at 8m depth, in 4 stations, Porto Garibaldi, Ravenna, Cesenatico and Cattolica, located along the Adriatic main current which runs southwards and therefore differently influenced by the trophic load carried by the Po river. Benthic samples were collected using a 0.06  $\mathrm{m}^2$  van Veen grab; chemical-physical data were measured on an approximately weekly basis. On benthic data we calculated the Ecological Quality Ratio (EQR), defined by the Directive as the ratio of the observed index value versus the value of the same index under Reference Conditions (RC). Due to the difficulty to find unimpaired sites or historical pre-industrial data in order to define RC, we considered "virtual reference conditions", as proposed by Borja et al. [5]. We applied the Multivariate AMBI version (M-AMBI) [5], using the software AMBI 4.0 available on line, and Bentix as reported in Simboura et al. [6]. The calculation of the tolerance species value following Rosenberg's method [3] was applied to a data-set including 222 samples collected in the Northern Adriatic area.

## Results

The average annual values of Daphne index increase gradually southward, from Porto Garibaldi and Ravenna to Cesenatico and Cattolica (Tab. 1). The M-AMBI follows the same trend: the lowest values of EQR were obtained in Porto Garibaldi and Ravenna, while in Cesenatico and Cattolica the EQR increased. Contrasting results were obtained using Bentix, with an EQR value lower in Cattolica than in Porto Garibaldi.

For the application of BQI, the tolerance value was calculated for about 100 species with controversial results: species known from literature to be sensitive result more tolerant than species known as opportunistic. This is probably due to the low number of samplings used to calculate the tolerance values in the Northern Adriatic (222) compared to those used along the Swedish west coast (1114).

The results obtained by Daphne and M-AMBI match the trend of the chemical-physical and structural parameters.

The ecological quality classification indicates that differences in the indices values do not always correspond to differences in the ES. The Daphne index rates the northern stations to be in moderate ES, while Cesenatico and Cattolica in good ES; the AMBI classify in good ES Porto Garibaldi, Ravenna, Cesenatico and in high ES Cattolica. The Bentix classifies in moderate ES both Porto Garibaldi and Cattolica, showing the scarce reliability of the results.

Tab. 1. Average value of the Ecological Quality Ratio (EQR) and corresponding Ecological Status (ES) for Daphne, M-AMBI and Bentix in the 4 sampling stations.

| 8      | Porto<br>Garibaldi | Ravenna                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Cesenatico | Cattolica. |
|--------|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|------------|
| Daphne |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |            |            |
| EQR    | 0.49               | 0.54                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0.62       | 0.68       |
| ES     | moderate           | mo der ste                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | good       | good       |
| M-AMBI |                    | 1999 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - C. 1997 - | 5          |            |
| EQR    | 0.65               | 0.63                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0.77       | 0.92       |
| ES     | good               | good                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | good       | high       |
| Bentix |                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 1          |            |
| EQR    | 0.49               | 0 39                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0.50       | 0.46       |
| ES     | moderate           | poor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | moderate   | moderate   |

## Discussion and conclusion

The Daphne index provide results that are in accordance with the M-AMBI trend and with the environmental condition pattern in the area. Bentix gives contrasting results. Differently from Daphne and AMBI, the Bentix EQR was derived by the relationship between the monitoring result and the theoretical maximum value of the index, so the EQR could be underestimate. The critical point is to determine the correspondence between the EQR value and the ecological quality status. In fact, although Daphne and AMBI show a similar trend, they assess the same stations in different ES, Daphne being more severe. A more reliable definition of the quality class boundaries can be obtained using larger data sets including sites that are in very good or very bad ecological conditions.

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# IN SITU OBSERVATIONS ON NEW AND RARE GOBIES FROM THE EASTERN MEDITERRANEAN SEA

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# Abstract

Two goby species, *Didogobius splechtnai* and *Thorogobius macrolepis*, are being recorded for the first time from the eastern Mediterranean Sea, based on underwater observations carried ouilet at Turkish coasts. Updated information on the distribution of *Gobius auratus* is also presented.

Keywords : Aegean Sea, Eastern Mediterranean, Levantine Basin, Fishes.

Gobiidae is the most species rich family among fishes, represented roughly by 212 genera and 1875 species worldwide [1]. A diverse gobiid fauna with close to 60 species is encountered in the Mediterranean Sea, where almost half of the recorded species are endemic [2]. Data on the ecology and distribution of several small sized gobiids, which generally inhabit caves and crevices, are remarkably scarce. Such species are difficult to detect and generally overlooked due to their cryptic habits [3].

Until now, 25 gobiid species were known from the eastern Mediterranean Sea [4]. Scuba diving observations conducted along the Aegean Sea and Levant coasts of Turkey revealed the presence of two previously unrecorded species - *Didogobius splechtnai* and *Thorogobius macrolepis*. The data obtained also proved that, *Gobius auratus*, is a common species along Turkish coasts (from eastern Levant shores to northern Aegean Sea), which was previously believed to be rare. Due to the conspicuous and distinctive colour pattern of these species, they were identifiable *in situ* immediately upon discovery. Species accounts are presented below.

# Didogobius splechtnai Ahnelt & Patzner, 1995

This species was observed during 2005 along the southern Aegean Sea coast of Turkey (Bodrum Peninsula / Gokova Bay: 36°56'N, 27°15'E, from 8 m to 45 m depth). More than 10 individuals have been observed in Bodrum, indicating an established local population. All the specimens were found in the innermost parts of caves and were only detectable using artificial light. The size range of the caves inhabited by D. splechtnai varied from small cavities (0.7 m width x 0.5 m height x 1 m depth) to large caves (3 m x 3 m x 5 m) where the fishes were always observed in small cavities (0.2 x 0.2 x 0.3 m) in the innermost part of the cave. The fish usually (80% of the observations) rested on the sandy bottom close to an entrance of a nearby hole. In all cases, the bottom of the hole/cave was sand without mud. Habitat preferences of D. splechtnai from the southern Aegean Sea is well in accordance with those recorded from Ibiza (Balearic islands) coasts [3,5]. The species is included to the eastern Mediterranean ichthyofauna for the first time, where previous records were all confined to the western Mediterranean Sea [3,5,6]

### Gobius auratus Risso, 1810

The golden goby, Gobius auratus (= G. luteus Kolombatovic, 1891), was observed in 2003 at Oludeniz (near Fethiye; 36°33'N, 29°05'E; 26 m depth), in 2004 at Candarli Bay (northern Aegean Sea; 38°55'N, 27°01'E; 16 m depth) and in Kas (eastern Levant; 36°06'N, 29°38'E; 28 m depth), and finally in 2005-2006 along the peninsula of Bodrum (36°56'N, 27°15'E; 20-40 m depth). These fishes all presented a distinct canary yellow body colouration corresponding to the classical pattern described for the northwestern Mediterranean populations, but not the pattern (red dots forming longitudinal lines on head, trunk and median fins) reported from the Adriatic Sea [7]. For most instances, G. auratus specimens were observed hovering at steep fields of large rocky and coralligenous substrates, but specimens hiding in small cavities (mostly less than 10 cm width x 10 cm height) were also determined. The species has probably a larger distribution range along Turkish coasts. Until now, the northernmost verified record of G. auratus in Turkey was given from Saros Bay, northern Aegean Sea [8], but previous records from the Sea of Marmara and Iskenderun Bay are still yet to be substantiated.

Thorogobius macrolepis (Kolombatovic, 1891)

This species has been first observed in 2003 at Oludeniz ( $36^{\circ}33^{\circ}N$ ,  $29^{\circ}05^{\circ}E$ ; 30 m depth), later in 2005 at Bodrum ( $36^{\circ}56^{\circ}N$ ,  $27^{\circ}15^{\circ}E$ ; 20-45 m depth) and at Bozyazi (eastern Levant;  $36^{\circ}04^{\circ}N$ ,  $33^{\circ}05^{\circ}E$ ; 45 m depth). Most recently, a single specimen was observed at Fethiye Bay during July 2006, at a depth of 26 m. All scuba observations indicate that the species occurs on sandy bottom, at the foot of vertical or at least distinctly sloping rock walls, in accordance with previous habitat descriptions [5]. The species is endemic to the Mediterranean, which was previously known as far as to northern Adriatic coasts [9]. Our findings reveal that, *T. macrolepis* has a wide distribution range - extending from the southern Aegean Sea to eastern Levantine coasts.

The aforementioned records expand the known distribution of small sized Mediterranean Gobiidae species, with new species for the eastern Mediterranean basin. The previous discontinuous distribution of those cryptobenthic or shy species may be interpreted as an artefact due to the difficulty of the sampling and *in situ* observation, rather than a true numerical rarity. The accumulation of such data provides further raw material to discuss the biogeography of Gobiidae in the Mediterranean Sea.

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# THE DIET OF *SEPIA ELEGANS* (BLAINVILLE, 1827) DISCARDED FROM BOTTOM TRAWLS IN THERMAIKOS GULF

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# Abstract

The diet of cuttlefish, *Sepia elegans*, discarded by trawls in Thermaikos Gulf, Greece, was examined during one fishing season. The main prey was crustaceans and fish. Its trophic level was estimated to be 3.53. *Keywords : Aegean Sea, Cephalopods, Diet, Fisheries.* 

The geographical distribution of *Sepia elegans* (Blainville, 1827) extends in the eastern Atlantic and throughout the Mediterranean Sea [1]. It is a demersal species that lives on diverse bottoms at depths from 2 to 430 m [1, 2]. The information on the diet of *S. elegans* is limited [2, 3], while there are no references on the diet of the species in the Aegean Sea, Greece.

The study of the diet of *S. elegans* was carried out by examining the stomach contents of 86 specimens caught with bottom trawls in the Thermaikos Gulf (North Aegean Sea) during one fishing season (October 2005 to April 2006). Sampling took place seasonally at 21 stations in conditions of commercial fishery. Each haul lasted 2 to 6 hours. Sampling took place at depths from 32 to 96 m. The cod-end mesh size was 40 mm (stretched).

In general, *S. elegans* was found to feed mainly on crustaceans and secondarily on fish (Table 1). The trophic level of the cuttlefish was calculated at 3.53 (*S.E=0.53*) [4]. The percentage of crustaceans in the gut content increased with the size of cuttlefish, in contrast to the percentage of fish. Seasonal differences were also found, as the proportion of fish increased between autumn and spring, while the proportion of crustacean remained practically the same.

Similar results on the diet of the species were reported in NW Spain (Ría de Vigo) [2, 3]. The other *Sepia* species, *Sepia* officinalis was also reported to has the same diet, as reported in studies off the coast of Portugal [5], in Morbihan Bay, in France [6], and in NW Spain [2, 3].

Tab. 1. Ratio of stomach content of *Sepia elegans* by sex, season and size (N= total number of individuals, ML=mantle length of cuttlefish).

| Stomach    | TN   | males | Females | A utumn | Winter | Spring | ML<41,3 | $ML \geq 41,3$ |
|------------|------|-------|---------|---------|--------|--------|---------|----------------|
| content    | (%)  | (%)   | (%)     | (%)     | (%)    | (%)    | (%)     | (%)            |
| Crustacean | 74,4 | 42,1  | 57,9    | 32,1    | 40,6   | 27,3   | 39,1    | 60,9           |
| Fish       | 44,2 | 20,9  | 79,1    | 23,2    | 25,0   | 51,8   | 57,9    | 42,1           |
| Others     | 10,5 | 10,1  | 89,9    | 33,3    | 33,3   | 33,4   | 33,4    | 66,6           |
| Empty      | 22,1 | 31,6  | 68,4    | 42,1    | 26,3   | 31,6   | 68,4    | 31,6           |

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# EVIDENCING GROWTH-DEPENDENT SURVIVAL OF ALBORAN SEA SARDINE (*SARDINA PILCHARDUS*) LARVAE IN THE FIELD

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# Abstract

A field exercise based on the collection of pre-flexion sardine larvae in a nursery site at a determined site which was revisited two weeks later aiming to sample the surviving post-flexion larval cohorts showed that back-calculated post-flexion larvae lengths were larger at age than pre-flexion larvae, thereby indicating that survival is linked to higher growth potential, which is corroborated by the significant differences in the average widths of daily increments and the size of the otolith core between the pre- and post-flexion larvae. *Keywords : Alboran Sea, Growth, Larvae.* 

# Introduction

Growth of larvae and juveniles in many fish species may be an important causative factor inducing relative recruitment success [1], because lower growth rates may cause higher mortality by shortening the vulnerable periods of early life. Inshore waters of the Bay of Málaga constitute nursery grounds for sardines and anchovies that were exploited by artisanal fisheries in the past [2]. Advanced larval stages concentrate in shallow waters off Málaga, thus providing ideal conditions to investigate larval growth by otolith analysis. To test the growth mortality hypothesis [1] in the field, larval cohorts at early life periods were sampled in their nursery ground and revisited in the future to analyze the growth characteristics of surviving larval cohorts.

#### Material and Methods

A larval sampling survey on board the *R/V Odón de Buén* was carried out in the inshore nursery sites off the coasts of Málaga during February 14-17 2004 with the objective of collecting pre-flexion larvae (Nursery I). Larval sampling methods and on-board conservation procedures are described in [3]. Over two weeks later (March 2-4) the same site was revisited to sample post-flexion larvae (Nursery II).

Bearing in mind that the relationship between sardine larval size and otolith radius follows non-linear power functions, the back-calculation formula of [4] was applied,

# $\mathbf{L}_i = (\mathbf{S}_i / \mathbf{S}_c)^{\nu} \cdot \mathbf{L}_c$

where, Li is back-calculated standard length (SL) at radius size Si, and Lc and Sc corresponds to the individual SL at catch and radius at catch, respectively, and  $\nu$  is the exponent of the larval size vs otolith radius regression equation. Statistical tests were done by ANCOVA using the natural logarithm of increment counts as covariable.

## Results and Discussion

The Nursery I survey sampled a total of 75 pre-flexion larvae that were born from February 3-11, 2004, while the Nursery II captured a total of 95 post-flexion larvae whose birthdates ranged from 20/01/2004-16/02/2004. Among these, 37 larvae had coincident birthdates with larvae sampled in Nursery I (February 3-11). Since the elapsed time between the first and second sampling period was approximately 17 days, a group of 79 post-flexion larvae that were born from March 27-February 12 was established to trace their early growth trajectories. The back-calculated growth trajectories of the original population sampled in the Nursery I survey was compared to the back-calculated growth history of the surviving larvae (Nursery II) born during the same period (February 3-11) as the original population, as well as, the larval cohort born from March 27-February 12 (Fig. 1). The larvae born during the coincident birthdate period of Nursery I larvae, as well as, those born for the extended dates from the Nursery II samples show significantly greater back-calculated standard lengths at age than the original population (F2,35=71.7, p<0.001). To corroborate this finding through back-calculation procedures, it was necessary to examine otolith growth and increment width deposition in the original and the surviving cohorts, as these parameters are correlated with the somatic daily growth and metabolic rates [5]. The difference in growth between the original larval population and the surviving cohorts sampled at a later period is sustained by the significant difference observed in the mean width of increment deposition (Fig. 2) in favour of the surviving larvae (ANCOVA: F1,23=55.8, p<0.001). This difference is in agreement with otolith growth difference between the original population and their survivors (F1, 23=19,9, p<0.001). Furthermore, the average otolith core at hatch was significantly greater (over  $2\mu$ m) in the surviving cohorts than in the original population (ANOVA, F<sub>1,168</sub>=716.1, p<0.001) in agreement with the difference observed in the estimated larval size at hatch between the back-calculated growth trajectories of both larval populations, which showed an average a difference of 1.5 mm between the surviving and the original larval population, thereby possibly inducing greater growth potential at early life stages as evidenced by [6].



Fig. 1. Back-calculated growth trajectories of the original and surviving larval population.



Fig. 2. Increment widths of the original and surviving larval population.

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# SUB-SURFACE ICHTHYOPLANKTONIC ASSEMBLAGES OFF THE BALEARIC ARCHIPELAGO DURING THE 2004 BLUEFIN (*THUNNUS THYNNUS*) SPAWNING SEASON

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# Abstract

Key ichthyoplanktonic species associations are established on the basis of hydrographic and geographic distribution over the open sea waters surrounding the Balearic archipelago. Tuna species comprise a community linked to open sea waters of Atlántic origin. Another ichthyoplankton community is comprised by neritic species, which show different distributional tendencies based on their preferential water masses and their respective environmental characteristics.

Keywords : Balear Sea, Ichthyoplankton.

# Introduction

The waters off the Balearic archipelago form part of the spawning habitat of larval top predator species, among which bluefin (*Thunnus thynnus*) and other tuna-like species represent an important fraction of the ichthy-oplanktonic assemblages [1]. The hydrography of the area is characterized by the encounter of Atlantic and Mediterranean water masses causing an intense circulation pattern coupled to important mesoscale features such as gyres and fronts [2]. Consequently, contrasting environmental conditions occur that contribute to the high ichthyoplanktonic diversity in the area [3] and the distribution of the early life history stages of many fish species, among which bluefin and its associated species, are strongly influenced by the environmental features of water mass origin.

#### Material and Methods

The ichthyoplankton samples were collected in the TUNIBAL 06/04 survey on board the *R/V Cornide de Saavedra* from June 18-July 10, 2004. A total of 157 sub-surface plankton horizontal tows with a Bongo (500 microns) cuadrangular net whose aperture measures 1 m diagonally were carried out over a regular 10x10 nautical mile station grid, mostly distributed over the southern part of the archipelago (Fig. 1). All tows were fixed at 10 minutes duration. In each station a CTD rosette (Seabird 25) was cast.

To define ichthyoplankton assemblages, a hierarchical cluster analysis of a Bray-Curtis similarity matrix calculated between species by ranked larval abundance was performed [4], considering only those species or groups that represented 1% of the total catch.



Fig. 1. TUNIBAL survey map: dots represent stations and shaded greys salinity at 10 m depth.

## Results and Discussion

A total of 19,993 larvae and pre-juveniles were sorted from one cod-end of the net that were categorized under taxonomy levels of 21 species, 12 genera, 9 families and 1 order. Larvae of top predator species (tuna and swordfish) represented 29% of the total ichthyoplankton catch, among which bluefin (*T. thynnus*) and frigate tuna (*Auxis rochei*) were most abundant (Fig. 2a). The main bulk of the tuna species were distributed in the oceanic waters south of Menorca where transitional and warm water masses of Atlantic origin (23.5-25°C) forming a large anticyclonic gyre in the area (Fig. 1). The tuna species form part of the cluster association A whose distributional grounds is mainly centred south of Menorca.

Mesopelagic species comprised the most important group of the ichthyoplankton (38%), with two species, *Ceratoscopelus maderensis* (15%) and *Cyclothone spp.* (12%) representing the major part. While, *C. maderensis* was mainly distributed over the northern part of Ibiza and the Mallorca Channel in cooler waters of Mediterranean origin, *Cyclothone spp.* was more widely dispersed over the survey area but showing highest abundances in the area south of Menorca. Due to their oceanic distribution both species were grouped under species association A (Fig. 2b).

The B species association defined by the cluster analysis shows two subgroups (B1, B2) differentiated by their spatial location and thereby, its hydrographic characteristics. Among the species of neritic character, the most abundant was *Chromis chromis* (11.3%), which showed more preference for water masses of Mediterranean characteristics (B1).

The main coastal pelagic species found was *Engraulis encrasicolus* (9.3%). It was mainly distributed north of Ibiza, most likely indicating its drifted origin from the northern coasts of Catalonia. The species was mostly found in Mediterranean waters, thus forming part of the B1 species association. In contrast, *Sardinella aurita* (2.6%), as key species of the B2 sub-group, was mainly found north of Menorca. In terms of abundance, the *Trachurus spp.* (3.5%) was important in terms of abundance, showing a distributional overlap with both of the previous species.



Fig. 2. (a) Ichtyoplankton composition, (b)Species cluster dendogram.

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# BIOLOGY (GROWTH AND REPRODUCTION) OF THE MEDITERRANEAN DEEP WATER ROSE SHRIMP ( PARAPENAEUS LONGIROSTRIS (LUCAS, 1846) CRUSTACEA, DECAPODA) FROM THE ALICANTE GULF (S.E. SPAIN)

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# Abstract

The deep-water rose shrimp (*Parapenaeus longirosntris*) is a demersal species and an important resource for the trawl fishery in the Alicante Gulf (S.E. 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 relative growth and high rates of absolute growth, both particularly in males. However, females dominated in the catch proportion. The spawning period occurred throughout the year, but especially in June-July and in October-November and the maturation stage for females takes place within the second year of life.

Keywords : Decapoda, Growth, Reproduction, Western Mediterranean.

## Introduction

The deep-water rose shrimp (*Parapenaeus longirosntris*) is a demersal species that is found on sandy and muddy bottoms in the Mediterranean Sea and the south Atlantic coast of the Iberian peninsula, being more abundant at depths of between 150 m to 400 m. It is considered a by-catch species of the trawl fishery, except in years of high abundance when it becomes a target species. Landings at the studied port can represent 65 tons per year in average, meanwhile for the whole GSA6 area can reach 332 tons per year. It shows a high inter-annual variations. Despite the fact that it has been studied in others Mediterranean areas [1-2], we describe for the first time some biological parameters of the species from an area defined between Cape Palos and Cape San Antonio (Alicante Gulf).

## Materials and Methods

A total of 60 samples were obtained, by means of monthly random stratified samplings from January 2001 to December 2005 in the Santa Pola port, on the landings come from commercial fleet that operates at the Alicante Gulf. A total of 17.428 specimens were sexed and their cephalothoracic length (CL) measured. In addition, 36 samples were obtained by monthly sampling carried out during the 2003-2005 period, providing 9,785 additional individuals that were analysed in detail. The parameters of the size-weight relationship were determined by regression. The estimates of the Von Bertalanffy growth parameters were obtained from monthly length frequency distributions by sex for the 2001-2005 period. Sexual ratios were calculated by size class. Maturity for females was determined by macroscopic observation, following a scale of three maturity stages: (1) Immature; (2) Developing; (3) Mature. Finally, the percentages of maturity by size for each sex were calculated, in order to determine the size at 50% first maturity, adjusting a logistic model. All calculations were made using the INBIO statistical package in R language.

#### Results and Discussion

The sizes of the females varied from 10.0 mm to 42.0 mm CL, with a mean size of 27.7mm CL. The males varied from 14.0 mm to 33.0 mm CL, with an average of 23.2 mm CL. Males represented 45% of the landings in number, whereas the remaining 55% corresponded to females. The mean size of the landings was 25.7 mm of CL. The contribution of the individuals to the yearly total landings by sex showed a size dimorphism for the species, with males being smaller than females (Fig.1). The results obtained for the different size-weight relationships by sexes ( $W = a^* CL^b$ ) (males: a = 0.0029; b = 2.483;  $R^2 = 0.91$ ; n = 4,258. females: a = 0.0024;  $b = 2.567; R^2 = 0.96; n = 5,527. m + f: a = 0.0020; b = 2.61; R^2 =$ 0.96; n = 9,785) showed a negative allometry, more noticeable in males. Absolute growth parameters gave high growth rate values (males:  $L_{inf}$ = 30 mm; K = 0.742; t0 = -0.5. females:  $L_{inf}$  = 43 mm; K = 0.419; t0 = 0.114. m + f :  $L_{inf}$  = 45 mm; K = 0.344; t0 = -0.057), which were higher in males. The sexual ratio showed that, after an initial stage (19-27 mm) where males predominated significantly, females started to dominate significantly throughout the whole range of sizes above 28.0 mm CL. Ripe females were found throughout the year with two peaks of activity, one from June to July and another from October to November. The percentages of maturity by size class showed a 50% size at first maturity of 25.3 mm for females. Therefore, the maturation stage would have to take place within the second year of life, with a life expectancy of five years.



Fig. 1. Average percentage contribution (2001-2005) by size class and sex, of *Parapenaeus longirostris* landings in the Santa Pola port.

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# LES DIGÈNES PARASITES DU MARBRE *LITHOGNATHUS MORMYRUS* (L., 1758) DES CÔTES TUNISIENNES

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# Résumé

La biodiversité des digènes mésoparasites du marbré, *Lithognathus mormyrus*, a été établie après examen de 84 individus provenant des côtes tunisiennes. Cette étude a permis de recenser 5 espèces de parasites (*Holorchis pycnoporus, Lepocreadium pegorchis, Macvicaria mormyri, Pycnadenoides senegalense, Diphterostomum brusinae*) qui se répartissent différemment au sein du tube digestif de l'hôte. L'étude de la dynamique évolutive des digènes a montré que *H. pycnoporus* et à moindre degré *L. pegorchis* sont les plus fréquents et les plus abondants. Les infracommunautés sont pauvres. Mise à part *D. brusinae* et *P. senegalense* qui se limitent à un ou à deux lieux de récolte, les autres parasites se trouvent dans tous les milieux prospectés. *Mots clès : Biodiversity, Parasitism, Fishes.* 

Introduction

Le présent travail représente la première contribution à la connaissance des digènes parasites du Marbré, *Lithognathus mormyrus*, poisson très estimé par les consommateurs tunisiens. Les recherches effectuées sur ce téléostéen, en Méditerranée occidentale, [1-6] ont montré une faible diversité digénétique. En Méditerranée orientale aucune analyse comparative n'a été réalisée d'où l'intérêt de cette étude.

## Matériel et méthodes

Les marbrés (84 spécimens) examinés proviennent de la baie de Bizerte, du golfe de Tunis et du littoral de la région de Sfax. Les différentes parties du tube digestif prélevé (oesophage, estomac, coecums pyloriques, intestin antérieur, moyen et postérieur) sont placées séparément dans des boites de pétri contenant du liquide physiologique puis disséquées. La place et le nombre de chaque parasite sont notés. Les parasites récoltés sont soit étudiés directement in vivo au microscope, soit fixés entre lame et lamelle dans le bouin-hollande. Ces digènes fixés sont par la suite lavés à l'eau distillée, colorés au carmin boracique, déshydratés, éclaircis dans l'essence de girofle et montés entre lame et lamelle dans une goutte de baume de Canada. La nomenclature appliquée pour la détermination des valeurs globales de la prévalence et de l'abondance des digènes est celle utilisée habituellement [7-8].

#### Résultats et discussions

L'examen du tube digestif du marbré nous a permis de recenser 5 espèces de digènes : deux Lepocreadidae (*Holorchis pycnoporus, Lepocreadium pegorchis*), deux Opecoelidae (*Macvicaria mormyri, Pycnadenoides senegalense*) et un Zoogonidae (*Diphterostomum brusinae*). L'étude de la distribution de ces parasites, au sein du tube digestif de l'hôte, a montré que *L. pegorchis* occupe les caecums pyloriques, l'intestin antérieur et rarement l'intestin moyen. *M. mormyri* se localise au niveau de l'intestin antérieur et moyen. *H. pycnoporus* colonise essentiellement l'intestin moyen et occasionnellement l'intestin antérieur et postérieur. *P. senegalense* et *D. brusinae* se limitent respectivement à l'intestin moyen et à l'intestin postérieur.

Chez un individu hôte, le nombre maximal d'espèces récoltées ne dépasse pas 2. Les infracommunautés sont donc pauvres. La coexistence de deux espèces de parasites de grande taille chez un même individu hôte oblige l'une des espèces à changer d'habitat.

Tab. 1. Prévalence (P %) et abondance (A) des digènes récoltés chez le marbré provenant des côtes tunisiennes et de la Méditerranée occidentale.

|                | Présen | t travail | Méditerranée or | cidentale |
|----------------|--------|-----------|-----------------|-----------|
|                | P (%)  | A         | P (%)           | A         |
| H. pycnoporus  | 28.6   | 1.68      | 50              | 2.1       |
| L. pegorchis   | 15.5   | 1.06      | 5.8             | 0.7       |
| M. mormyri     | 9.52   | 0.46      | 25              | 0.4       |
| P. senegalense | 3.6    | 0.11      | 3.8             | 0.15      |
| D. brusinae    | 2.4    | 0.04      | 3.8             | 0.06      |

Ainsi, *H. pycnoporus* qui, à l'état solitaire, occupe préférentiellement l'intestin moyen, en présence de *M. mormyri*, décale son microbiotope vers l'intestin postérieur pour échapper, sans doute, à la compétition. Si l'une de ces deux espèces se trouve en présence de *L. pegorchis*, trématode de petite taille, la coexistence ne semble pas avoir d'influence sur la répartition de ces parasites. L'évaluation des indices parasitaires montre que

*H. pycnoporus* et à moindre degré *L. pegorchis* sont les espèces les plus fréquentes et les plus abondantes (Tableau 1). En Méditerranée occidentale, la faune digénétique du marbré est dominée par *H. pycnoporus* et *M. mormyri* [6]. Par ailleurs, *H. pycnoporus* est plus fréquent et plus abondant en Méditerranée occidentale que sur les côtes tunisiennes (Tableau 1).

Le suivi de la répartition des parasites suivant les lieux de récolte montre que *M. mormyri*, *H. pycnoporus* et *L. pegorchis* sont présents dans les trois lieux de récolte prospectés. *P. senegalense* se limite au littoral de la région de Sfax et au golfe de Tunis. *D. brusinae* provient uniquement du golfe de Tunis.

#### Conclusion

L'étude de la faune digénétique du marbré provenant des côtes tunisiennes montre une faible diversité (5 espèces). Cette faune, dominée par *H. pycnoporus* et à moindre degré *P. pegorchis*, présente des valeurs épidémiologiques relativement faibles. Ces parasites se répartissent différemment au sein du tube digestif de l'hôte. Les infracommunautés maximales représentées par 2 espèces sont donc pauvres. A l'exception de *P. sene-galense* et *D. brusinae* qui se limitent à un ou à deux lieux de récolte, les autres parasites se trouvent dans tous les milieux prospectés.

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# CANNIBALISM IN ANCHOVY ( ENGRAULIS ENCRASICOLUS) IN THE NORTH AEGEAN SEA (GREECE)

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# Abstract

Egg and larval cannibalism was characterized in the European anchovy (*Engraulis encrasicolus*) during the spawning season in the North Aegean Sea. About 3 % of the sampled fish had consumed eggs and 7 % larvae. Egg consumption was observed during the night and larval consumption during the day. Cannibalism seems to be an opportunistic feeding strategy of anchovy, depending on prey availability and proximity of adults, larvae and eggs in relation with the diel vertical migrations of the fish. *Keywords : Fish Behaviour, Pelagic, Diet, Aegean Sea.* 

In the North Aegean Sea, as in other parts of the Mediterranean Sea, anchovy (*Engraulis encrasicolus*) has a high economic importance. It constitutes one of the main target species of the fisheries and occupies a key role in balancing the energy flows through the food web, being one of the main links between secondary producers and higher level predators. Anchovy is known to be mainly zooplanktivorous and feeds preferentially on copepods and other small prey items [1]. Egg cannibalism has been reported in anchovy [1] but only a few indications have been given on the mechanisms implicated in this behaviour and its incidence. However, conspecific larvae have never been described in anchovy diet. This is the first study of cannibalistic behaviour in anchovy in the North Aegean Sea.

Sampling was carried out in the Thracian Sea and Thermaikos Gulf (North Aegean Sea) during survey cruises in June 2004 and June-July 2005, which corresponded to the spawning season of anchovy in eastern Mediterranean. 21 samples, comprised of 11 to 21 fish each (total number of fish = 356) were caught at different hours of day and night with a semipelagic trawl or a mid-water trawl. Total length and sex were determined and the stomach content qualitatively analyzed. For each fish sample, the volume contribution of anchovy eggs and larvae to the diet was calculated and, when possible (depending on digestion state), their total length was measured.

The total length of the analysed fish ranged between 80-160 mm (mean =  $125 \pm 17$  mm). Females made up 58.1 %. Of the total of 356 anchovies, 11 (3,1 %) were egg-feeders, with their stomachs containing from 1 to 6 anchovy eggs (egg size range = 0,38-1,45 mm; mean size = 0,62 mm; n = 21) and 25 (7,0 %) were larva-feeders, with their stomachs containing from 1 to 24 anchovy larvae (larval size range = 3,75-25 mm; mean size = 10,54 mm; n = 144). Egg-feeders were therefore not abundant and the contribution of eggs to the diet was low, representing at most 0,5 % of the stomach content volume in one sample (caught at 4:16 h; n = 13). In contrast, predation on larvae was a feeding strategy more frequently used by anchovy. In one sample (caught at 18:39 h; n=19), 57 % of the fish were larva-feeders and the diet was clearly dominated by anchovy larvae (volume contribution = 73,6 %).



Fig. 1. Number of anchovy eggs and larvae found in the anchovy stomachs versus sampling time.

Neither sex nor size had a significant effect on the occurrence of canni-

balism (Mann-Whitney U test, difference between two proportions test, p >0.05). On the other hand, the intensity of cannibalistic behaviour varied with time of the day (Fig. 1). Except in one sample where only 1 egg was found in the stomach of one individual, egg consumption was observed only during the night. In contrast, larval cannibalism was only diurnal and a consistent proportion of individuals specialized on anchovy larvae consumption a few hours before sunset.

In our study, cannibal and non-cannibal fish were found in the same samples, suggesting that egg and larval cannibalism must be considered as an opportunistic behaviour underlying prey availability dependence [2]. As observed in the Catalan Sea [1], egg consumption was very low and could result from spatio-temporal segregation of feeding and spawning activity. Eggs were found in the stomach contents during night, when anchovy migrates to the upper layers where the bulk of the eggs are confined [3]. In contrast, consumption of larvae was high in some samples, oriented towards large-sized larvae and observed only during daylight, when fish are close to the bottom. Whereas small larvae are mainly distributed above the thermocline, larvae longer than 10 mm carry out vertical migrations from the surface at night to deeper layers during the day [4]. Thus, larval cannibalism could result from adults and larvae proximity and conditions of reduced availability of other prey items. Indeed, increased consumption of larvae occurred just before sunset, when a consistent proportion of zooplanktonic organisms started to vertically migrate towards the surface lavers

Consequently, the factors influencing egg, larval and adult distributions as well as the diel rhythm of anchovy activity and food availability might play an important role in anchovy feeding and potential cannibalism.

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# HARD BOTTOM ASSEMBLAGES IN THE STRAIT OF MESSINA: DISTRIBUTION OF *ERRINA ASPERA* L. (HYDROZOA: STYLASTERIDAE)

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# Abstract

Distribution of the stylasterid *Errina aspera* L. in the Straits of Messina has been surveyed by means GIS technology. The species is confined to a narrow rocky zone, prone to "intermediate" water upwelling. Potential risks of damage by an increased sedimentation rate are discussed.

Keywords : Biogeography, Endemism, Mapping, Western Mediterranean.

# Introduction

Seismic activity and strong tidal currents determine an erosive regime affecting the Straits of Messina at least down to 300-350 m [1]. The rocky seafloor of the straits is inhabited by rich benthic communities and some particular assemblages that are unknown in other Mediterranean regions [2, 3]. Since the geological and topographical study carried out in the late 1970s [4] no further work was conducted, so most of the continental slopes and related communities are still unexplored. A revision of literature and original data on the distribution of the stylasterid hydrocoral *Errina aspera* and its related community was studied, as part of a larger project investigating biodiversity in the Straits of Messina.

#### Methods

In August 1995, a preliminary survey provided 25h of videotape recordings, and 183 bottom samples, from 10 to 220 m depth. The distribution of *E. aspera* was subsequently verified by means of grab and dredge samplings, ROV observations and direct scuba diver surveying, in additional 53 stations. The data was stored in a geo-database model, tailored specifically for the marine community, with a GIS platform. The coordinate system used was WGS84 UTM Zone 33N.

#### Results and discussion

Surveys provided 35 records of E. aspera, located in the rocky bottoms of the sill and along a narrow area of the Sicilian part of the straits. A single finding was made on the south-eastern Calabrian coast (Capo dell'Armi), thus extending the known area of the species in the Straits of Messina [5]. Our findings suggest the coverage by E. aspera had been overestimated in previous surveys. Due to the erosive and depositional processes that asymmetrically affect seafloors, a narrow rocky zone extends exclusively south-west from the sill, gradually increasing in depth, from 90-150 m down to 150-220 m. Coarse sediment slumpings are responsible for the frequent discontinuities observed in the rocky zone, with a consequent patchy distribution of E. aspera. With regard to this distribution, we show how E. aspera populations, which need an erosive sedimentary regime, could suffer from an altered sedimentation rate. According to Giacobbe [5], E. aspera population density tends to a bipolar distribution, reaching a peak to the north of the sill, and a trough at the lowest depth, to the south. The first record of E. aspera in a deep-water sea cave was videotaped, in this latter area (Giaccone, personal communication). Given only a single finding of E. aspera, distribution on the south-eastern Calabrian side is not well known. Nevertheless, its occurrence near Capo dell'Armi, at 95 m depth, is in accordance with the hydrological regime in the Strait, representing a further indication of the prominent role of "intermediate"upwelling currents [6] in determining E. aspera distribution [5].

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# SPATIAL MODELING OF THE EUROPEAN SARDINE HABITAT IN THE EASTERN MEDITERRANEAN BASIN USING GIS TOOLS

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# Abstract

Acoustic survey data from June 2004 and 2005 were combined with environmental satellite data to investigate the spatial distribution of the European sardine in the Greek seas (Eastern Mediterranean basin). The link between the presence of sardine with environmental variables was identified by GAMs, while GIS techniques were applied, to map the areas where this set of environmental parameters is present, implying the existence of potential sardine habitat.

Keywords : Aegean Sea, Acoustics, Mapping.

#### Introduction

The present work is a first approach to identify the environmental characteristics that describe areas that serve as potential habitat of the European sardine (*Sardina pilchardus W.*) in the Greek Seas (Eastern Mediterranean Sea) during June. For this purpose acoustic data together with environmental satellite data were used and a specific set of environmental parameters associated with sardine's presence was defined. GIS techniques were applied to map the areas where this set of environmental parameters is met, implying the existence of potential habitat of sardine stocks, which is essential for management purposes.

# Materials and Methods

Acoustic data were collected during two research surveys (June 2004 and 2005) on board the R/V Philia, in the Aegean Sea by a Biosonic Split Beam DT-X echosounder at 38kHz. Sardine echoes were discriminated based on the characteristic echogram shape of the schools and integrated per 1 nautical mile. Environmental data (i.e., mean monthly values of sea surface temperature-SST in °C, chlorophyll-a CHLO in mg/m<sup>3</sup>, sea surface salinity-SSS, sea level anomaly-SLA in cm and photosynthetic active radiation-PAR in Ein/m<sup>2</sup>/day) were derived from satellite imagery using GIS procedures ([1]). Generalized Additive Models (GAMs) were applied in a presence/absence approach in Thracian Sea on pooled data from the examined years, in order to identify the link of sardine's presence with environmental variables and define the set of the parameters values that describe potential areas of sardine presence. Thracian Sea was used as a pilot area, being characterized by strong heterogeneity of environmental conditions. Model selection was based on the minimization of the AIC criterion with a backward selection method [2], a binomial error distribution and the cubic spline smoother (s) was chosen as appropriate. In a next step, GIS techniques used the specific range of values from Thracian Sea (indicated by GAMs results to have a positive effect on sardine presence), to map those areas in the Greek Seas as well as the entire Mediterranean basin, where the specific environmental conditions are met, using mean monthly satellite data from June 2004 and 2005. Acoustic data from Thermaikos and Evoikos gulf in June 2004 and June 2005 as well as acoustic data from past studies in Central Aegean and Ionian Sea in June 1998 and June 1999 ([3]) were used for the cross validation of the results.

# Results and Discussion

GAMs results of the final selected model [s(SST,df=4)+s(PAR,df=4) +s(CHLO,df=4), p<0.01, Deviance explained = 25.9%] indicated a certain range of values of the environmental parameters within the available ones, that there was a higher probability of finding sardine present. GIS mapping of the estimated conditions of environmental parameters derived from the Thracian Sea seems to describe quite reasonably also the areas of the actual sardine distribution in the Thermaikos and Evoikos gulfs in June 2004 and 2005, as well as in the Central Aegean and Ionian Seas as data from June 1998 and 1999 ([3]) are showing in Fig. 1. Mapping also indicated the specific set of environmental conditions for other areas in the Mediterranean Sea (e.g. the Adriatic Sea, the north Tyrrhenian Sea) as well as areas in the Eastern Mediterranean basin where the distribution of sardine is unknown (e.g. in the Nile Delta area, Fig. 2). The use of data from additional areas as well as pooled data from several years could better define the set of the environmental parameters that characterize the areas of the main sardine's concentrations and improve estimations results.



Fig. 1. A GIS extrapolated map of sardine's potential habitat in the Aegean and Ionian Seas based on the set of the parameter values estimated from the Thracian Sea acoustic data and mean monthly satellite data from June 2004.



Fig. 2. A GIS extrapolated map of sardine's potential habitat in the Mediterranean basin based on the set of the parameter values estimated from the Thracian Sea acoustic data and mean monthly satellite data from June 2004.

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# DISTRIBUTION AND BIOLOGY INFORMATIONS ABOUT SEPIOLIDAE (MOLLUSCA, CEPHALOPODA) OF THE SOUTHERN TYRRHENIAN SEA (CENTRAL MEDITERRANEAN)

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# Abstract

This note provides data on sepiolid distribution in the Southern Tyrrhenian Sea in which the Sepiolidae have an important commercial value. All three sepiolid subfamilies (Sepiolinae, Heteroteuthinae and Rossiinae) are represented in the Southern Tyrrhenian Sea *Keywords : Cephalopods, Trawl Surveys, Tyrrhenian Sea*.

The diversity of sepiolid species is particularly rich in the Mediterranean Sea. A lot of systematic studies [1-2], faunistic [3-4] life cycle [5] and behaviour have been carried out on sepiolis species in the Mediterranean. Up to now 16 sepiolid species have been listed in the Mediterranean Sea [6-7], amongst these 12 species have been found in the lower Tyrrhenian Sea [8-9].

The data come from ten years of bottom trawl surveys (1994-2004) on the evaluation of demersal resources within the area comprised between Suvero Cape (Calabrian side) and San Vito Cape (Sicilian side) along the Italian coasts (Southern Tyrrhenian Sea).

Material was frozen on board and then fixed in 4% buffered formalin in the laboratory. The identified species were *Sepiola rondeletii* (Leach, 1917), *Sepiola intermedia* (Naef, 1912), *Sepiola ligulata* (Naef, 1912), *Sepiola robusta* (Naef, 1912), *Sepiola affinis* (Naef, 1912), *Sepietta oweniana* (Orbigny, 1941), *Sepietta neglecta* (Naef, 1916), *Sepietta obscura* (Naef, 1916), *Rossia macrosoma* (Delle Chiaje, 1830) *Neorossia caroli* (Joubin, 1902), *Heteroteuthis dispar* (Ruppel, 1844) and *Rondeletiola minor* (Naef, 1912). The identification key was based for the males on the observing of the hectocotylized arm and for the females on the bursa copulatrix characteristics.

A total of 1963 individuals belonging to twelve sepiolid species were collected and 1555 of these were identified. *Sepietta oweniana* (720 specimens), *Rossia macrosoma* (293 specimens), *Rondeletiola minor* (249 specimens) and *Sepiola rondeleti* (156 specimens) were the most common species encountered.

Only one specimens of *Sepiola ligulata* (mature female of 13 mm ML), *Sepiola intermedia* (mature male of 15mm of ML) and *Sepiola robusta* (mature male of 16 mm of ML) were collected between 180 and 260 m of depth. The more coastal species was *Sepietta obscura* (26 specimens), that was caught from 50 to 100 m of depth; the size ranged for males between 13 and 19 mm ML and for females between 12 to 24 mm ML. Only four specimens of *Sepietta neglecta* were found on the continental shelf (50-100 m), three were mature males measuring 12,12.5 and 14 mm ML respectively and one was mature female (15 mm ML).

Sepiola affinis (32 specimens), Heteroteuthis dispar (15 specimens) and Neorossia caroli (57 specimens) were found only in the continental slope, in particular the bathyal range were 200-500 m for Sepiola affinis and 500-800 m for Heteroteuthis dispar, Neorossia caroli and Rossia macrosoma. The mantle length ranged from 18 to 20 mm (males) and 19 to 25 (females) for Sepiola affinis and from 11 to 16 mm (males) and 16-20 mm (females) for Heteroteuthis dispar.

The most abundant species was *Sepietta oweniana*. A total of 720 specimens was taken during twenty trawl surveys (159 in spring and 561 in autumn). The DML size ranging from 11 to 34 mm for females and 12 to 31 mm DML for males while the mean total weight ranging from 1.67 to 8.86 g. Mature females with big eggs (ovary weight between 0.05 and 0.058 g; diameter eggs between 2 and 3.5 mm) were collected. The bursa copulatrix dimension varied from 3 to 16 mm and 0.011 to 0.899 g. For males both immature and mature specimens were found; the spermatophoric complex weight ranging from 0.025 and 0.382 g. This study represent a preliminary note on the presence, distribution and biology of the Sepiolid in the study area.

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# DEMERSAL FISH AND MEGAFAUNAL ASSEMBLAGES ON THE CYPRUS CONTINENTAL SHELF AND SLOPE (EASTERN MEDITERRANEAN)

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## Abstract

The demersal fish and megafaunal assemblages on the Cyprus continental shelf and slope were sampled for the first time during the MEDITS CY 2005 and 2006 projects. Species distribution and density varied between depth strata. A total of 173 species were recorded, 5 of which were Lessepsian migrants, whereas 1 fish species was recorded for the first time in the Eastern Mediterranean. *Keywords : Demersal, Eastern Mediterranean, Trawl Surveys.* 

# Introduction

The Cyprus continental shelf and slope had never been studied before in terms of composition and bathymetric distribution of fish assemblages. This study was a first attempt for such an approach, based on data taken from the MEDITS surveys of 2005 and 2006. The main objective of the study was to determine species assemblages in different depth zones, given that the sampling stations were bathymetrically stratified. Another point taken into consideration was the abundance and biomass changes in each stratum between the two years, since samplings were not carried out during the exact same season.

# Materials and methods

The survey method was the standard MEDITS protocol, i.e. stratified trawl surveys at depths ranging from 10 to 800 m. 25 hauls were conducted each year covering the area from Agia Napa to Chrysochous Bay. Sampling took place in August 2005 and June 2006. For data analysis, the sampling year was noted as 5 for 2005 and 6 for 2006, and the following strata codes were used: A (10-50 m), B (50-100 m), C (100-200 m), D (200-500 m) and E (500-800 m). Thus C14\_5 is haul 14, which belongs to the 100-200 m stratum, sampled in 2005. The dendrogram of similarities between the 50 stations was calculated with PRIMER, using the triangular similarity matrix, based on the Bray - Curtis similarity index, between stations (using 4th square root transformation) [1]. The statistical testing for the differentiation between strata and the determination of the main species responsible for the calculated differences was done with ANOSIM and SIMPER.

# Results and discussion

A total of 172399 individuals were fished (63528 in 2005 and 108871 in 2006), belonging to 173 species (114 osteichthyes, 16 chondrichthyes, 15 cephalopods and 28 crustaceans). The dendrogram of similarities indicates that stations were grouped per stratum (fig. 1).



Fig. 1. Dendrogram of similarities for 50 stations (cluster analysis, groupaverage linkage) sampled during August 2005 and June 2006.

The average similarity was 50,97%, 49,05%, 54,82%, 66,01% and 53,92% for strata A, B, C, D, and E respectively. The only stations that were grouped outside their actual stratum were B8 and A25. Station 8 was the only station in stratum B with high abundance of *Centracanthus cirrus, Macroramphosus scolopax* and *Trachurus mediterraneus* during both sampling years. These species were mostly occupying strata C and D in their total appearance. Station 25 was the only station of stratum A located

on the northern shore of Cyprus and presented species that were mainly found in stratum B in the southern part of the island. SIMPER revealed that the main species responsible for the grouping of stratum A stations were: Serranus hepatus, Spicara smaris and Serranus cabrilla. The main species responsible for the grouping of stratum B were: S. hepatus, Lepidotrigla cavillone and S. smaris, for Stratum C: M. scolopax, S. hepatus and L. cavillone, for Stratum D: Argentina sphyraena, Capros aper and Aspitrigla cuculus, and Stratum E: Plesionika martia, Chlorophthalmus agassizii and Argyropelecus hemigymnus. Strata differed between them (ANOSIM, R global >0.75, p <0,001). The pair wise comparisons of strata revealed *R*-values higher than 0.84 in every case, apart from the test between strata D and E, (R = 0.68). These were the deepest strata and differed but overlapped (R >0.5). The intra-stratum differentiation between the two sampling years revealed an abundance increase in 2006 for strata C, D and E (252.8%, 376.3% and 92.6% respectively) and decrease for strata A (514%) and B (15.5%). The high abundance in stratum A for 2005 was mainly due to Spicara smaris (73.7% of total individuals caught in stratum), which were just being recruited to the fishery [2]. The 2006 sampling took place in June and therefore recruitment did not started yet. The highest abundance increase in 2006 was noticed in stratum D, mainly due to the presence of A. sphyraena, M. scolopax and C. aper that increased by 567%, 1658% and 308% respectively. The increase in stratum C was also significant and was related with the presence of M. scolopax (76% of total individuals caught in the stratum). During the MEDITS CY surveys 5 Lessepsian migrant species were caught: 4 fish, Pteragogus pelycus (Randall, 1981), Dussumieria elopsoides (Bleeker, 1849), Stephanolepis diaspros (Fraser-Brunner, 1940) and Upeneus moluccencis (Bleeker, 1855) [3] and 1 crustacean species, Thalamita poissonii (Audouin, 1826) [4]. A deep living species of the family Stomiidae, Bathophilus nigerrimus (Giglioli, 1884), was also recorded at a depth of 610 m during the 2006 survey. This species has never been reported before in the eastern Mediterranean. In conclusion, depth zones were characterized by specific assemblages and differentiation between strata was clear.

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# IS THE EASTERN MEDITERRANEAN A DEEP-SEA DESERT?

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# Abstract

A study of deep sea (1000-1500 m) fish conducted off the northern coast of Israel added new data. Though extremely sparse, the number of deep-water fish species known from the Levant increased from 8 to 39 (*vs.* 59 in the entire Mediterranean). Our findings suggest that the ichthyofaunal richness is correlated with the intensity of research. Interestingly, ca. 20 species are known from depths greater than reported from the western Mediterranean.

Keywords : Bathyal, Biodiversity, Deep Sea Ecology, Fishes.

The Levantine Sea at the easternmost Mediterranean is isolated from the deep Atlantic and western Mediterranean waters by the shallow Gibraltar Straits and the Siculo-tunisian sill. The Levantine deep waters are ultraoligotrophic and distinguished by temperature values that are higher than in the rest of the sea.

Tab. 1. List of deep sea fish species known from the Levant (\* collected during the present research).

| Family           | Species                                              |  |  |  |  |
|------------------|------------------------------------------------------|--|--|--|--|
| Bythitidae       | Cataetyx laticeps Koefoed, 1927*                     |  |  |  |  |
| Centrophoridae   | Centrophorus granulosus (Schneider, 1801)*           |  |  |  |  |
| Chimaeridae      | Chimaera monstrosa Linnaeus, 1758*                   |  |  |  |  |
| Cynoglossidae    | Symphurus ligulatus Cocco, 1844*                     |  |  |  |  |
| Dalatiidae       | Etmopterus spinax (Linnaeus, 1758)*                  |  |  |  |  |
| Gonostomatidae   | Cyclothone pygmaea Jespersen & Tåning, 1926*         |  |  |  |  |
| Heterenchelyidae | Panturichthys fowleri (Ben-Tuvia, 1953)*             |  |  |  |  |
| Hexanchidae      | Hexanchus griseus (Bonnaterre, 1788)*                |  |  |  |  |
| Ipnopidae        | Bathypterois mediterraneus Bauchot, 1962*            |  |  |  |  |
| Macrouridae      | Coelorhynchus coelorhynchus (Risso, 1810)*           |  |  |  |  |
| Macrouridae      | Coelorhynchus labiatus (Koehler, 1896)*              |  |  |  |  |
| Macrouridae      | Coryphaenoides guentheri (Vaillant, 1888)*           |  |  |  |  |
| Macrouridae      | Hymenocephalus italicus Giglioli, 1884               |  |  |  |  |
| Macrouridae      | Nezumia sclerorhynchus (Valenciennes, 1838)*         |  |  |  |  |
| Myctophidae      | Ceratoscopelus maderensis (Lowe, 1839)               |  |  |  |  |
| Myctophidae      | Diaphus holti Taning, 1918*                          |  |  |  |  |
| Myctophidae      | Diaphus rafinesquei (Cocco, 1838)*                   |  |  |  |  |
| Myctophidae      | Electrona rissoi (Cocco, 1829)*                      |  |  |  |  |
| Myctophidae      | Gonichthys coccoi Cocco, 1829                        |  |  |  |  |
| Myctophidae      | Hygophum hygomii (Lütken, 1892)*                     |  |  |  |  |
| Myctophidae      | Lampanyctus crocodilus (Risso, 1810)*                |  |  |  |  |
| Myctophidae      | Lampanyctus pusillus (Johnson, 1890)                 |  |  |  |  |
| Myctophidae      | Lobianchia dofleini Zugmayer, 1911                   |  |  |  |  |
| Myctophidae      | Myctophum punctatum Rafinesque, 1810                 |  |  |  |  |
| Nettastomatidae  | Nettastoma melanurum Rafinesque, 1810*               |  |  |  |  |
| Notacanthidae    | Notacanthus bonapartei Risso, 1840*                  |  |  |  |  |
| Notacanthidae    | Polyacanthonotus rissoanus (Filippi & Vérany, 1859)* |  |  |  |  |
| Ophichthidae     | Echelus myrus? (Linnaeus, 1758)                      |  |  |  |  |
| Ophidiidae       | Ophidion barbatum Linnaeus 1758*                     |  |  |  |  |
| Paralepididae    | Paralepis speciosa Bellotti, 1878*                   |  |  |  |  |
| Phosichthyidae   | Vinciguerria poweriae (Cocco, 1838)*                 |  |  |  |  |
| Phycidae         | Phycis blennoides (Brünnich, 1768)*                  |  |  |  |  |
| Scyliorhinidae   | Galeus melastomus Rafinesque, 1810*                  |  |  |  |  |
| Squalidae        | Squalus acanthias Linnaeus, 1758*                    |  |  |  |  |
| Squalidae        | Squalus blainvillei (Risso, 1826)*                   |  |  |  |  |
| Sternoptychidae  | Argyropelecus hemigymnus Cocco, 1829*                |  |  |  |  |
| Stomiidae        | Chauliodus sloani Schneider, 1801*                   |  |  |  |  |
| Stomiidae        | Stomias boa (Risso, 1810)*                           |  |  |  |  |
| Trachichthyidae  | Hoplostethus mediterraneus Cuvier, 1829*             |  |  |  |  |

A series of cruises conducted off the northern coast of Israel as part of pollution monitoring surveys at depths between 1000-1500m, afforded us an opportunity to examine the deep Levantine ichthyofauna. Though extremely sparse, the number of deep-water fish species known from the Levant increased to 39 (Table 1), as compared to the number of deepwater fish species known from the entire Mediterranean (59). The species richness in the Levantine Sea is comparable to other Mediterranean basins of a similar size. Contrary to the widely perceived notion of Mediterranean eastward progressive faunistic decline, our findings suggest that the ichthyofaunal richness is correlated with the intensity of research. Among the fish presented in Table 1-2, ca. 20 species are known from depths greater than reported from the western Mediterranean. It may be indeed that the Levant basin's distinct ecological conditions are reflected in bathymetric modifications, with the same species occurring deeper in the Levant than anywhere else in the Mediterranean Sea. Marenzeller's [1] echinoderm depth records, which show similar trend, were considered inaccurate, a result of possible "systematic mistake on the depth measurement that needs to be cleared up in the future" [2]. Recent records support Marenzeller's results of the deepening of the Levantine fauna [3-4].

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# HARMONIZATION OF SAMPLING METHODS AND TREATMENT OF ZOOPLANKTON TIME SERIES

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# Abstract

Zooplankton is considered as indicator of the Global Change impact and may be used to forecast the combined effects of the physical and biological parameters operating at the sea basin scale. A concerted approach is necessary to obtain coherent data from biogeographical studies and retrospective analyses of historical time series. In order to build the ability to determine the composition of past and present assemblages of zooplankton in different Mediterranean geographic locations we propose here to harmonize the sampling, faunistical classification, statistical treatment and data archiving.

Keywords : Zooplankton, Sampling Methods, Time Series, Biometrics, Biodiversity.

#### Introduction

Climate Change has been a major concern in the last decade, not only for the scientific community but also for the general public. One of the major issues is to be able to propose scenarios of changes and foresee the variations that ecosystems will experience in the future. Global climate change is expected to impact the biodiversity, the structure and the functioning of plankton ecosystems [1]. In fact, zooplankton is known to be a good indicator of climate change because most of the species are not being commercially exploited, and the long-term changes observed in their stocks can, therefore, be attributed to changes in environmental conditions. As organisms living in suspension in the water column, they are good indicators of features and dynamics of water masses. In addition, they have a short life span that helps to relate population size to environmental conditions. And finally, plankton, with their non-linear responses to environmental changes, can amplify subtle environmental perturbations that otherwise would not be perceived. It is therefore necessary to study changes of past and present assemblages of zooplankton at interannual and longer time scales [3]). Because of the easy and low cost sampling, long term zooplankton time series are available in a number of locations.

In order to simplify the comparison of zooplankton time series we are proposing here to harmonize the collection methods, facilitate the transfer of samples to secure electronic archives, and share protocols for data summarisation and statistical analysis.

Since zooplankton is considered as indicator of regime shifts and its community composition impacts the fishery and the carbon cycle, a concerted approach is necessary to determine the variability of populations in time and space and the correlation with climate and fishery [2]. In order to intercompare the different series both quantitatively (biovolume, derived weight, community size spectra) and qualitatively (community structure, species assemblages, species ratio, indicator species) the different steps from sample collection, treatment and storing, to quantification, classification and data treatment in the different geographic locations should be coherent.

#### Methods

The proposed approach is based on the net sampling, sample digitization by the ZOOSCAN [4], the use of the free ZooProcess software for image treatment (www.zooscan.com) and the use of the free TANAGRA software (www.obs-vlfr.fr/LOV/ZooPart/ZooScan/article.php3?id\_article=55) for numerical analyses. The proposed methodology allows a standardised non destructive treatment of samples including enumeration, morphometry and faunistical classification of samples for biogeographical or historical time series analyses.

#### Expected results

Using the proposed approach we are expecting to better define the changes in the range and spatial distribution of species, shifts in the location of biogeographical boundaries and provinces, change in the phenology of species (e.g. earlier reproductive season), modification in dominance (e.g. a key species can be replaced by another one), change in diversity, and also change in the structure and dynamics of ecosystem with possible regime shifts (fig. 1).



Fig. 1. Nine years time series of copepods (in blue) abundance concentration and (in red) cumulative deviation from the mean at Point B (Ville-franche sur Mer, France) obtained using the Zooscan.

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# THE LIFE CYCLE OF THE SYMBIONT-BEARING LARGER FORAMINIFERA AMPHISTEGINA LOBIFERA, A NEW ARRIVAL ON THE ISRAELI SHELF

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# Abstract

The SE Mediterranean, the warmest and the most oligotrophic region in the entire Mediterranean, was invaded lately by *Amphistegina lobifera*. This symbiont-bearing larger foraminifera proliferates along the Israeli coast mainly on rocky substrate. *A. lobifera* reproduces once a year, during summer (July-August), unlike its counterparts in the Gulf of Aqaba which reproduce twice a year (June and January). It therefore can survive the low winter temperatures of  $15^{\circ} - 17^{\circ}$  C of the eastern Mediterranean, but it fails to reproduce in the winter. *A. lobifera* is a major carbonate producer, with a contribution of about 200 g CaCO<sub>3</sub> m<sup>-2</sup> yr<sup>-1</sup> on rocky coasts of Israel. *Keywords : Foraminifera, Migrant Species, Eastern Mediterranean, Life Cycles.* 

# Introduction

The opening of the Suez Canal 135 years ago opened the gates to a major faunal invasion from the Red Sea to the eastern Mediterranean. The widespread invasion is changing the biota on the Israeli shelf, in particular suppressing the native inhabitants on rocky environments. *Amphistegina lobifera* is the most common species among the symbiont-bearing larger foraminifera that invaded the southeastern Mediterranean [1, 2]. In this study, we investigate the population dynamics of *A. lobifera*, as an example of an invader species living on the edge of its environmental tolerance. The Mediterranean is one of the northernmost locations in the world where this low latitude shallow water species lives today.

A. *lobifera* was first recorded on the Israeli shelf during the late 1950's [3] occurring in rather low numbers (10%). Recently it was found that this species comprises the majority up to 90% of the rocky foraminiferal assemblage off Akhziv and Haifa, between  $\sim 10$  and 30 m water depth [2].

## Material and methods

The annual population dynamics of *A. lobifera* was studied off Tel Shiqmona, Haifa, Israel in a rocky area densely covered by macroalgae. Sampling was carried out by scuba diving at  $\sim$ 1.5 m water depth, every 3-5 weeks from August 2003 to September 2004, in triplicate samples of intergrowing brown algae *Cystoseira* sp. and the red coralline *Jania rubens*. The abundance of the entire foraminiferal population was normalized against the total dry algal weight.

# Results and discussion

Sea surface temperatures vary between 15 and  $30^{\circ}$  C, salinity between 38.5 and 40 permil, and nutrient concentrations are raised in winter but much lower in summer. *A. lobifera* is the most common larger foraminifera off Shiqmona, occurring throughout the year.



Fig. 1. Variations in relative abundance of *Amphistegina lobifera* population including juveniles <500 um, intermediate growth stage 500-710 um and adults >710 um, off Tel Siqmona, Haifa, Israel.

Its numbers vary considerably indicating patchy distribution with somewhat higher numbers in late summer/early fall and late winter/early spring (650 specimens/g dry algae) and low numbers during summer (100 specimens/g dry algae). The reproduction period is short and is restricted to July and August, as evident by the high percentages of juveniles (Fig. 1). Light intensity and water temperature seems to regulate its reproduction cycle in the eastern Mediterranean. Daily juvenile growth rate during summer is 2.2%, slowing during winter, at adult stage, to 0.3%. Full-sized specimens (up to 1.5mg) were recorded during fall and winter. A. *lobifera* is a major carbonate producing foraminifera, with a contribution of about 200 g CaCO<sub>3</sub> m<sup>-2</sup> yr<sup>-1</sup>on rocky coasts of Israel. In some samples it is the largest single contributor to carbonate production.

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# MARINE MAMMAL STRANDINGS ON THE TURKISH AEGEAN SEA COASTS: FISHERMEN REPORTS

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# Abstract

This study assesses the anecdotal marine mammal stranding reports of fishermen from the central Turkish Aegean fishing ports. For this, a poll survey was conducted with 30 % (n=179) of the fishermen. Forty-four reports involving Delphinidae (n=38), *Physeter macrocephalus* (n=4) and *Monachus monachus* (n=2) were collected. One of the reported *P. macrocephalus* was misidentified. *Keywords : Cetacea, Eastern Mediterranean.* 

### Introduction

Our knowledge of the marine mammals with the exception of the *M. monachus* [e.g. 1] of the Turkish Seas is scarce. To date, a few opportunistic studies were carried out along the Turkish Aegean Sea. The occurrence of *Delphinus delphis*, *Grampus griseus*, *P. macrocephalus*, *Stenella coeruleoalba*, *Tursiops truncatus*, *Ziphius cavirostris* and *Pseudorca crassidens* were reported from this region [2,3,4]. With the present study, we aim to collect and assess the anecdotal marine mammal stranding reports of the fishermen from the central part of the Turkish Aegean Sea coasts.

# Methodology

This study was a part of the poll survey among the fishermen, and was conducted from November 2003 to November 2004 at 8 fishing ports located between Ayvalik and Didim-Taşburun (Fig.1).



Fig. 1. The locality of fishing ports from north to south (1) Ayvalik, (2) Dikili, (3) Foça, (4) Urla, (5) Çeşme Dalyanköy, (6) Siğacik, (7) Kuşadasi and (8) Didim-Taşburun, and stranding localities of marine mammals - 7 of them overlaps - in the Turkish Aegean coasts.

It was aimed that 30 % of the artisanal fishing boat owners at each port to be inquired. Moreover, the same approach - the number of skippers/owners was derived from [5] - was also used for entire fleet of purse-seiners and trawlers - regardless of their port of origin - of the whole study area. The fishermen were interviewed singly so as to prevent being influenced by each other's responses. Prior to questionnaire application, each of them was shown with three cards, measuring 22 x 28 cm, depicted black and white drawings [6] - with scale - of the followings species: *Balaenoptera physalus, Balaenoptera acutorostrata, P. macrocephalus, Z. cavirostris, P. crassidens, Orcinus orca, Globicephala melas, D. delphis, T. truncatus, G. griseus, S. coeruleoalba, Phocoena and M. monachus.* For the present study, each fisherman was asked to show which species he saw stranded and its locality.

#### Results and Discussion

During study period, a total of 179 (30 %) fishermen were inquired. Except in one occasion, involving two unidentified small delphinids, they all reported single animal strandings (n=43), as expected from the vicinity of the ports, between 1989 and 2004 (Fig.1). Though a weak evidence on mass stranding due to an epizootic were reported previously [3], no mass die-off was reported from the region. Because the majority of the stranding reports comprised dead animals (n=37) and/or seen from distance, the fishermen could not accurately identify the small cetacean species from the drawings shown. Therefore, all of them were categorised as Delphinadae in Figure 1. Moreover, they reported four P. macrocephalus strandings among which one of them - the southernmost standing in Figure 1 - was not the species that they claimed. This species well identified to be a B. physalus [7]. In addition, M. monachus (n=2) strandings were also reported from the current distribution range of the species in the region [1]. Though the reported number of injured stranded animals from deliberate killing attempts was expected to be negatively bias, there still be two incidences reported (Tab.1). As mentioned previously [2,3], with the line of our findings (20 strandings between 2001 and 2003), we still believe a functioning stranding network is still required for better monitoring of the marine mega-fauna along the Aegean sea coasts.

Tab. 1. Live stranded Delphinidae in the Central Turkish Aegean Sea coasts.

| LOCALITY                  | DATE        | AGE CLASS | CAUSE        |
|---------------------------|-------------|-----------|--------------|
| Alibeyköy Island, Ayvalik | 04.2003     | ?         | ?            |
| Alibeyköy Island, Ayvalik | 01.2004     | Calf      | ?            |
| Alibeyköy Island, Ayvalik | 1989        | ?         | Injured      |
| Ayvalik                   | 2002        | ?         | Pellet wound |
| Dikili                    | Summer 2002 | ?         | ?            |
| Hekim Island, Urla        | 06.2003     | Calf      | Injured      |
| Taşburun, Didim           | Summer 1997 | ?         | Pellet wound |

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# INVESTIGATION OF FIN WHALES (BALAENOPTERA PHYSALUS) DISTRIBUTION INFERRED FROM SATELLITE TRACKING AND STABLE ISOTOPES : CONSERVATION IMPLICATIONS

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# Abstract

We provide the first evidence from satellite telemetry and stable isotope techniques that a small portion of the fin whale population occurring in the north western Mediterranean Sea during summer migrates to Atlantic foraging areas. *Keywords : Cetacea, Western Mediterranean, Circulation.* 

Fin whales (*Balaenoptera physalus*) are the largest marine predator in the Mediterranean Sea, where they feed exclusively on the zooplankter *Meganyctiphanes norvegica*. An estimated 1500 to 3500 individuals concentrate during summer in the northern occidental basin and are heavily exposed to shipping collision [1]. Mediterranean fin whales are genetically distinct from North Atlantic populations and the prevailing hypothesis that these stocks are also geographically isolated [1].

The summer distribution of fin whales was investigated using geostatistics [2]. Fin whales movements were monitored using Argos satellite telemetry and by measuring carbon stable isotope ratio variation along baleen plates indicative of feeding areas. Whale baleen plates grow continuously and thus provide a record of stable isotope variation. Furthermore the year round variation in abundance and distribution in the western Mediterranean sea is currently investigated from ship-surveys conducted along the Dyfamed transects between Marseille and Algeria. The fin whales sightings data base merges data coming from a broad range of organization and associations and cover the period 1993 to 2001. And fin whale were found to be more likely encountered over 2 main areas centred about 43° S, 8°10' E and 42° 40 S and 5° 30. The main oceanographic process taking place in the area is associated with the sinking of denser (i.e. saltier) surface water [3] inducing intense spring bloom which in turns allows the development and growth of *M. norvegica*. These areas of sinking dense waters also induce the creation of cyclonic gyres in locations roughly similar from year to year [3]. The summer distribution of fin whales probably mirror the spatial recurrence of these features while the Northern Current could also play an active role in the transportation and in concentrating the preys.

11 fin whales were tagged in August 2003 with Argos satellite tags, which supplied useful locations for up to 301 days from 8 individuals. The resultant tracks documented 13.356 km of travel and provided the first evidence of a summering Mediterranean fin whale traveling into the Atlantic. Seven whales remained in the northwestern Mediterranean for their entire tracking periods. Stable isotope ratios provided useful information of migration patterns and trophic levels. The  $\delta^{13}C$  was measured every centimeter from base (the most recent growth) to tip (the oldest part) of individual baleen plates from 8 whales stranded along the French Mediterranean. The longitudinal record of  $\delta^{13}$ C values in baleen for all individuals, except one male killed in a ship strike in the northwestern Mediterranean, had similar  $\delta^{13}$ C variation patterns. This lone individual exhibited large cyclic variation of  $\delta^{13}$ C fluctuating consistent with the higher enrichment in  $\delta^{13}$ C typical of both the northwestern Mediterranean and Atlantic, suggesting that this individual undertook migrations between the Mediterranean sea and the Atlantic. The  $\delta^{15}$ N values are consistent with fin whales feeding mainly on M. norvegica both in the Mediterranean and in the Atlantic .

The survey initiated in summer 2006 confirmed that fin whales were most commonly observed in the northwestern Mediterranean sea but could be seen in the southwestern part of the Mediterranean sea in fall. This study show for the first time that most Mediterranean fin whales are resident and foraged mainly in the northwestern part through summer and fall and tended to disperse more widely later in fall. This study also show that a small proportion of the population migrates to the Atlantic. From a conservation perspective, the whales remaining in the northwestern basin during fall and early winter are exposed to more shipping than previously thought.

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# REPRODUCTION OF COMMON CUTTLEFISH (SEPIA OFFICINALIS, L., 1758) IN ANTALYA BAY

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# Abstract

The reproduction of common cuttlefish was studied between September 2002 and March 2004 in Antalya Bay. 490 individuals were collected during the studied period. The mantle lengths and total weight of common cuttlefish varied from 55 to 177 mm, and 29.7 to 652.3 g for females and 45-170 mm, 16.8-510.8 g for males (mean total mantle length and body mass for females and males:  $105\pm1.6$  mm,  $174.83\pm7.79$  g and  $98.8\pm0.15$  mm,  $135.46\pm5.65$  g, respectively). Four maturity stages were described. Based on the proportions of each maturity stage, as well as on various maturity indices, spawning was found to take place throughout the year with an increase between May and August.

Keywords : Cephalopods, Reproduction.

### Introduction

The reproduction of the common cuttlefish of the Eastern Atlantic and Western Mediterranean Sea is known in considerable detail [1,2,3,4,5,6]. Its life cycle is closely related to environmental factors. Thus, in the northern part of their distribution, they begin their reproduction cycle in the second year of their life, during a short breeding season lasting 2 to 3 months. In contrast, in warmer waters such as the Western Mediterranean, the majority of cuttlefish reproduce when 1 year old and over a long period [5]. Little is known about its reproductive biology in the Mediterranean coast of Turkey.

# Material and methods

Samples were collected between September 2002 and March 2004, from local fishermen and the industrial fishing fleet of Antalya Bay. A total of 490 individuals (246 female and 244 male) were examined. Mantle length (ML), to the nearest 1 mm, and total body mass (BM), to the nearest 0.1 g, were recorded. For females the ovary mass (OM), and nidamental gland mass (NGM), and for males testis mass (TM) and spermatophoric complex mass (SCM), were also recorded. Four maturity stages for each sex were determined using a scale proposed by [7]: females, I-immature, II-maturing, III-prespawning and IV-spawning; males, I-immature, II-maturing, III-fully mature, and IV-spawning. The spawning peaks were identified using the indices of reproductive status [3,7]: (a) females: GSI (Gonadosomatic index): 100 x OM / BM, and NGI (Nidamental gland index): 100 x NGM / BM; (b) males: GSI: 100 x TM / BM and SCI (Spermatophoric organ index): 100 x SCM / BM.

### Results and discussion

The length distributions are shown in figure 1a. To determine the spawning season the occurrence of mature females and males was examined [Fig.1b]. Spawning females (Stage IV) were observed from March to July, while most of the males fully matured (Stage III) from March to July. Female maturity indices increased in February and peaked between May and July. All maturity indices declined gradually starting in August, and reached their lowest values between October and December (Fig. 1d). Male maturity indices increased in December and peaked in June and July (Fig. 1c). This coincides with the peak percentage values of specimens in spawning conditions. During the spawning season (from May to August), only one generation can be distinguished based on ML [Fig.1a]. The change in mean number of ova with ML, BM and NGM are shown in Table 1.



Fig. 1. (a) Length frequency distribution of females and males; (b) Monthly frequency distribution of spawning females (Stage IV) and males (Stage III); (c) Variations in monthly means of GSI and SCI for males; (d) Variations in monthly means of GSI and NGI for females.

This study indicated that the main spawning season of S. officinalis in Antalya Bay started in spring and lasted through summer with a peak in June and July. This agrees with most of other studies [8,5,6]. In all months some maturing and mature individuals were found, indicating that this species probably spawns during the whole year, but its reproduction peaks during June-July. Maturity indices show that cuttlefish are able to mature before they are 1 year old in the Mediterranean Sea as noted by [1], while they mature at an age 1 and 2 years in the Atlantic [5].

Tab. 1. The change in mean number of ova with ML, BM and NGM.

| N  | ML (mm)   |                 | BM (g)        |                    | NGM             | A (g)              | Number of ova |                |
|----|-----------|-----------------|---------------|--------------------|-----------------|--------------------|---------------|----------------|
| 14 | min - max | $M \pm sd$      | min - max     | $M \pm sd$         | min - max       | $M \pm sd$         | min - max     | $M \pm sd$     |
| 2  | 60 - 75   | 69.5±4.9        | 43.0 - 53.7   | 48.35 ± 7.57       | 1.221 - 2.698   | $1.960 \pm 1.044$  | 51 - 106      | 78.5±38.89     |
| 21 | 75 - 90   | 81.5±3.6        | 52.1 - 116.9  | 76.11±16.09        | 2.083 - 3.842   | 2.083±0.475        | 56 - 202      | 115.14±35.59   |
| 18 | 90 - 105  | 97.6±3.9        | 89.7 - 150.2  | $124.98 \pm 18.67$ | 2.447 - 6.404   | $4.422 \pm 1.103$  | 50 - 298      | 141.61±61.88   |
| 25 | 105 - 120 | $111.3 \pm 4.6$ | 126.5 - 231.1 | 182.93 ± 22.53     | 3.676 - 9.521   | $6.300 \pm 1.397$  | 74 - 324      | 173.84±79.57   |
| 18 | 120 - 135 | $126.2 \pm 4.0$ | 199.8 - 348.8 | 251.53 ± 41.99     | 4.258 - 20.642  | 10.177±4277        | 83 - 543      | 238.83±99.54   |
| 8  | 135 - 150 | $141.1 \pm 4.5$ | 294.7 - 382.6 | 340.10 ± 31.27     | 6.593 - 15.495  | $12.945 \pm 3.231$ | 127 - 529     | 274.75±118.62  |
| 7  | 150 - 165 | 155.3±3.8       | 380.5 - 540.4 | 447.86 ± 63.91     | 9.502 - 19.278  | $12.755 \pm 4.005$ | 208 - 348     | 253.43 ± 50.55 |
| 2  | 165 - 180 | $172.0 \pm 7.1$ | 627.0 - 652.3 | 639.65 ± 17.89     | 16.228 - 24.156 | $20.192 \pm 5.606$ | 337 - 425     | 381.00 ± 62.23 |

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# REPRODUCTIVE BIOLOGY OF DIPLODUS VULGARIS (FAMILY SPARIDAE) IN THE SYRIAN COAST

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# Abstract

In this work, results on the reproductive cycle, the length at first maturity, and hermaphroditism of *Diplodus vulgaris* in the coast of Syria are presented. The spawning period occurs from December to February, and the length at first maturity is 18 and 18.5 cm for females and males. This species is characterized by a rudimentary hermaphroditism, with sexual inversion taking place at 16-19 cm. *Keywords : Fishes, Reproduction, Mediterranean Ridge, Species Introduction.* 

### Introduction

The Sparidae is one of the most important marine fish families that inhabit the Syrian Coast. *Diplodus vulgaris* is one of the most abundant species of the family, but its biology is not well known. The aim of this study is to describe the reproductive biology of *D. vulgaris*, including the spawning season, length at first maturity and hermaphroditism.

#### Materials and methods

Samples of *Diplodus vulgaris* were collected on a monthly basis with a commercial bottom trawler off the coast of Syria from November 1999 to March 2001.

The depth of sampling stations ranged from 5 to 50 m. A total of 435 specimens were collected. The maturity stage was determined using the gross sexual classification scale of Nikolsky [1]. The monthly evolution of GSI mean values and the proportion of spawning specimens during a period of 17 months were used to determine the spawning season. The size at first maturity ( $L_{50}$ ), the size at which 50% of the individuals were mature, was estimated by fitting the logistic function (using non linear least squares regression):

 $P=1/1+exp[b(L-L_{50})]$ 

Lenght frequency distribution was used for calculating the length at sexual inversion.

## Results and discussion

The mean values of GSI% ranged from 0.09% in June to 10.91% in January for females and from 0.05% in August to 4.52% in December for males.

Figure 1 shows that *D.vulgaris* is a winter spawner, with the highest GSI values occurring between December and the end of February for females, with a single annual spawning peak in January. The resting period clearly extends from April to the end of September.

Analysis of advanced maturity stages showed that females were in emission from December to the end of February, with the greatest percentage of females in maturity stage (V) in January. Males showed the same patterns as the females in terms of maturity stages. Nevertheless the presence of stage (V) males in December, with a single spawning peak in December, suggests earlier maturation for males.

The GSI values of the females throughout the year were larger than those for males. This is due to the fact that the eggs as the end product of ovogenesis in females are much heavier than spermatozoa or the end product of spermatogenesis for males, as noticed by ather authors for *D. sargus* [2]. However, the spawning period is different in the Mediterranean, occurring earlier in the North and West and later in the South and East [3-5], reflecting the differences in the environmental conditions in this region.

Length at first maturity was not significantly different between sexes (Hotelling's  $T^2$  test, p>0.05), being 18 cm and 18.5 cm for females and males respectively, corresponding to 2 years of age. Therefore, an increase in the minimum legal length should improve the stock management and conservation of this species.

Histological examination of gonads in the present study indicated that D.vulgaris shows a rudimentary hermaphrodism, in addithion to the rate of individuals that developed directly as a primary females and primary males. We found that 32.16% of the individuals had both male and female tissue, and most often these gonads showed one sex as being more developed than the other, with higher average total length for the individuals with a more developed ovary. Females at the onset of development and with a small male part were found up to the beginning of the spawning

season. Functional males under spermiation (stage V) with a reduced and developing female part were also found in January, during the spawning season.

In all hermaphrodite gonads the testis and ovary were clearly separated by connective tissue. Sexual inversion takes place at approximately 16-19 cm (2-3 years of age).

However the size or age at which sex reversal happens is not established genetically, and this may be dependent on demographic changes [6].



Fig. 1. The mean monthly gonadosomatic indices for females and males of *Diplodus vulgaris*, coast of Syria.

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# DEVELOPING AN *FLR* OPERATIONAL MODEL FOR EVALUATION OF FISHERIES MANAGEMENT STRATEGIES: AN APPLICATION TO HAKE FISHERY

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# Abstract

An operational population model for hake developed in *FLR* framework of the *R* language under the EFIMAS project is presented. Two effort restriction scenarios were tested (10% and 20% reduction of fishing mortality F). The response of the hake fishery in these two management measures was evaluated for a 10-year projection period.

Keywords : Aegean Sea, Demersal, Models, Population Dynamics, Fisheries.

Hake is one of the main target species of several multi-species Mediterranean fisheries and especially of the bottom trawlers exploiting the continental slope. On the basis of the available data most of the hake stocks in the Mediterranean are either fully exploited or overexploited. In most of the cases a decreasing trend in individual lengths of the hake caught and in the catches per unit of effort of the trawlers can be observed. Fisheries management in the Mediterranean is based mainly on technical measures and control effort regimes i.e. a minimum landing size of 20 cm, a prohibition of bottom trawling within three miles of the coast or in depths less than 50 m (whatever comes first), a 40 mm minimum mesh-size of bottom trawls cod-end and a control capacity regime, i.e. limitation on national fleets' horsepower and gross tonnage.

In the Aegean Sea, hake is one of the main target species of the demersal trawl fishery and around to 300 vessels are currently involved into this fishery having an annual hake production of about 3000 t. Demersal trawlers operate from October 1 to May 31 exploiting the continental shelf and the upper part of the continental slope from 30 to 400 m [1].

Under the framework of EU EFIMAS (Operational evaluation tools for fisheries management options) project two management measures and corresponding strategies will be evaluated in the light of potential future increase of hake biomass using either effort or technical measures. The first will deal with effort restrictions, e.g. reduction of fishing mortality F, closed seasons, etc. The scenario will evaluate the trade-offs between effort, fishing intensity and stock status when limiting the trawling intensity to certain bounds (e.g. a single percentage cut off F / Effort, a closed fishing season). It is more than likely that the effect of these bounds on age composition of the stock and thus on interannual catches and yields, in the short term, will be dependent on the initial status of the stock. The second scenario will explore the impact of management regulations addressing specific technical measures, e.g. gear selectivity measures such as mesh type (e.g. knotted or not), on catchability dynamics.Gear selectivity will be evaluated against two scenarios, i.e. 40 mm cod-ends with and without knots. It is anticipated that the above analyses and scenarios testing will highlight if effort- or selectivity-based management is preferable for demersal trawl fisheries of hake.

A population model for hake fishery in the Aegean Sea was developed using the *FLR* (Fisheries Science in *R*) framework of the *R* language [2] in order to estimate future catches. First results are presented here from the application of the operational model to 2004 data of catch at age, weight at age, VPA derived estimates of F-at-age and recruitment. Stochasticity was incorporated in the operational model by introducing random variability in the recruitment values.

Two effort restriction scenarios were tested: one with a single 10% and another with a single 20% cut off F in the following year (2005). Under the assumption of constant catchability these F cuts may well reflect analogous reduction in effort E. The response of the hake fishery in these two management measures was evaluated for a 10-year projection period (Figure 1). Under fixed management rules the catch of the hake fishery remains relatively stable. A 10% cut in the fishing mortality F results in a 6% reduction in that year's catch (2005). However, the fishery soon (2006) returns to the previous level of exploitation and catches gradually increase in the following years (up to 10%). A 20% reduction in F induces a 13% decrease in the following year's catch. Hereafter the catches increase and level at higher values (17.5%) compared to the base and 10% case studies.



Fig. 1. Simulation results of operational model applied to hake catches in the Aegean Sea (2004). Projection period: 10 years. Scenarios with the current F, 10% and 20% reduction of current F.

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# NOUVELLE LISTE COMMENTÉE DES RAIES DU BASSIN ALGÉRIEN

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# Résumé

Les raies capturées dans le bassin algérien sont recensées régulièrement depuis 1996. La liste actuelle non exhaustive est comparée à celle de [1]. De nombreux spécimens présentent des caractères morphologiques qui ne correspondent à aucune espèce de Rajidae signalée en Méditerranée . Leur position spécifique n'est toujours pas établie et la liste reste donc largement incompléte. *Mots clès : Biodiversity, Elasmobranchii, Demersal, Algerian Basin.* 

## Introduction

Il existe un grand nombre d'espèces dans la famille des Rajidae dans le monde, réparties en plusieurs genres dont quatre se retrouvent dans le bassin algérien (*Raja, Dipturus Rostroraja* et *Leucoraja*). Malgré leur importance dans l'économie de la pêche locale, les raies ne font toujours pas l'objet de travaux de synthèse. S'il n'existe aucun problème de diagnose pour des espèces comme *Raja miraletus* ou *Leucoraja melitensis*, l'identification de nombreuses espèces reste encore très problématique. L'inventaire réalisé, basé uniquement sur les apports de la pêche commerciale, est un préalable à la connaissance exacte de ce groupe.

### Matériel et méthodes

Les données ont été récoltées à la grande poissonnerie d'Alger, de 1996 à 2004. Les espèces proviennent des différentes régions de la côte algérienne. Après consultation des documents spécialisés [1-8] la détermination des espèces est faite avec vérification de tous les caractères indiqués.

# Résultats et discussion

Quinze espèces ont été recensées, sur les 17 signalées dans le bassin méditerranéen [4] : Rostroraja alba (Lacépéde 1803) ; Dipturus oxyrinchus (Linnaeus 1758) ; Dipturus batis (Linnaeus 1758) ; Raja miraletus Linnaeus, 1758 ; Raja clavata Linnaeus, 1758 ; Raja brachyura Lafont, 1873 ; Raja montagui Fowler, 1910 ; Raja asterias Delaroche, 1809 ; Raja undulata Lacépéde, 1802 ; Raja polystigma Regan, 1923 ; Raja africana Capapé, 1977 ; Leucoraja circularis (Couche, 1838) ; Leucoraja melitensis (Clark, 1926) ; Leucoraja naevus (Müller et Henlé, 1841) ; Raja radula Delaroche 1809.

La liste, actualisée en 2004 a été comparée aux résultats de [1]. On notera que toutes les espèces signalées par ces auteurs ont été rencontrées à l'exception de *R. fullonica* qui n'apparaît plus dans les captures, alors que *R. africana* est signalée pour la première fois dans les eaux algériennes. Certaines raies considérées comme fréquentes et même très fréquentes par [1] ont tendance à se raréfier (*Leucoraja circularis, Leucoraja melitensis* et *Leucoraja naevus*) ou à disparaître (*Rostroraja alba*).

La littérature consultée présente beaucoup d'ambiguïtés et ne facilite pas l'identification des raies, dont les individus sont très polymorphes. La position spécifique de nombreux spécimens n'est toujours pas établie et de ce fait la liste reste toujours ouverte. La confusion et l'erreur subsistent encore pour les espèces suivantes : *Raja asterias* et *R. brachyura*; *R. polystigma* et *R. montagui; Dipturus batis* et *D. oxyrhincus.* 

L'observation d'un grand nombre d'individus de *Raja clavata* confirme la discontinuité morphologique intraspécifique déjà observée par [9]. *R. clavata* caractérisée par un pédoncule caudal où alternent des bandes claires et sombres, présente de nombreux individus dépourvus de boucles. Certaines formes de *Raja clavata* peuvent se confondre avec des espèces voisines, telles que *Raja brachyura, Raja montagui* et surtout *Raja asterias*.

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# ANALYSE DES DONNÉES MORPHOMÉTRIQUES DE QUELQUES ESPÈCES DU GENRE *RAJA* LINNAEUS, 1758 DANS LE BASSIN ALGÉRIEN

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# Résumé

Une analyse en composantes principales des données morphométriques est réalisée sur quatre espèces de raies du genre *Raja*, capturées dans le bassin algérien. L'analyse permet de séparer très nettement *R. clavata* en deux catégories, confirmant ainsi la discontinuité morphologique mentionnée par la littérature [1, 2].

Mots clès : Systematics, Elasmobranchii, Demersal, Algerian Basin.

# Introduction

L'étude morphométrique porte sur quelques raies ornées de points, du genre *Raja: R. asterias* Delaroche, 1809 ; *R. brachyura* Lafont, 1873; *R. clavata* Linnaeus, 1758 ; *R. montagui* Fowler, 1910. Le but de nos investigations est de comparer les résultats de l'analyse des données morphométriques de quelques espèces de raies voisines, à ceux de la taxonomie actuelle. La systématique des raies, très délicate, nécessite une amélioration des critères d'identification.

# Matériel et méthodes

Deux cent sept spécimens mâles et femelles provenant de la pêche commerciale de toutes les régions de la côte algérienne ont été mesurés et se répartissent en 60 individus pour R. asterias (I), 53 pour R. brachyura (II), 54 pour R. clavata avec boucles (III), 28 de R. clavata sans boucles (IV) et 12 pour R. montagui (V). Douze caractères en plus de la longueur totale (LT) ont été relevés : largeur du disque (LD) ; longueur du disque (DD); espace inter -orbitaire (IO); espace pré-orbitaire (PO); espace prénasal (PN); longueur pré-buccale (PB) ; espace pré-anal (PA) ; longueur du pédoncule caudal (LQ); distance allant du museau à l'origine de la première nageoire dorsale (LD1); distance allant du museau à l'origine de la deuxième nageoire dorsale (LD2) ; largeur du museau, en avant des yeux (LAM) ; largeur du museau, en arrière des yeux (LAD). Les données morphométriques des quatre espèces de raies, obtenues entre 1998 et 2001 standardisées par le logiciel Sizestd [3], ont fait l'objet d'une analyse en composantes principales avec rotation par Varimax brut, réalisée par le progiciel STATISTICA, 5.1. [4].

### Résultats et discussion

La projection des individus sur le plan I-II-III (fig. 1) forme globalement deux nuages de points : le premier nuage est formé par la majorité des individus de l'espèce *Raja clavata* avec boucles, qui se détachent nettement de l'ensemble et sont par conséquent dissemblables. Le second nuage regroupe *R. asterias, R. brachyura, R. clavata* sans boucles et *R. montagui. Raja brachyura* fait l'objet d'une confusion et est souvent identifiée comme *R. asterias* [5].



Fig. 1. Projection des individus des 4 espèces sur le plan factoriel I-II-III et variables contribuant à la formation des 3 axes.

Quelques individus de *R. clavata* sans boucles (IV) se rapprochent des individus de la même espèce mais portant des boucles (III). L'examen de leurs coordonnées permet de déterminer les caractéristiques des points

voisins : ce sont surtout les mâles des deux catégories de cette espèce. *R. clavata*, présente une grande variabilité relative à la la livrée mais qui se traduit aussi par la présence ou l'absence de boucles; de plus ces boucles sont très polymorphes et réparties différemment sur le disque, d'un individu à l'autre. L'analyse des données morphométriques met en évidence deux catégories de *R. clavata*. Les résultats confirment également les affirmations de [2] et de [3] qui mentionnent l'existence d'une similitude morphologique entre certaines espèces : *R. asterias* (les jeunes surtout), *R. brachyura*, *R. montagui* et *R. clavata* sans boucles. Les descripteurs qui ont été mis en évidence peuvent concrétiser les frontières entre les groupes difficiles à séparer. Ces caractères, qui gagneront à être quantifiés, se retrouvent surtout au niveau du museau (PN, PB, PO, LAM) et de la tête (IO et LAD).

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# MUGIL CEPHALUS: COSMOPOLITAN SPECIES OR SPECIES COMPLEX?

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# Abstract

The cosmopolitan distribution of *Mugil cephalus* is under discussion at present. Morphometrics based on Landmark distances, meristics and 12S rRNA (domain 1 and 2), cytochrome c oxidase subunit I (COI) and cytochrome b (cytb) mitochondrial DNA markers data from several locations worldwide are presented. Combined results indicate a global species complex in need of taxonomic revision. *Keywords : Biometrics, Genetics, Fishes, Systematics, Biogeography.* 

*Mugil cephalus*, *Mugil platanus* and *Mugil liza* form species group with close morphological relationships. According to [1] grey mullet, *M. cephalus*, has a worldwide distribution (51N - 42 S) and *M. platanus* is considered as a synonymy in South American waters. Nevertheless, extreme conservative morphology of this species stands in contrast with the degree of allozimic differentiation detected at a global scale [2]. The aim of the present work is to compare the taxonomic relationships of *Mugil cephalus* with *M. platanus* and *M. liza*, based on a multidisciplinary approach, using meristic, morphometric and mitochondrial DNA sequencing techniques.

Tab. 1. Tamura-Nei genetic distance and standard error for each sample and gene.

|                | 12S rRNA-1          | 12S rRNA-2          | COI                 | Cytb                |  |
|----------------|---------------------|---------------------|---------------------|---------------------|--|
| Med-USA        | 0.0170 ± 0.0059     | $0.0163 \pm 0.0061$ | $0.0414 \pm 0.0077$ | $0.0586 \pm 0.0107$ |  |
| Med-Miya       | $0.0101 \pm 0.0046$ | $0.0201 \pm 0.0070$ | $0.0269 \pm 0.0077$ | $0.0574 \pm 0.0100$ |  |
| USA-Miya       | $0.0274 \pm 0.0079$ | $0.0201 \pm 0.0071$ | $0.0420 \pm 0.0082$ | $0.0576 \pm 0.0104$ |  |
| M.pl/M.li-Med  | 0.0139 ± 0.0052     | $0.0168 \pm 0.0057$ | $0.0229 \pm 0.0053$ | $0.0479 \pm 0.0091$ |  |
| M.pl/M.li-USA  | 0.0289 ± 0.0082     | $0.0253 \pm 0.0073$ | $0.0325 \pm 0.0066$ | $0.0498 \pm 0.0090$ |  |
| M.pl/M.li-Miya | $0.0243 \pm 0.0071$ | $0.0269 \pm 0.0077$ | $0.0248 \pm 0.0059$ | $0.0406 \pm 0.0079$ |  |

Samples of *M. cephalus* were collected from the Mediterranean (Med), the western Atlantic (USA); *M. platanus'* from South America, and *M. liza* from the Caribbean. Twenty-one morphometric variables were taken as interlandmark distances of involved species. Meristic data were also considered for each specimen following [3]. Genetic analysis of 12S rRNA (domain 1 and 2), cytochrome c oxidase subunit I (COI) and cytochrome b (cytb) were carried out following [4] and using GenBank *M. cephalus* sequences as reference. Phylogenetic relationships were inferred by neighbor-joining analysis based on Tamura-Nei model.



Fig. 1. Neighbor-Joining tree based on Tamura-Nei distance. *M. cephalus* from the Mediterranean (empty circle), USA (solid circle) and Genbank reference (triangle) and *M. platanus/ M. liza* (square).

The interlandmark distances showed differentiation between the individuals of *M. platanus* and *M. cephalus* analysed. The number of lateral scales differentiated *M. liza*, *M. platanus* and *M. cephalus* being a diagnostic character in meristic analysis. However, the high genetic closeness detected between *M. platanus* and *M. liza* haplotypes and shared haplotypes did not support species level differentiation. Besides, the distances detected among *M. cephalus* samples overlapped with values shown between *M.pl/ M.li* and *M. cephalus* (Table 1). Phylogenetic trees had similar topology for all molecular markers (Figure 1). Although a monophyletic group for *M.pl/ M.li* was detected, it was included in *M. cephalus* lineage.

This evidence coupled with [2] suggest that the cosmopolitan distribution of *M. cephalus* should be reconsidered and new levels of species assignation are expected.

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# CONDITION OF EUROPEAN HAKE (*MERLUCCIUS MERLUCCIUS* L.) OFF THE BALEARIC ISLANDS: AN APPROACH OF PHASE TRANSITIONS OCCURRENCE IN THE POPULATION

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# Abstract

Population dynamic of the exploited demersal fish European hake (*Merluccius merluccius*. L.) off the Balearic Islands were explored in relation to the relative condition index ( $K_n$ ) and mean length-at-age (ML).  $K_n$  was significantly correlated with hake population characteristics as recruitment, spawning stock biomass (*ssb*) or total biomass. Furthermore, ML also appeared to be significantly related to age-0 class abundance, but with a different relationship before and after 1995, driven by a stronger density-dependence effect of *ssb* for low values of ML. This suggests that changes or phase transitions in the population could be occurring, affecting the intraspecific relationships. *Keywords : Balear Islands, Demersal, Fisheries, Recruitment*.

Fish condition is a measure of environmental and biological circumstances during previous periods. Condition indices are often used to represent the amount of energy stored within individual fish, although it is also relevant to estimate condition at the population level. Several morphometric and physiological indices used to be explored using individual observations. However, Mean Length-at-age (ML) can also be used as a proxy of the population condition when computation individual-level observations on weight and length are not readily accessible [1]. Condition of fish could reflect changes in the denso-dependent relationships and the population age structure. Inter-annual fluctuations of marine population can undergo abrupt changes which can be ecological, anthropogenic or climatologically driven [2]. This study aims to explore: 1) the effect of condition indices on the population abundance of European hake (Merluccius merluccius L.) (recruits abundance, rec, spawning stock biomass, ssb, and total biomass, tb) and, 2) explore the occurrence of possible phase transition in the population dynamic using ML as a proxy of condition of fish.

A total of 7447 individuals were sampled over the year from 1980 to 1992 (except 1987), estimating the relative condition index  $(K_n)$ :  $K_n = 100(W_{obs}/W_{est})$ , where  $W_{obs}$  is the observed weight and  $W_{est}$  the estimated weight.  $K_n$  was calculated for two groups, individuals lower that 30 cm (not maturing) and larger than 30 cm (maturing). ML at different ages was also calculated using yearly length distribution from 1980 to 2004. The outputs of the Virtual Population Analysis (VPA) were used in the analysis: rec, ssb, tb and number of individuals per age class [3]. Non-parametric Spearman correlations were used to compare  $K_n$ and hake population time series, being  $K_n$  index values ln transformed. However, as we got relatively longer time series for ML, we used a generalized additive model (GAM) to fit estimates of abundance at different age and ML. For studying the presence of changes in the time series, which may be indicative of phase transitions, changes in the condition as a threshold non-additive effect on ML throughout the time was explored. being the denso-dependency effect included trough ssb, also threshold by ML. The average per year of the ln transformed  $K_n$  (i<30 cm) index was significantly correlated with rec (r = 0.36, p<0.05), showing as well significant correlation with ssb and tb (lagged by one year) (r = 0.77 and r = 0.70 respectively, p<0.05) (Fig. 1a). Correlations with ln transformed  $K_n$  (i>30cm) were not significant (p>0.05). Although similar GAM approaches were followed for other ages, only results for age-0 are shown here. Figure 1b shows the different relationship between the covariate ML at age 0 (ML<sub>0</sub>) and age 0 abundance (N<sub>0</sub>), being 1995 the threshold in the relationship. Although higher N<sub>0</sub> is related to low ML<sub>0</sub> for the entire period, before 1995 around 15.5 cm  $ML_0$  was linked to higher  $N_0$ , while after 1995 higher N<sub>0</sub> of small individuals were related to lower ML<sub>0</sub>, around 14.5 cm. Ssb effect shows an increase of density dependence for low ML<sub>0</sub> values (<15.8 cm).

The results show that the recruits condition and ML are related to the abundance. *Ssb* and *tb* of the previous year could also affect the condition of the offspring between 1980 and 1992. However, the different biological meaning of  $K_n$  and ML must be taken into account. While  $K_n$  reflects the energy allocated to the body, ML shows the mean size of an annual class which can have a positive or negative effect of the population, or being a reflection of the population state. Our results reveal that the density-

dependence effect of *ssb* on  $N_0$  are mediated by  $ML_0$ . This suggests the occurrence of a possible phase transition in the population which must be explained within an ecological and fishery perspective (Hidalgo et al., in prep), because of the fishery-induced truncation of the age structured [4].



Fig. 1. a) Kn (i<30cm), tb and ssb time series from 1980 to 1992. b) Covariates effect of ML at age 0 (ML0) on the abundance of age-0 annual class (N0), under different period effect before and after 1995, and the density-dependent effect of ssb under different groups of ML0.

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# ANTHROPOGENIC EUTROPHICATION AFFECTING BENTHIC FORAMINIFERA AND POLYCHAETES OF THE EASTERN MEDITERRANEAN SHALLOW SHELF

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# Abstract

Seasonal variation in distribution of benthic foraminiferans and polychaetes was studied in the vicinity of a sewage sludge disposal site off the Mediterranean coast of Israel, where a full spectrum of oligotrophic to hyper-eutrophic conditions occurs. The foraminifera *Ammonia tepida* acts as a typical opportunist, reproducing rapidly and colonizing the sea floor anew following each episode of sludge winnowing. Opportunist polychaetes belonging to the Capitellidae respond in extremely high numbers only to the spring event of sludge dispersion. *Keywords : Eastern Mediterranean, Foraminifera, Polychaeta, Sewage Pollution, Eutrophication.* 

The ultra-oligotrophic shallow water environment of the southeastern Mediterranean has been subjected to man-made influences during the last decades. The activated sewage sludge (=biosolids) dumped into the sea off Palmahim exposes marine benthic biota to elevated levels of organic matter and nutrients, and has been monitored for two decades. There is a marked, seasonally dependent, localized impact on the benthic faunas and on sediment quality. Episodes of severe O<sub>2</sub> depletion leads to elimination of all benthic groups close to the sewage outfall, but peripheral eutrophication leads to temporary increase in abundance of opportunistic meio- and macrobenthos species (we studied Foraminifera and Polychaeta) [1, 2]. The opportunistic polychaete family Capitellidae becomes very abundant close to the sewage outfall and is an indicator for organic pollution [3]. We here compare the response of benthic foraminifera in this environment with the polychaete response pattern.

Two stations in the vicinity of the sludge outlet off Palmahim, PL3 (200m N of the outlet; hyper-eutrophic) and PL29 (5.5km to the N; oligotrophic) were sampled at 36m water depth bi-monthly between January 2003 and May 2004, for living (stained with Rose-Bengal) benthic foraminifera and sediment properties (the polychaetes were sampled from July 2003 to May 2004). Formalin-preserved and stained macrofauna >500 $\mu$ m are given as the average of triplicate samples (0.062m<sup>2</sup>).

Comparison between the meio- and macrobenthos at the two stations focused on seasonal variations in opportunists and presence of rare species. The abundance of polychaetes varied seasonally in both stations, with lowest numbers in late fall/winter, doubling in spring (500) at PL29 and much more at PL3 (up to  $14*10^3$ ). The simple diversity is highest at PL29 with 22 polychaete families, and lowest at PL3, with only 5 families. A different seasonality is shown by the foraminifera with the highest total standing stock (TSS) occurring at PL29 during late summer/fall (more than  $10*10^4$ ), and lowest TSS in mid-winter ( $8*10^3$ ). At PL3 TSS is lower, with maximal numbers in January and May (up to  $6*10^3$ ), coinciding with periods of intensive sludge winnowing during storm events (Fig. 1). Species richness at PL29.

The benthic foraminiferan *Ammonia tepida* and the capitellid polychaetes are opportunists that thrive in stressed environments. In the Palmahim stations the TSS maximum of *A. tepida* coincides with maximal abundance of the entire foraminiferal assemblage, comprising 70% of the assemblage. Capitellid polychaetes, the dominant polychaete family at Palmahim, comprise 99% of the polychaetes at PL3 and only 40% at PL29, where they are accompanied by paraonids and cirratulids.

The variations in TSS of *A. tepida* at PL3 track the changes in the sludge accumulation, with highest numbers coinciding with periods of total sludge dispersion during winter (01/04) and spring (05/03, 05/04) (Fig. 1). In fall, the hyper-eutrophic PL3 station became azoic due to water column stratification and high organic matter load (9cm in thickness). *A. tepida* behaves as a typical opportunist, inhabiting the newly exposed sea floor each time sludge is dispersed by winnowing. On the other hand, the opportunist capitellid polychaetes only respond to the spring event of sludge dispersal, at which time they occur in extremely high numbers.

Several foraminiferal species living at PL29 are not present at all at PL3. Their absence suggests that they are long-lived or specialized species that cannot survive the periodic ultra-eutrophic conditions in PL3. We conclude that the macro- and meiobenthos used for tracking the eutrophically overwhelmed environment off the Israeli coast have broadly similar seasonal patterns but differ somewhat in the magnitude of their response. The

foraminiferan *A. tepida* shows the most typical opportunist response, and is less affected by seasonality. It is a sensitive recorder of recurring sea floor aeration episodes at the most disturbed station, and as such has a potential for monitoring similarly disturbed coastal regions.



Fig. 1. Ammonia tepida and Capitellidae abundance (number of specimens per  $0.062m^2$ ), taken at station PL3 from 01/03-05/04 (bars) and the depth accumulation of the sludge on the sediment layers (diamonds).

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# A PRELIMINARY STUDY OF ZOOPLANKTON DYNAMICS COUPLED WITH ENVIRONMENTAL PARAMETERS IN AN URBANIZED HARBOR

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# Abstract

Coastal systems exhibit a wide array of anthropogenic impacts which can alter ecosystem components. Therefore, a through knowledge of the system and the processes affecting it is required to understand the individual and/or mutual effects of physical and biological environments. Field samplings were performed to gather information on the zooplankton community and the environmental parameters of an urbanized harbor located at Kepez-Dardanelles. Weekly observations (between 26 April 2005 and 12 July, 2005) of on site measurements and microscopic analysis showed that environmental parameters and zooplankton community composition changed considerably among sampling depths.

## Keywords : Zooplankton, Dardanelles, Coastal Systems.

Zooplankton biomass, distribution and abundance are of extreme importance in aquatic systems. They maintain a crucial role as the secondary production of aquatic habitats in allowing energy to flow up the food web. Zooplankton are also very sensitive to disturbances, such as nutrient enrichment, fish introductions, thermal discharges, or toxic effluents, therefore make ideal indicators of a healthy aquatic system. In this study we examined the relations between zooplankton abundance and some environmental parameters in Kepez Harbor (Dardanelles). Located between the Sea of Marmara and the Aegean Sea, the flow dynamics in the Dardanelles Strait is complex in many ways. The unique flow dynamics and localization of Kepez Harbor in the Dardanelles Strait makes it an excellent test area for the effects of anthropogenic stress on the water quality and the ecosystem components.



Fig. 1. Zooplankton abundance placed into generic taxonomic groups in the surface, 10 m, 20 m depths in Kepez Harbor between 26 April-12 July 2005.

For this research, water quality and zooplankton data were analyzed from one station located at Kepez Harbor, Dardanelles  $(40^{\circ}09'N, 26^{\circ}24' E)$ . Samples were collected from the surface, 10 m and 20 m depths. Sampling trips were conducted weekly between 26 April 2005 and 12 July, 2005. Water-quality parameters such as temperature, salinity, pH and dissolved oxygen (DO) were measured in situ using an YSI 6600 MPS. Zooplankton samples were collected using a closing plankton net and preserved with 4 % buffered formalin (v/v). Zooplankton species identification was performed according to [1].

Water quality parameters varied considerably among sampling depths. Temperature ranged between 14.2 and 20.5 °C while salinity changed between 20-39 ppt. When different depths were considered pH was less variable changing between 8.7 and 9.3 while DO ranged between 3.3 and 7.1 mg L<sup>-1</sup>. Results showed that all zooplankton groups increased in number starting from the end of May through June (Fig. 1). During this period, Oithona and Acartia species dominated the copepods while *Oikopleura dioica* (Fol, 1872) was abundant in Appendicularians. Considering cladocerans, *Pleopsis polyphemoides* (Leuckart, 1859) was the dominant species by the end of May through arity June. However, after 21 June 2005 *Penilia avirostris* (Dana, 1849) was the common species in all sampling depths. Copepod nauplii showed an increase parallel to an increase in copepod adults in the surface and 10 m depths while numbers were less pronounced in 20 m.

The natural zooplankton community structure in Kepez Harbor was diverse and community structure changed depending on the changes in environmental parameters, i.e., changes in temperature.

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# ÉTUDE DE LA FAUNE ASSOCIÉE À L'ESPÈCE INVASIVE *PINCTADA RADIATA* SUR LE LITTORAL NORD ET EST DE LA TUNISIE

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# Résumé

L'étude des macro-invertébrés associés à *Pinctada radiata* sur le littoral nord et est de la Tunisie met en évidence la présence de 118 espèces vivantes avec cette espèce. Le calcul de la dominance révèle qu'à l'exception des trois stations de la lagune de Bizerte *P. radiata* compte parmi les plus dominantes dans le reste des stations d'études. Quant aux indices de diversité (H' et E), ils traduisent la présence de peuplements benthiques structurés et équilibrés pour la totalité des stations prospectées. *Mots clès : Mollusca, Bivalves, Migrant Species, Competition, Biodiversity.* 

L'huître perlière *Pinctada radiata* compte parmi les premiers immigrants invasifs arrivés en Méditerranée [1]. En effet, depuis son arrivée en Tunisie [2], ce Mollusque a montré un important pouvoir d'extension, notamment dans le secteur sud. L'introduction des espèces érythréennes pourrait induire des variations touchant parfois l'abondance et la distribution bathymétrique des espèces indigènes [3]. Afin de pouvoir évaluer l'impact de cette espèce invasive sur la diversité de la macrofaune benthique autochtone et d'apprécier les relations interspécifiques éventuelles entre la Pintadine et ces espèces dans les différents biotopes prospectés, nous avons entrepris une étude du peuplement des macro-invertébrés associés à cette espèce.

Pour cela, trois régions ont été prospectées, à savoir le littoral de Bizerte (avec trois stations : Canal, Baie des Carrières et Njila), le golfe de Tunis (avec trois stations : Ecluse d'entrée côté canal Kheireddine, Ecluse d'entrée côté lagune et la Marsa) et le littoral de Monastir (avec deux stations : port de Stah Jaber et Stah Jaber). Les prélèvements des macroinvertébrés (Pintadine et la faune associée) ont été effectués au moyen d'un quadrat de 0,25 m<sup>2</sup> de surface. Le contenu de chaque quadrat a été tamisé à l'aide d'un tamis de 1 mm de vide de maille. Le refus de chaque tamis a été conservé dans une solution d'eau formolée à 7% puis déterminé et dénombré. Des descripteurs numériques classiques ont été utilisés pour la caractérisation des entités faunistiques : richesse spécifique (RS), dominance, diversité spécifique de Shannon Weaver (H') et équitabilité (E).

Tab. 1. Variations spatiales de la dominance, de la richesse spécifique (RS), de l'indice Shannon-Weaver (H') et de l'Equitabilité (E).

| de l'                                           | indice | Shann | on-W | eaver (H') et de l'Equitabilité (E).                                                      |
|-------------------------------------------------|--------|-------|------|-------------------------------------------------------------------------------------------|
| Stations                                        | RS     | H,    | E    | Espèces les plus dominantes                                                               |
| Canal                                           | 29     | 4.55  | 0.93 | Balanus eburneus (14.2%)<br>Serpula vermicularis (7.3%)<br>Hexaplex trunculus (6.3%)      |
| Baie des<br>Carrières                           | 32     | 4.73  | 0.94 | Mytilus galloprovincialis (12%)<br>Protula tubularia (6.5%)<br>Diogenes pugillator (6.5%) |
| Njila                                           | 20     | 4.11  | 0.95 | Sabella pavonina (12.2%)<br>Bulla striata ( 9.2%)<br>Chtamalus depressus (9.2%)           |
| Ecluse d'entrée<br>côté canal de<br>Kheireddine | 43     | 5.04  | 0.93 | Pinctada radiata (17.9%)<br>Aiptasia mutabilis (10.7%)<br>Arca noae (10.7%)               |
| Ecluse d'entrée<br>côté lagune                  | 37     | 4.9   | 0.94 | Sabella pavonina (8.1%)<br>Pinctada radiata (7.5%)<br>Aiptasia mutabilis (5.7%)           |
| La Marsa                                        | 16     | 3.73  | 0.93 | Pinctada radiata (8.2%)<br>Balanus eburneus (7%)<br>Serpula vermicularis (5.8%)           |
| Port de Stah<br>Jaber                           | 44     | 4.82  | 0.88 | Bittium reticulatum (14.8%)<br>Pinctada radiata (9%)<br>Sabellaria alveolata (6.7%)       |
| Stah Jaber                                      | 43     | 4.97  | 0.91 | Pinctada radiata (10.7%)<br>Bittium reticulatum (8.7%)<br>Sabellaria alveolata (7.3%)     |

Au total, 118 espèces associées à la Pintadine appartenant à 9 groupes zoologiques ont été identifiées. Les pourcentages calculés des différents taxons, révèlent la dominance des Mollusques (41.2%), suivis par les Crustacés (19.3%) puis par les Annélides (15.2%). Quant aux Tuniciers, ils constituent uniquement 7.6%. Les Echinodermes, les Spongiaires, les Cnidaires, les Bryozoaires et les Sipunculidés sont très faiblement représentés avec des proportions respectivement égales à 5%, 5%, 3.4%, 2.5% et 0.8%. La richesse spécifique atteint son maximum (44 espèces) au niveau du port de Stah Jaber. Quant à la valeur minimale (16 espèces), elle caractérise la station de la Marsa (Tab.1). Les variations de la richesse spécifique semblent être dues aux fluctuations des facteurs environnementaux.

Les valeurs de la dominance (Tab. 1) révèlent qu'à l'exception des trois stations de la lagune de Bizerte (Canal, Baie des carrières et Njila), l'espèce invasive, P. radiata, compte parmi les plus dominantes dans le reste des stations (La Marsa, Ecluse d'entrée côté canal de Kheireddine, Stah Jaber), avec un pourcentage supérieur à 8.2%. Ainsi, au niveau du canal de Bizerte, Balanus eburneus est l'espèce la plus prépondérante. Le Mytillidae Mytilus galloprovincialis (12%) est le plus dominant dans la Baie des carrières. Le Polychète, Sabella pavonina, est prépondérant à Njila et au niveau de l'Ecluse d'entrée côté lagune avec des valeurs respectives de l'ordre de 12.2% et de 8.1%. Le Gastéropode, Bittium reticulatum (14.8%) présente la valeur de dominance la plus élevée au niveau du port de Stah Jaber. Ces données (Tab. 1) plaident en faveur d'une compétition trophique et spatiale entre ces espèces et la Pintadine. En effet, ces espèces partagent avec la Pintadine le même biotope. Elles sont essentiellement des filtreurs comme elle et présentent toutes les mêmes exigences trophiques et occupent ainsi la même niche écologique. Certaines d'entre elles se servent de sa coquille comme substrat, c'est le cas des Polychètes et des Balanes.

Les valeurs de l'indice de Shannon-Weaver oscillent entre un minimum de 3.72 bits, valeur minimale enregistrée à la Marsa et un maximum de l'ordre de 5.04 bits, enregistré au niveau de l'écluse d'entrée côté canal Kheireddine. Les résultats de cet indice (Tab.1) montrent qu'à l'exception de la plage de la Marsa (3.73 bits), toutes les autres stations sont fréquentées par des peuplements normaux, traduisant ainsi une certaine stabilité (Tab.1). Les valeurs de l'équitabilité varient entre 0,88 bits, minimum enregistré au niveau du port de Stah Jaber et 0.95 bits, maximum observé à Njila. Ainsi, ces résultats montrent que les peuplements appartenant à ces différents écosystèmes sont en état d'équilibre et que les espèces rencontrées dans toutes les stations sont équitablement réparties (Tab.1).

Cette analyse met en évidence la présence des peuplements benthiques structurés et équilibrés pour la totalité des stations. En effet, l'introduction de la Pintadine n'a pas constitué un élément perturbateur de l'organisation de la biodiversité de ces écosystèmes littoraux des côtes nord et est de la Tunisie.

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# DISTRIBUTION PATTERNS OF MESOPELAGIC FISH LARVAE IN RELATION TO HYDROGRAPHY OF THE NORTH EASTERN AEGEAN SEA

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# Abstract

Distribution of mesopelagic fish larvae was studied during June 2003 and June 2004 in the Northeastern Aegean sea (NEA). In 2003, certain taxa (*Ceratoscopelus maderensis*, *Hygophum benoiti*) showed unusual distribution patterns with increased presence over a continental shelf area.

Keywords : Aegean Sea, Ichthyoplankton.

# Introduction

Fish larvae distribution patterns are defined not only by the living habitat of adults but also by the water circulation pattern that may occasionally drift the reproductive products away from the spawning environment. In the present study, distribution patterns of mesopelagic fish larvae are examined in the NEA, an area characterized by high hydrodynamic complexity due to the movement of Black Sea water [1].

# Materials and Methods

A grid of 24 stations (Fig. 1a) were sampled in 1-12 June 2003 and 31 May-12 June 2004, with a 60 cm bongo-net (0.250 mm meshed net) towed obliquely from 200 m to the surface (bottom permitting). Hydrographic profiles were collected on a denser grid of 68 stations. Preflexion larvae were identified and their abundance was standardized to numbers per 10 m<sup>2</sup>. More details are provided in [1].

### Results and Discussion

A total of 15 mesopelagic taxa were identified in both cruises (Table 1).

Tab. 1. Mean abundance values (larvae per 10 m<sup>2</sup>) of the larval mesopelagic taxa identified in the bongo-net collections. N% per cent of positive stations (frequency of occurrence).

|                              | June 20                | 003 | June 2004              |    |  |
|------------------------------|------------------------|-----|------------------------|----|--|
| Larval taxa                  | ind. 10m <sup>-2</sup> | N%  | ind. 10m <sup>-2</sup> | N% |  |
| Lestidiops jayakari jayakari | 2.1                    | 21  | 3.6                    | 29 |  |
| Arctozenus risso             | 0.3                    | 4   | 0.5                    | 8  |  |
| Benthozema glaciale          | 4.2                    | 13  | 1.9                    | 13 |  |
| Ceratoscopelus maderensis    | 77.9                   | 79  | 104.6                  | 75 |  |
| Diaphus holti                | 0.8                    | 17  | 0.8                    | 17 |  |
| Diaphus rafinesquii          | 0.2                    | 4   | 0.2                    | 4  |  |
| Hygophum benoiti             | 84.3                   | 67  | 87.8                   | 58 |  |
| Lampanyctus crocodilus       | 0.5                    | 13  | 7.0                    | 25 |  |
| Lobianchia dofleini          | 0.8                    | 17  | 1.9                    | 25 |  |
| Myctophum punctatum          | 11.5                   | 33  | 29.0                   | 42 |  |
| Argyropelecus hemigymnus     | 2.0                    | 21  | 5.0                    | 21 |  |
| Cyclothone braueri           | 0.3                    | 8   | 2.0                    | 17 |  |
| Maurolicus Muelleri          | 6.7                    | 42  | 9.1                    | 38 |  |
| Stomias boa boa              | 0.7                    | 8   | 0.6                    | 8  |  |
| Vinciguerria spp.            | 2.8                    | 29  | 6.9                    | 33 |  |
| TOTAL ABUNDANCE              | 195.1                  | 92  | 259.7                  | 79 |  |

In 2003, mesopelagic larvae were collected in 22 stations. Abundance ranged from 8 to 1140 ind. 10 m<sup>-2</sup>. In 2004, it ranged from 4 to 2069 ind.  $10 \text{ m}^{-2}$  in 19 positive stations. Although mean abundance was higher in 2004 (259 ind.  $10m^{-2}$  vs 195 ind.  $10m^{-2}$  in 2003), this difference was not statistically significant (t=0.1359; p>0.1). The myctophiids Hygophum benoiti and Ceratoscopelus maderensis were the most abundant taxa. Early summer is within the peak of the spawning period of these species [2]. Myctophum punctatum was also important in both years. Large concentrations and maximum number of mesopelagic taxa were recorded beyond the continental shelf (depth>200 m). Abundance and species richness was generally low at sites <200 m especially in 2004. However, in 2003 continental shelf stations in the western part of the surveyed area (St. B108, B106) had increased abundance of mesopelagic fish larvae (654 and 293 ind.  $10 \text{ m}^{-2}$ respectively) (Fig. 1b,c), mostly due to thespecies C. maderensis and H. benoiti. Mesopelagic fishes live offshore at depths >200 m, hence the presence of their larvae over the shelf cannot be explained in terms of local spawning. The unusual presence of the mesopelagic larvae over the continental shelf could be explained in terms of hydrology. Horizontal distribution pattern of temperature, salinity and density (eg. Fig. 1b,c) showed that in contrast to 2004, pelagic water intruded over the continental shelf in the western part of the region in 2003, as a result of a meandering cyclonic movement of the prevailing current (the Lemnos-Imvros jet, [1]). Consequently mesopelagic fish larvae were advected inshore, especially *C. maderensis* and *H. benoiti* which are known to have a more surface vertical distribution [3].



Fig. 1. (a) Station map [squares: ichtyoplankton and CTD; circles: CTD] (b,c) Horizontal distribution of water density (kg  $m^{-3}$ ) at 10 m. Total abundance of mesopelagic taxa of the stations is also shown.

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# ABUNDANCE OF GELATINOUS ZOOPLANKTON IN IZMIT BAY, THE SEA OF MARMARA

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# Abstract

Distribution and abundance of macrogelationous zooplankton were investigated from a total of 11 stations in Izmit Bay, Sea of Marmara with monthly intervals from July 2001 to September 2002. The maximum abundance of all gelatinous zooplankton was calculated as 0.485 ind.m<sup>-3</sup> in September 2001. *A. aurita* was dominant species in Izmit Bay. Overall, the abundance of gelatinous zooplankton varied greatly spatially and temporally.

Keywords : Zooplankton, Ctenophora, Sea Of Marmara.

## Introduction

Izmit Bay is a 310 km<sup>2</sup> large, elongated semi-enclosed water body with a length of 50 km, and a width varying between 2 and 10 km [1]. The bathymetry of the bay is comprised of three sub-basins separated from each other by shallow sills. Several industries have been developing rather rapidly around Izmit Bay. In addition to the increase of untreated, or partly treated domestic waste disposal enhanced by the heavy demographic pressure, the substantial industrial development, the heavy maritime traffic and the agricultural activities in the surrounding areas have caused a considerable pollution burden to enter Izmit Bay. Under the oceanographic point of view, the latter is an extension of the Sea of Marmara, having a permanent two-layer water system, characterized by the presence of less saline waters (Black Sea origin), overlying a more saline bottom layer (Mediterranean origin). Gelatinous zooplankton may affect pelagic food webs by exerting a top-down control on their ecosystems [2]. This has been well documented for estuaries and enclosed seas [3]. The aim of this study is to describe the abundance and distribution of gelatinous zooplankton in Izmit Bay.

## Material and Methods

Between July 2001 and September 2002, gelatinous zooplankton was collected from the upper layer of the Black Sea waters in Izmit Bay at montly intervals. A total of 11 stations were sampled by horizontal towing, using a WP2 closing net (157  $\mu$ m mesh size, 0.5 m mouth diameter). Gelatinous zooplankton samples were identified and measured onboard immediately after collection.



Fig. 1. Location of sampling stations in Izmit Bay, Sea of Marmara.

## Results and Discussion

Four species of gelatinous macrozooplankton were found in Izmit Bay: one scyphozoan medusae Aurelia aurita and three ctenophores, i.e., Mnemiopsis leidyi, Beroe ovata and Pleurobrachia pileus. Totally, 768 individuals were counted from all the 11 stations, of which 382 specimens of A. aurita, 184 of M. leidyi, 129 of B. ovata and 73 of P. pileus. The maximum abundance of gelatinous zooplankton (0.485 ind.m<sup>-3</sup>) was found in September 2001. At that time A. aurita was the most abundant species (51.4 %), followed by M. leidyi (23.3%), B. ovata (17.5 %), and P. pileus (7.8 %). All 4 species were ubiquitously present in the bay. M. leidyi (38%) was the dominant species in the eastern part of the bay, while A. aurita replaced M. leidyi in the middle (51%) and in the western areas (62 %). The maximum abundance of *B. ovata* (31%) was found in the middle of the bay, whilst P. pileus (12%) was in high quantity in the western part. Overall, the abundance of gelatinous zooplankton in the eastern bay was higher than in the western and middle areas. In general, there was a significant negative correlation between the abundances of A. aurita and M.

*leidyi*, probably due to the high competition between them [4]. Finenko *et al.* (2001) demonstrated that, in the Black Sea, *B. ovata* could control the *M. leidyi* stock. Likewise, the present study reveals that the abundance of *M. leidyi* becomes limited in summer, when *B. ovata* is present in Izmit Bay. In the Black Sea, high abundances of *M. leidyi* were found during winter, while the abundance of *A. aurita* and *P. pileus* increased in summer [4,6,7]. On the other hand, in Izmit Bay, the abundance of *M. leidyi* reached its peak in summer, that of *P. pileus* in spring, whereas *A. aurita* and *B. ovata* were numerous in late summer and autumn. In spring, the latter began to spread all over the bay, although the highest abundances were observed in the eastern part of the bay during summer. As a result, the abundance of gelatinous zooplankton in Izmit Bay displays a great variability, both geographically and temporarily.



Fig. 2. Regional abundance of gelatinous zooplankton in Izmit Bay between July 2001 and September 2002.

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# NON-INDIGENOUS SPECIES AT THE ALICANTE HARBOR (SE-SPAIN): OCULINA PATAGONICA DE ANGELIS, 1908 AND BOTRYCAPULUS ACULEATUS (GMELIN, 1791)

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# Abstract

Two non-indigenous species, an haermatypic coral (*Oculina patagonica*) and a gastropod (*Bostrycapulus aculeatus*) have been reported 30 years ago from Alicante harbour. But whereas *B. aculeatus* has not spread outside the harbour, *O. patagonica* has colonized an extensive area of the Spanish Mediterranean (from Catalonian to Andalusia) and competes with indigenous species. *Keywords : Species Introduction, Western Mediterranean, Cnidaria, Gastropods.* 

## Introduction

The scleractinian coral *Oculina patagonica* De Angelis, 1908 and *Bostrycapulus aculeatus* (Gmelin 1791) (= *Crepidula aculeata*) are exotic species. The first the originates from the Southwest Atlantic [1] and the second is a cosmopolitan gastropod in the tropics and subtropics [2]. Both species were first recorded in Alicante harbour in 1973 [3,4], probably introduced by way of vessel fouling. Since, *O. patagonia* spread to the rest of the Mediterranean helped by the intense maritime traffic [4,5], whereas *B. aculaeatus* is confined to Alicante harbour. Considering the importance of the development of non-indigenous species in the Mediterranean [6], we present preliminary data on the biology and density of the population of these exotic species in Alicante harbour.

### Materials and methods

The study was carried at spring 2006 at the Alicante harbour in 2 localities: "Levant quay" (N 38°19'52.1" W 00°29'10.3"; 12m depth) near the harbour entrance with good water circulation; and "Fishing Dock" (N 38°20'11.1" W 00° 29'11.8"; 6m depth) in a more enclosed area and low water replacement rate. The sampling has been carried by scuba diving: i) *O. patagonica* by means of 5 underwater pictures (square 20x20cm) per site and 3 sites (0.5, 3 and 6m depth) in each locality (90 pictures), to calculate the % of cover; ii) *B. aculeatus* taking 2 samples by removing 20x20 squares of the substrate at 3 depths (0.5, 3 and 6m) in each locality (total 36 samples).

## Results and discussion

*O. patagonica* is abundant at both localities (fig. 1), but more abundant in shallower depths (0-3m), where in some sites it covers almost 100% of the substrate. It present two morphotypes: encrusting (frequent in shallow sites) and branched (rare in the deeper and shadow sites).



Fig. 1. Cover percentage (%) of *Oculina patagonica* at two localities of Alicante Harbour. (LQ) Levant Quay; (FD) Fishing Dock.

*Bostrycapulus aculeatus* is present in borh localities (fig. 2), with variable density, though more abundant at deeper sites (6m). The maximum density (275 ind/m<sup>2</sup>) was at the LQ, vs. 50 ind/m<sup>2</sup> at FD. The size range has been 13-31mm, and we have observed ovigerous capsules in early November.

The introduction of exotic species across the Mediterranean is increasing [4, 6], and it is important to monitor them. *Oculina patagonica* is a successful invader that spread along the entire coast of Spain (anthropized and natural environments). Thirty years after the first record from Alicante harbour, *Oculina* covers most of the harbour walls from surface to bottom (11m depth), and it spreads quickly to newly built structures within the harbour (unpubl. data).



Fig. 2. Density of *Bostrycapulus aculeatus* at two localities of Alicante Harbour. (LQ) Levant Quay; (FD) Fishing Dock.

It competes with the native fouling species, limiting the space available for new recruits and even covering most of the sessile organisms. *Oculina* may suffer 'bleaching' with high temperatures [8], but at Alicante the bleaching is localised - limited to overshadowed sites and in contact zone with the sponge *Crambre crambe*.

Although *B. aculeatus* is established inside Alicante harbour, its distribution is confined to the harbour, where its density increases with depth, perhaps due to the competition with *Oculina*.

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# INFORMATION TECHNOLOGY FOR ENDANGERED MARINE SPECIES MANAGEMENT: AFBIKA GEO-DATABASE

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# Abstract

This study presents the Mediterranean Monk Seal Information and Rescue Network (AFBIKA geo-database), which has been designed and constructed to improve the monitoring of the critically endangered Mediterranean monk seal, *Monachus monachus* (Hermann, 1779) in Turkey. Sighting data gathered by SAD-AFAG through various projects and expeditions are entered to the system using Geographic Information System (GIS) and a linked database in order to gather information about distribution and habitat use of the species. With proceeding modifications to the network in the following years, it will probably serve as an effective management tool that may contribute to continuation of species survival.

Keywords : Conservation, Eastern Mediterranean, Gis.

## Introduction

Effective formulation and implementation of any strategies, policies and plans are highly dependent on accurate, comprehensive and timely information [1]. Thus, management of the endangered marine wildlife needs to make use of Information Technology (IT) more frequently to achieve broader conservation goals. GIS, together with Database Management Systems (DBMS), may increase the capability of specialists concerned with endangered species issues. The aim of this study is to present the AF-BIKA geo-database, which was built to enhance already established monk seal sighting database Fok-Data by SAD-AFAG in 1990 [2] which will serve better for the conservation of critically endangered M. monachus -with a population of around 100 individuals [3]- in Turkey.

## Methodology

The field study was performed in 2005 and 2006 on the Aegean and Mediterranean coastal cities and villages of Turkey in order to invite the local stakeholders, who are likely to interact with the species, to AFBIKA membership. In this 72-day field study, 78 settlements were visited, and seal sightings were collected. AFBIKA geo-database was constructed on three components: database (MS Access), internet site and GIS (Manifold 6.5). The database includes each sighting record and member information whereas GIS includes additional tabular and geographical elements in different layers. Landsat satellite images were used as the background of the GIS environment and a grid system was created to map M. monachus sightings since it is often not possible to gather coordinates from observers. Turkish coasts were divided into three differently scaled grid cells: site (15" x15"), parcel (1' x 1') and region (1' x1') grids. Thus, the mappability of the records was increased and analysis in different scales was made possible if required. Seal sighting and member counts per grids were also calculated and entered into grid tables in order to create presence/absence maps by querying and thematic mapping (Figure 1).

#### Results

The reactions of the coastal stakeholders were generally affirmative; the number of AFBIKA members has reached to 186 and 83 seal sightings were recorded from these members. As well as sighting data, the locations of the members were also mapped to manage the expected and unexpected areas of data flow in the future. It was observed that although the number of individuals is few, M. monachus uses a wide geography in the Aegean Sea, Mediterranean Sea and the Sea of Marmara.

## The Way Ahead: Next generation of AFBIKA

It is planned to improve the capabilities of AFBIKA geo-database in both species specific and managerial issues in the following years. The evolution includes addition of new components to the network as well as enhancing the existing GIS, database and web components. With sufficient budget and human capacity, following built-ups are designed to obtain an effective management tool for the conservation of the species:

User-friendly interfaces; for the data providers (AFBIKA members) via internet, and for data input to the system in order to minimize user errors.

Ready-to-use queries; for the specialists and managers for the species specific issues, and for habitat, ecosystem and human activities

management.Sub-programs; for enhancing the integration of existing database and GIS and for adding new capabilities such as link with a statistical software.

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Fig. 1. The presence/absence maps of the locality of AFBIKA members (A) and *M. monachus* (B) for the Turkish Aegean coasts in 2006.

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# SEXUAL MATURITY OF LITTLE TUNNY, *EUTHYNNUS ALLETTERATUS*, IN THE NORTH-EASTERN LEVANTINE BASIN

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# Abstract

A total of 96 little tunny, *Euthynnus alletteratus*, caught in the north-eastern Levantine Basin with commercial purse-seiners and trolling lines, were examined in order to determine the sexual maturity and the age and size distribution. The maximum age was 6 years. The length-weight relationship was  $W= 0.0381 L^{2.77}$ . Out of a total of 60 females examined 8 were mature. *Keywords : Fishes, Growth, Reproduction, Spawning, Levantine Basin.* 

In this study, we determined the sexual maturity of the little tunny. The age determination, first maturity length, gonadosomatic index, sex ratio, and spawning period have been investigated by [1, 2, 3] in various areas. The spawning period in the Mediterranean has been reported to occur from June to September [2, 3]. Sexual maturity of the females is reached at 55-60 cm FL [1].

In this study, a total of 96 little tunny were caught by commercial purseseiners and trolling lines used by artisanal fishermen.in the north-eastern Levantine Basin (especially Mersin Bay and northern Cypriot waters-off Kyrenia) between November 2002 and May 2005, and studied. For each specimen, fork length (FL), total weight (TW), and gonad weight (GW) were measured, and their sex was determined. The age analysis was performed according to [4]. Furthermore, the length and weight relationship was calculated. A total of 96 gonads were examined externally, and the reproductive aspects of the species were observed. The gonadsomatic index (GSI) of both males and females were calculated according to [5]. The minimum, maximum, and mean values of FL and TW were 43 cm, 87 cm, 69.5 cm (SE=0.948) and 1215 g, 8930 g, 5070 g (SE=0.183), respectively. The a and b values of the length-weight relationship (Figure 1) were compared with those reported by other authors. In the Mediterranean, these values were 0.0476 and 2.723 for 1085 individuals of sizes 52-97.5 cm [6]; in the south western Spanish coast: 0.0441 and 2.755 for 217 individuals of sizes 56-67.7 cm [7]; and in this study, 0.0381 and 2.77 for 96 individuals (sizes 43-87 cm). Our findings for a and b values are compatible with the results of [6] and [7]. A total of 36 male and 60 female gonads were examined. The sex ratio was 1:1.7 M/F. The GSI values of both males and females are shown in Figure 2. GSI reached a peak in July, and generally GSI remarkably increased in summer, when the reproductive activities were intensive. It is reported that the gonads of the 1 and 2 year old specimens are not mature, as opposed to those of the 3 year old ones [1]. In this study, all specimens were larger than 60 cm, and their ages were 3-4 years. It is reported that the spawning period of the species ranges between May and September [1]. In the Mediterranean, spawning occurs from late spring through summer [8]. In our study, spawning occurred in July and August, being compatible with other studies. Our results support [9] that this basin is a new spawning area.



Fig. 1. Length-weight relationship.



Fig. 2. GSI values of males and females.

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# SEASONAL SPECIES ASSEMBLAGES IN AN ARTIFICIAL REEF IN NORTH AEGEAN SEA (GREECE)

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# Abstract

The seasonal changes in fish assemblages in the artificial reef (AR) in Fanari, (North Aegean, Greece) were studied in January, June and October 2002. Species of the families Labridae, Sparidae, Serranidae and Centracanthidae were responsible for dissimilarities between January and June and the same species together with Mullidae for dissimilarities between June and October. *Keywords : Artificial Reefs, Aegean Sea.* 

The main objective of the study is to determine the seasonal fish assemblages in the artifcal reef (AR) after four years of establishment. The fishing gear used was bottom trawl (cod-end mesh size 10 mm) and samplings were carried out in January, June and October 2002 over a net of 11 stations. Data were analysed using multivariate analysis and groupings were based on species densities with percentage higher than 0,3% of the total monthly catch. Cluster analysis was performed with PRIMER [3] using data transformed with the Bray - Curtis similarity index (between stations) [4]. The determination of the differentiation between seasons and of the species responsible for the calculated differences were based on ANOSIM and SIMPER [3].

Cluster analysis indicated that the stations were grouped per season (Fig. 1). The average station similarity, calculated using ANOSIM, was 68.11% in January, 79.35% in June and 76.06% in October.

SIMPER, showed that the species responsible for the grouping of the January stations were: Symphodus cinereus, Scorpaena notata, Octopus vulgaris, Serranus cabrilla, Scorpaena porcus, Sepia officinalis, Deltentosteus quadrimaculatus, Eledone moschata and Trigloporus lastoviza (total contribution 70.47%); for the June stations: S. cinereus, Serranus hepatus, Coris julis, S. cabrilla, S. notata, Diplodus annularis, S. porcus, Diplodus vulgaris, Symphodus rostratus, O. vulgaris, Symphodus mediterraneus (total contribution 70.71%); and for the October stations: S. cabrilla, S. cinereus, D. annularis, C. julis, O. vulgaris, S. notata, Mullus barbatus, Mullus surmuletus, S. hepatus, Spicara smaris, S. porcus, Sarpa salpa, Boops boops, Scyllarus arctus, D. vulgaris, S. rostratus, Sympathus acus, Symphodus ocellatus (total contribution 71%).

Statistical analysis indicated that the seasons differed among them (ANOSIM, *R* global >0.91, *p* <0.001). In the per pair comparisons of months, the *R* values were higher than 0.93 in every case. The main environmental factor most probably responsible for the presence of different assemblages was temperature, which was 14 °C in January, 18 °C in June and 22 °C in October.

Comparison of the January and June samplings showed an average dissimilarity of 45.5% with 14 species contributing 70.44% to the differentiation. The highest abundances were recorded in June. The species *C. julis, S. cinereus* and *S. rostratus* differentiated the two seasons by 22.83%, *D. annularis, D. vulgaris* and *Pagrus pagrus* by 15.64%, *S. hepatus, S. cabrilla, S. scriba* by 14.87% and *Spicara maena* and *S. Smaris* by 6.56%. The June and October samplings showed an average dissimilarity of 36.8% with species *M. surmuletus, S. salpa, M. barbatus, S. hepatus, Blennius ocellaris, B. boops, Spondyliosoma cantharus, Dentex dentex, C. julis, S. ocellatus, S. smaris, S. cinereus, Gobius niger, D. annularis, S. scriba, S. arctus, Pagellus erythrinus, S. mediterraneus and Diplodus sargus being responsible for 70.47% of the differentiation.* 

*D. vulgaris* was one of the most abundant species in the AR during the whole year. Stomach content studies have shown the importance of polychaetes in the diet of this species that are generally found on the substratum of ARs [5]. The species *C. julis, G. niger, B. ocellaris*, the species of the genus *Symphodus* and the species of the family Serrranidae, assembled near the AR in June for reproduction (which takes place in spring, summer), while *D. quadrimaculatus* in January (reproduction takes place

in early spring) [1]. The presence of *P. pagrus, M. surmuletus, S. salpa* and *M. barbatus* increased in October and this could be due to the recruitment of the species that takes place during summer [1]. Furthermore, young individuals of *P. erythrinus, O. vulgaris* and *D. dentex* were found in all sampling periods. It is believed that they use the AR as a nursery area [1, 6].

In conclusion, each season was characterized by certain species that inhabit or visit the AR for spawning or feeding reasons. Young individuals were present inside the AR during the whole year and sexually mature individuals of most species assembled in the protected area during their reproductive period. So the reef can be considered as spawning and nursery ground.



Fig. 1. Dendogram of similarities for 11 stations (cluster analysis, groupaverage linkage) sampled during January, June and October 2002.

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# AGE AND GROWTH OF THE DEEP WATER ROSE SHRIMP PARAPENAEUS LONGIROSTRIS IN THE HELLENIC IONIAN SEA

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# Abstract

The age and growth parameters of the deep water rose shrimp *Parapenaeus longirostris* in the unexploited fishing grounds of the Hellenic Ionian Sea were examined in the present work. The data were collected during four experimental surveys in the framework of one scientific project of HCMR, carried out in the Ionian Sea. The mean modal length and the growth parameters showed that females had higher growth rate of males.

Keywords : Deep Waters, Ionian Sea, Decapoda, Growth.

*P. longirostris* constitutes a valuable target species for most fisheries in the Mediterranean Sea. It is considered one of the most important species of the crustacean fishery in Greece, in terms of landings being very widespread both in the Aegean and Ionian Seas, mainly at depths ranging between 150-400 m. In the Hellenic seas, only very few studies exist on its biology and fishery [1-3].

All samples were collected during four trawl surveys in the northern part of the Hellenic Ionian Sea (eastern Mediterranean Sea) (October 1999, April, July, September 2000) (INTERREG project) at a depth range from 300 to 500 m. The Bhattacharya length-based method as implemented in FiSAT was used to estimate the age. The VonBertallanffy model was used for growth parameter estimation as applied by ELEFAN I programme. The growth index  $\phi$ ' was also estimated for comparison purposes.

The carapace length of females ranged from 8 to35 mm, with the bulk of the stock being between 21-29 mm. In males, in spite of the same range of the carapace length, the majority ranged from 18 to 24 mm, in both areas. Size distributions of males showed 1-2 well-separated modes. Modal groups in females varied from 2 (in April and September 2000) to 3 (September1999, July 2000) well discriminated. The standard deviation and separation index values derived from the length-based analysis indicated well-separated age groups. Autumn months were better represented for both sexes as these included more -well separated- age groups (Table 1).

Tab. 1. Identified mean lengths-at-age from the length-frequency analysis of females and males *Parapenaeus longirostris* during the five seasonal surveys in the Ionian Sea, using the Bhattacharya method.

|       | <i></i>      | FEMALES      | 5           | ~            |
|-------|--------------|--------------|-------------|--------------|
| Madaa | 9/1999       | 4/2000       | 7/2000      | 9/2000       |
| Modes | N=415        | N=274        | N=234       | N=75         |
|       |              | Mean         | n CL        |              |
| 1     | 13,77        | 19,61        | 21,77       | 22,86        |
| 2     | 22,63        | 24,64        | 25,02       | 27,64        |
| 3     | 27,67        |              | 29          |              |
|       |              | MALES        |             |              |
| Modes | 9/1999 N=513 | 4/2000 N=301 | 7/2000 N=67 | 9/2000 N=198 |
|       |              | Mean         | n CL        |              |
| 1     | 12,32        | 18,64        | 21,52       | 21,95        |
| 2     | 21,21        | 24,82        |             | 27,35        |
| 3     | 27,04        |              |             |              |

The parameters of the von Bertalanffy growth equation were estimated as follows: L $\infty$ =33.2 mm, K=0.68 1/yr for males and L $\infty$ =37.2 mm, K=0.76 1/yr for females. Rn was calculated as 0.219 and 0.168 for males and females, respectively. The growth performance index  $\phi'$  was calculated as 2.85 for males, and 3.03 for females. The greater values of L $\infty$ , K and  $\phi'$  and the mean lengths-at-age reinforce the hypothesis that growth is faster in females than males. Similar growth rates for both sexes have been shown in various areas of the Mediterranean [3-4].

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# BLOTCHED PICAREL, SPICARA MAENA L. 1758, IN THE TRAMMEL AND GILL NET CATCHES IN THE AEGEAN SEA (TURKEY)

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# Abstract

In this study, the length frequency distribution, preliminary data of gill and trammel net selectivity and observed sex inversion ratios for blotched picarel in the Aegean Sea are presented. Males were significantly larger than females in mean TL (p < 0.05). Sex reversal was mainly observed when the body length reached 16.0-17.0 cm. Females were observed up to a total length of 18.1 cm. *Keywords : Fishes, Coastal Waters, Aegean Sea*.

# Introduction

The blotched picarel, *Spicara maena* L. 1758, is a common fish species in Turkish waters. It is caught with gill and trammel nets in the Turkish coastal fishery. Published data on the biology and net selectivity of this species are limited. There has been only one study concerning length-weight relationship for this species in Turkish waters [1]. The aim of this study is to give some new information on sex inversion length and preliminary data of trammel and gill net selectivity for the blotched picarel in Turkish waters.

## Materials and methods

Experimental trials were conducted in Gökceada Island (northern Aegean Sea, Turkey), at depths of less than 30 m from April 2004 to February 2005. Multifilament trammel and gill nets of four different mesh sizes (16, 18, 20 and 22 mm bar length) were used. All nets were the same in terms of length, hanging ratio, twine and colour. The constructed nets were also similar to those used by the local fishers. Fish samples obtained by the fishery trials were classified according to their species and the net they have been captured with. A total of 783 *Spicara maena* were analyzed. The student's *t*-test was used to test difference in mean size with sex.

## Results and discussion

Total length of the specimens ranged from 11.0 to 21.9 cm (mean 14.8 $\pm$ 1.9 cm). The length of females (N=133) ranged from 11.5 to 18.1 cm TL (mean 14.6 $\pm$ 1.7 cm) and that of males (N=142) from 13.5 to 21.9 cm TL (17.1 $\pm$ 2.3 cm) (Fig.1). Male picarel was significantly larger than female fish (*p*<0.05).

The blotched picarel is a protogynous hermaphrodite [2]. Dulčić et al.[3] report that in the Adriatic Sea the sex reversal of 56.1% of blotched picarel was observed at lengths between 17.5 and 18 cm; the minimum and maximum sex inversion lengths were 16.7 and 19.8 cm, respectively [3]. In this study, we observed the sex inversion (50% of blotched picarel population) at 16.0 and 17.0 cm TL; we also found that the minimum and maximum sex inversion lengths were 13.5 and 18.9 cm TL, respectively. (Fig.1).

Preliminary data of trammel and gill nets selectivity for blotched picarel are shown in Table 1. The number of captured blotched picarels using gill nets of mesh sizes 16 and 18 mm was more than those captured by other nets. As the mesh size increased, average total length and total weight increased as well.

Tab. 1. Spicara maena. Preliminary data of trammel and gill net selectivity.

| Mesh size | N   | TL        | (cm)     | W (g)      |           |  |
|-----------|-----|-----------|----------|------------|-----------|--|
| (mm)      |     | Range     | Mean±SD  | Range      | Mean±SD   |  |
| 16G       | 249 | 11.0-18.6 | 13.4±1.0 | 12.8-79.8  | 25.6±6.4  |  |
| 18G       | 219 | 12.7-18.9 | 14.7±0.9 | 21.0-77.7  | 34.2±9.3  |  |
| 20G       | 76  | 12.9-19.2 | 15.7±1.5 | 27.1-105.6 | 46.8±16.8 |  |
| 22G       | 34  | 13.0-20.3 | 17.7±1.6 | 31.0-124.4 | 76.6±24.1 |  |
| 16T       | 75  | 11.5-18.5 | 13.6±1.5 | 14.5-79.4  | 27.3±10.8 |  |
| 18T       | 73  | 12.0-20.3 | 14.6±1.6 | 18.8-110.2 | 36.0±16.5 |  |
| 20T       | 47  | 12.8-21.9 | 15.3±2.0 | 22.4-135.3 | 42.4±23.1 |  |
| 22T       | 10  | 16.8-19.0 | 18.2±0.6 | 49.5-85.5  | 72.9±12.2 |  |



Fig. 1. Length frequency distribution for blotched picarel in the Aegean Sea (top) and sex of blotched picarel by length and percentage of females and males in the population (bottom)

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# ALBACORE ( *THUNNUS ALALUNGA* BONNATERRE, 1788 ) FISHERY IN ANTALYA BAY (LEVANTINE BASIN)

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# Abstract

This study presents data on the albacore drift-net fishery which was carried out for the first time in 2006 in the Turkish waters. Fishing was carried out with 18 vessels in Antalya Bay between May and July. The length frequency distribution and length-weight relationship for 171 captured albacore were calculated.

Keywords : Migrant Species, Pelagic, Fisheries, Levantine Basin.

# Introduction

Albacore (*Thunnus alalunga*) is a temperate tuna widely distributed throughout the Atlantic Ocean and the Mediterranean Sea. In the Atlantic, three stocks are commonly recognized by ICCAT (The International Commission for the Conservation of Atlantic Tunas): the northern and southern stocks separated by latitude 5°N, and the Mediterranean stock [1].

Albacore is not a target species in the Turkish waters. It is caught as by-catch in the bluefin tuna purse seine fishery. The catches of albacore had not been recorded for a long time until 2004. The total catch in 2004 was 27 t [2]. In this study, the data of the albacore drift-net fishery, which was carried out firstly in 2006 in the Turkish waters, are presented.

### Materials and methods

Data on the number of fishing vessels, the properties of the nets, fishing areas and non-target species of this fishery which was carried out in 2006 in Antalya Bay (Levantine Basin) were collected on board. Fork length (FL) and weight (TW) of 171 albacore were recorded. The length-weight relationship was calculated by equation  $W=aL^b$ . The obtained coefficients were analysed with ANOVA.

#### Results and Discussion

The albacore drift-net fishery was carried out for the first time between May and July 2006 in the national and international waters in Antalya Bay (Fig. 1). The depth at the fishing grounds ranged from 150 to 2300 m. Albacore fishery was carried out by 18 vessels. These vessels had 14-25 m length and 200-500 engine HP. The drift-nets were approximately 2 km in length and 150 meshes in depth with a 150-170 mm mesh. Illuminated buoys were attached to each side of the net. Nets were set at sunset (20:00 h) and retrieved at sunrise (05:00 h). The fishing period lasted 30-40 days due to the migration of fish, meteorological conditions and the phase of the moon.



Fig. 1. The fishing grounds of albacore in the Levantine Sea

The total catch of the fishing boat, with which this study was realized, was 32 tones. Albacore constituted 94%, swordfish 4% and the remaining fishes 2%.

The total length of albacore ranged from 64.0 to 94.0 cm (mean length 75.7 $\pm$ 0.4 cm (Fig. 2) and the weight from 4.5 to 12.3 kg (mean weight 7.0 $\pm$ 0.1). The length-weight relationship was W= 0.132 x L<sup>2.52</sup> (standard

error of b= 0.095, r=0.927). The slope of the length-weight relationship indicated negative allometry (b<3), and the value of b is similar to that (b=2.88) reported for the Aegean Sea [3].



Fig. 2. Length frequency distribution of albacore caught by driftnets in the Levantine Sea.

Driftnet fishing is a simple method of fishing with a long history of use all around the world. There is, however, a concern that these nets also capture non-target species (e.g. fish near the surface, marine mammals, birds and reptiles) in relatively larger numbers when compared with the non-target catches in demersal trawls [4].

Bluefin tuna (*Thunnus thynnus*), swordfish (*Xiphias gladius*), Atlantic black skipjack (*Euthynnus alletteratus*), bullet tuna (*Auxis rochei*) and dolphinfish (*Coryphaena hippurus*) are non-target species. In this study, no common dolphin, sperm whales and birds were caught, although turtles were trapped in the nets (which, however, were released back into the sea by fishers).

In 2003, ICCAT enforced a recommendation prohibiting the use of driftnets for fishing large pelagic species in the Mediterranean [1]. The driftnet fishery was prohibited in Turkish waters (by the Ministry of Agriculture and Rural Affairs) in September 2006 [5].

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# LINSEED OIL AS AN ALTERNATIVE TO FISH OIL IN THE DIET OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*)

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# Abstract

A feeding trial was conducted to determine whether increasing linolenic acid (18:3n-3) in linseed oil based diets would lead to increased tissue deposition of 22:6n-3 in Nile tilapia (*Oreochromis niloticus*). The study suggests that Nile tilapia has a limited capacity to synthesize 20:5n-3 and 22:6n-3 from dietary 18:3n-3. The replacement of fish oil in the diet of farmed tilapia with vegetable oils could therefore lower tissue concentrations of 20:5n-3 and 22:6n-3, and consequently produce an aquaculture product of lower lipid nutritional value for the consumer.

Keywords : Aquaculture, Diet, Fishes.

# Introduction

Today industrialized societies are characterized by an increase in energy intake, saturated fat and n-6 polyunsaturated fatty acids (PUFA) and a decrease in n-3 PUFA intake [1]. This nutritional status has lead to many modern human health disorders [2]. It is recommended to increase the intake of n-3 PUFA, and particularly 20:5n-3 and 22:6n-3, and decrease the dietary intake of n-6 PUFA in the human diet [3]. Fish and marine mammals are by far the richest source of long chain n-3 PUFA in nature. As the farming of fish is becoming a major contributor to world fish supplies, it is important for the aquaculture sector to maintain the high lipid nutritional quality of the product and continue to provide large amounts of the health-promoting n-3 PUFA for the consumer.

# Materials and Methods

Male sex-reversed tilapia fry (*Oreochromis niloticus*) of initial weight 0.5-2 g were grown on five isonitrogenous (32% crude protein) and isoenergetic (17 KJ/g diet) diets that were supplemented with 3% of either a blend of refined palm olein oil with linseed oil (PO-LO 3:2) or a blend of linseed oil with refined palm olein oil (LO-PO 2:1) or linseed oil (LO), fish oil (FO) and corn oil (CO). The fish were stocked into 6 replicate net cages (3 m x 1.8 m x 0.8 m, 3 mm mesh size) per dietary treatment that were suspended in an earthen pond (40 m x 40 m x 1 m). After 20 weeks of feeding, 30 fish from each treatment were taken, the dorsal muscle tissue of each was dissected and used for fatty acids analysis. The fatty acid analysis was performed by using gas liquid chromatography [4]. The fatty acid composition of the five treatments was subjected to one-way analysis of variance (ANOVA) and differences were considered significant at an alpha value of 0.01.

### Results and Discussion

The results suggest that LO and its blends with PO could totally replace fish oil without any negative effects (P>0.01) on the growth, feed efficiency and survival of Nile tilapia. The muscle content of 18:2n-6 and 18:3n-3 strongly reflected dietary intake with the highest (P<0.01) amounts of 18:2n-6 in fish fed the CO diet and 18:3n-3 in fish fed the LO diets, while fish fed the FO diet contained the highest (P<0.01) amounts of long-chain n-3 PUFA (Table 1). The inclusion of increasing levels of LO in the diet, and thus graded amounts of dietary 18:3n-3, resulted in commensurate increases in tissue 18:3n-3 and all n-3 PUFA pathway anabolites. Therefore, the PUFA biosynthetic pathways are active in Nile tilapia. However, when comparing the FA compositions of the LO-based treatments with those of FO-fed fish, it is becoming clear that the conversion of 18:3n-3 to longer chain n-3 PUFA derivatives is not efficient, and particularly the synthesis of 20:5n-3 and 22:6n-3 is low (P>0.01). These findings are in agreement with studies in other fish species [4, 5] fed on vegetable oil (VO) diets. This is a conclusion of great importance indicating that the replacement of FO with VO in diets for farmed fish lowers their content of the nutritionally important long-chain n-3 PUFA.

It is recommended that VO alternatives that are rich in 18:3n-3 and low in 18:2n-6, such as LO, are used if the replacement of FO in fish feeds become inevitable. The inclusion of LO can maximise the retention of desirable 20:5n-3 and 22:6n-3 and can minimise the deposition of undesirable long-chain n-6 PUFA in the edible muscle tissue of fish compared to a VO is rich in 18:2n-6.

Tab. 1. The fatty acid compositions (ug/mg of TL) of muscle TL of fish fed the five diets at the end of the 20-week feeding period. Values are the mean of 6 replicate groups of 6 fish ( $\pm$  S.D.). Values in the same row, which do not share the same superscript letter (i.e. a, b, c, d, e) are significantly different at a=0.01; n.d., not detected.

| Fattyacid        | PO-LO                       | LO-PO                       | LO                          | FO                           | CO                        |
|------------------|-----------------------------|-----------------------------|-----------------------------|------------------------------|---------------------------|
| 18:2n-6          | 59.67±6.35 <sup>ª</sup>     | 58.84 ± 5.20 <sup>°</sup>   | 61.78 ±2.54                 | 38.83 ± 2.70 <sup>b</sup>    | 10895±1620                |
| 18:3n-6          | $1.46 \pm 0.18^{a}$         | 1.45 ± 0.15 <sup>a</sup>    | 1.17 ±0.09 <sup>ab</sup>    | $0.92 \pm 0.11^{b}$          | 2.59 ±0.38 <sup>C</sup>   |
| 20:2n-6          | 4.61±0.43 <sup>a</sup>      | 4.06 ± 0.30 <sup>ab</sup>   | 3.85 ±0.21 <sup>b</sup>     | 2.79 ± 0.15 <sup>C</sup>     | $9.08 \pm 1.12^{d}$       |
| 20:3n-6          | 5 23 ± 0.63 <sup>a</sup>    | 4.61 ± 0.18 <sup>ab</sup>   | 3 91 ±0.43 <sup>b</sup>     | $3.09 \pm 0.22^{\circ}$      | $9.10 \pm 1.42^{d}$       |
| 20:4n-6          | 11.14 ± 1.65 <sup>a</sup>   | 9.65 ± 0.85 <sup>a</sup>    | $8.96 \pm 1.12^{a}$         | 9.59 ± 0.70 <sup>a</sup>     | 19.23 ± 3.19 <sup>b</sup> |
| 22:4n-6          | 3.40±0.38 <sup>b</sup>      | $2.78 \pm 0.24^{ab}$        | $2.31 \pm 0.29^{a}$         | $2.63 \pm 0.30^{a}$          | 6.80 ±0.78 <sup>C</sup>   |
| 22:5n-6          | 595±0.90 <sup>b</sup>       | 4.85 ± 0.43 ab              | 4.18 ±0.84 <sup>a</sup>     | $4.18 \pm 0.37^{a}$          | 15.56 ± 2.39 <sup>C</sup> |
| Totaln-6 PUFA    | 91.46±9.22 <sup>a</sup>     | 86.24 ± 6.72 <sup>a</sup>   | 86.17 ±4.26 <sup>a</sup>    | 62.04 ± 4.04 <sup>b</sup>    | 17130 ±2192 <sup>6</sup>  |
| 18:3n-3          | 25 25 ± 3.68 <sup>a</sup>   | 3698±5.73 <sup>b</sup>      | 54 57 ± 5.89                | $596 \pm 1.16^{d}$           | $4.85 \pm 1.12^{d}$       |
| 18:4n-3          | $0.63 \pm 0.07^{a}$         | 0.85 ± 0.24 °               | 0.89 ±0.18 <sup>a</sup>     | $0.81 \pm 0.14^{a}$          | 0.08 ±0.11 <sup>b</sup>   |
| 20:3n-3          | 5.47±0.85ª                  | 7.47 ± 0.86                 | 11.14 ±0.63 <sup>C</sup>    | $1.06 \pm 0.21^{d}$          | $131 \pm 0.23^{d}$        |
| 20:4n-3          | $1.40 \pm 0.18^{a}$         | $1.82 \pm 0.18^{b}$         | $2.26 \pm 0.18^{\circ}$     | $1.73 \pm 0.17^{ab}$         | 0.23 ±0.15 <sup>d</sup>   |
| 20:5n-3          | $2.76 \pm 0.39^{a}$         | 3.18 ± 0.39 <sup>ab</sup>   | 4.00 ±0.41 <sup>b</sup>     | 8.47 ± 0.53 <sup>C</sup>     | 1.09 ±0.29 <sup>d</sup>   |
| 22:4n-3          | 0.54±0.16 <sup>a</sup>      | 0.68 ± 0.15 <sup>ab</sup>   | 0.90 ±0.13 <sup>b</sup>     | $0.11 \pm 0.13$ <sup>C</sup> | nd                        |
| 22:5n-3          | $7.42 \pm 0.76^{a}$         | 824 ±0.81 <sup>a</sup>      | 8 98 ±0.76 <sup>a</sup>     | 2037±193 <sup>b</sup>        | 4.53 ±1.05 <sup>C</sup>   |
| 22:6n-3          | 40 95 ± 5.51 <sup>ab</sup>  | 42.05 ± 2.96 <sup>b</sup>   | 44 99 ±6.48 <sup>b</sup>    | 86.98 ± 8.74 <sup>C</sup>    | 29 23 ±4 43 <sup>a</sup>  |
| Totaln-3 PUFA    | 84.42±9.93 <sup>b</sup>     | 101 28 ± 10 53 <sup>b</sup> | 127.72 ±7.26 <sup>C</sup>   | 125.49 ± 10.08 <sup>C</sup>  | 4131±6.04 ª               |
| Total PUFA       | 175 89 ± 18 95 <sup>°</sup> | 187.51 ± 17.03 ab           | 213 89 ± 10 64 <sup>b</sup> | 187.53 ± 13.29 <sup>ab</sup> | 21261 ±2260b              |
| n-3 /n-6 PUFA    | 092±0.03 <sup>a</sup>       | $1.17 \pm 0.05^{b}$         | $1.49 \pm 0.07^{\circ}$     | $2.02 \pm 0.12^{d}$          | 0.25 ±0.05 <sup>e</sup>   |
| Total saturate d | 180 .04 ± 18 .00            | 178.19 ± 16.05              | 167.17 ± 14.51              | 189 23 ± 9.42                | 175.11 ±24.21             |
| Totalmonoenes    | 156 28 ± 25 96              | $14928\pm22.87$             | $123\ 33\ \pm\ 16\ 21$      | 143.85 ± 9.72                | $13823\pm27.86$           |
| TotalDMA         | 14.18 ± 2.41                | 13.65 ± 1.56                | 14.49 ±0.73                 | 13.06 ± 0.85                 | 13.27 ±2.02               |
| Total FA         | 526 39 ± 51 96              | 528.64 ± 55.68              | 518.88 ±37.60               | 533.67 ± 27.07               | 539.22 ±67.42             |

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# BATCH FECUNDITY OF PICAREL SPICARA SMARIS (L.) IN THE SARONIKOS GULF (GREECE)

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# Abstract

Relative batch fecundity was studied for the multiple spawner *Spicara smaris* in the Saronikos Gulf (Greece) and compared with fecundity values reported in Greek waters. The picarel relative batch fecundity was estimated by the hydrated and migratory-nucleus method and was found to be equal to 339 oocytes per g fish weight.

Keywords : Aegean Sea, Demersal, Fishes, Spawning.

## Introduction

Picarel (*Spicara smaris* L.), is a very common species in the Mediterranean and the Black Sea but it is also found in the eastern Atlantic from Portugal to Morocco including the Canary Islands, inhabiting *Posidonia* beds and muddy bottoms at about 15-100 m [1]. The national catch recorded for 2003 was 4025 t constituting 5% of the total fish yield in Greek waters [2]. The fecundity of picarel has been estimated in Greek waters by counting the total number of oocytes above a certain size threshold [3]. However, this method results in the underestimation of the potential annual fecundity of a species characterized by batch spawning. Picarel is a multiple spawner [4] with a peak of spawning in April-May in the Saronikos Gulf [5]. Batch fecundity of picarel has been primarily estimated in the Saronikos Gulf [5]. In the present work additional females were examined and the overall batch fecundity estimate is compared with fecundity values eported in Greek waters.

## Materials and Methods

Samples of picarel were monthly collected in the Saronikos Gulf during 2003 from February to March by beach seiners and in April and May by nets and trawlers respectively. Specimens were randomly taken from the catch and were measured (total length) to the nearest mm and sexed; their total weight was measured to the nearest g. Females were classified to reproductive stages according to Nikolsky's [6] scale. Ovaries of macroscopically mature females (greater than stage II) were removed, weighed to the nearest 0.1 g and preserved in 10% neutral buffered formalin for histological examination. A piece of each preserved ovary was then dehydrated and embedded in paraffin wax. Sections (3 micron) were taken and stained with Harrish aematoxylin followed by eosin counter stain (H+E). From each ovary two subsamples of approximately 0.050 g were taken and after connecting membrane removal, were weighed to the nearest 0.001 g. The diameters of each oocyte in both subsamples were measured under the stereoscope using the Image Analysis Pro Plus 5.0 and the mean values were taken. Batch fecundity (Fb, number of oocytes per spawn) was taken to be the number of migratory-nucleus stage oocytes (MN) or the number of hydrated oocytes (H), still within their follicles, in the ovary [7]. The estimation of  $F_b$  was done by the gravimetric method [8]. Hydrated oocytes were easily recognized by naked eye. During histological examination it was also observed that the diameter of an oocyte with migratory nucleus ranged from 500 to 800 micron. Therefore, the size of 500 micron was taken as a threshold in order for all the migratory-nucleus stage oocytes to by counted. The ovaries used to estimate  $F_b$  were taken from samples at the peak of spawning (April-May).

#### Results and Discussion

The presence of post ovulatory follicles (pofs) in some ovaries in March showed that the spawning period has already started, while in February samples no spawning characteristics existed (MN, H or pofs). Thirty eight appropriate ovaries (10 with H oocytes and 28 with MN oocytes) ranging in weight from 7.1 to 50.2 g (ovary-free weight) were used for batch fecundity estimation. The numbers of oocytes per g fish weight between spawning states (MN and H) did not differ significantly (ANOVA, P=0.26). The relation between female weight (W, without ovary weight) and batch fecundity (F<sub>b</sub>) was determined by linear regression analysis. In the resulting equation:  $F_b = 369.1 + 321.7$  W with R<sup>2</sup>=84.3%, the intercept for the regression of  $F_b$  to W did not differ from zero (t=0.68). Therefore, the regression line (Fig. 1) was forced through zero (by multiple regression: [9]), weighting the regression line by the inverse of fish weight for each observation, in order that a minimum variance and unbiased estimates of regression coefficients could be obtained [7]. Thus, the resulting equation was:  $F_b = 339$  W with R<sup>2</sup>=96.0% and confidence interval equals to 316-362. Accordingly, the relative batch fecundity  $(F_{bw})$  was estimated as  $F_{bw} = 339$  oocytes per g fish weight. Vidalis [3] estimates for the same species in Greek waters the relative fecundity equal to 358 oocytes per g fish weight. Although this author has used a size threshold (250 micron) for counting the total of oocytes to be mature, his estimation should be considered as underestimated when compared to the present work, as batch fecundity represents here only the number of oocytes for one spawn (339 oocytes per g fish weight).



Fig. 1. Batch fecundity ( $F_b$ ) of picarel, *Spicara smaris*, as a function of female weight (W, ovary-free). Batch fecundity was estimated by counting hydrated oocytes (triangles) or migratory-nucleus stage oocytes (squares). Regression line (forced through zero) is: Fb=339 W.

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# DIVERSITY AND DISTRIBUTION OF ASTEROIDEA (ECHINODERMATA) WITHIN THE BAY OF BOKA KOTORSKA (ADRIATIC SEA, MONTENEGRO)

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# Abstract

The diversity and distribution of the asteroids in the Bay of Boka Kotorska (Adriatic Sea, Montenegro) were studied for the first time in 30 years. Two species, *Ophidiaster ophidianus* (Lamark, 1816) and *Hacelia attenuata* (Gray, 1840), are new records for the Bay of Boka Kotorska.

Keywords : Adriatic Sea, Echinodermata.

The Bay of Boka Kotorska penetrates about 20 km inland, and because of its complex geography, enjoys unique physico-chemical characteristics, that differ greatly from the open Montenegrin coast. The environmental features impact the diversity and distribution of the local asteroid fauna. The mention on the sea stars of Boka Kotorska bay is found in [1]. Subsequent authors [2-4] added to that knowledge.



Fig. 1. Bay of Boka Kotorska (Adriatic Sea, Montenegro) with studied positions

We studied 9 localities within the bay (fig. 1). Material was collected from may 2005 to may 2006, by diving, to depths of about 30 meters. Collected material was preserved by drying or in 70% ethanol and labeled according to ERMS [5].

We identified 8 asteroid species in an area of about 36km<sup>2</sup>. The most frequent species, found at all stations, were *Echinaster sepositus* (Retzius, 1783) and *Marthasterias glacialis* (Linnaeus, 1758) - species of wide ecological distribution, inhabiting different types of bottom. *Marthasterias glacialis* (Linnaeus, 1758) and *Coscinasterias tenuispina* (Lamarck, 1816) are known as predators in the shellfish farms in the Bay of Boka Kotorska [6]. *Astropecten aranciacus* (Linnaeus, 1758), *Astropecten platyacanthus* (Philippi, 1837), all widely distributed [7], were numerous. Two thermophilic species: *Hacelia attenuata* (Gray, 1840) and *Ophidiaster ophidianus* (Lamark, 1816), consitute new records for the Bay. They are known to inhabit the southern Adriatic Sea, where impact of warm Mediterranean current is strong. They were found on hard substrates, i.e. bedrock and cliffs, from shallow water up to 30 m, in the outer part of the Bay.

Our one-year investigation confirmed the presence of 8 out of 10 species of sea stars that had been recorded from Boka Kotorska Bay, about half of the species known from the Montenegrin shelf. While previous investigations relied on sampling by trawl net, grab and dredge, which are forbidden today, our research was based exclusively on scuba diving.

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# ÉTUDE COMPARATIVE DE LA CROISSANCE RELATIVE SAISONNIÈRE CHEZ LE BIVALVE LITHOPHAGA LITHOPHAGA (LINNÉ, 1758) PRÉLEVÉ DANS LA LAGUNE ET LA BAIE DE BIZERTE (TUNISIE)

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# Résumé

La croissance relative du bivalve *Lithophaga lithophaga* a été étudiée pendant l'été et l'automne dans la Baie de Bizerte en 2002 et dans la lagune de Bizerte en 2004. Les résultats ont montré que la population lagunaire croit plus en chair et en coquille que celle de la baie. *Mots clès : Mollusca, Bivalves, Infralittoral, Biometrics, Growth.* 

# Introduction

*Lithophaga lithophaga* est un mollusque endolithe des roches essentiellement calcaires, vit dans la zone infralittorale entre deux et huit mètres [1]. Ce bivalve est présent dans pratiquement tout le bassin méditerranéen, en mer Rouge, et en Atlantique, du Maroc au Sénégal. La datte de mer fait parti des espèces menacées et les études relatives à sa biologie sont rares. C'est pourquoi l'objet de ce présent travail a été l'étude de la croissance de la datte de mer en Tunisie.

## Matériels et Méthodes

Des prélèvements mensuels de blocs hébergeant *L. lithophaga*, ont été effectués pendant l'été et l'automne 2002 dans la baie de Bizerte et en 2004 dans lagune de Bizerte à une profondeur variant de trois à quatre mètres. L'extraction de 120 à 150 individus est réalisée au laboratoire suite à la destruction de la roche. Les spécimens, renfermant toutes les classes de taille, ont servi à l'étude comparative de l'évolution saisonnière des paramètres morphomètriques (la largeur : l et l'épaisseur : E) et pondéraux (poids de la chair sèche: Wch-s et le poids sec de la coquille: Wcoq-s) par rapport à une grandeur de référence: la longueur antéropostérieure. Le traitement statistique des données a été effectué à l'aide du test t de Student calculé au seuil de 5 % et des tests de pente (tpe) et de position (tpo).

# Résultats

Les valeurs du coefficient de corrélation montrent une étroite corrélation entre les paramètres étudiés deux à deux.

#### Relation largeur - Longueur

Les valeurs du test t révèlent une allométrie majorante en automne. La largeur croit plus rapidement que la longueur antéro-postérieure dans les deux stations. Entre les deux milieux, les valeurs du test de pente tpe (2.91>1.96), montre une différence significative de croissance entre les deux stations. Cette différence est en faveur de la population marine pour des tailles inférieures à 20mm. En été, la croissance de ces deux paramètres est la même en lagune. Par contre, en mer, l'allométrie est majorante (tab. 1). Le test de pente montre une croissance significativement différente entre les deux stations, elle est en faveur de la population marine pour les tailles inférieures à 55mm.

### Relation Epaisseur - Longueur

Les valeurs du test t montrent une allométrie majorante. Entre les deux stations, la croissance est différente (tpe = 2.56), elle est en faveur de la population lagunaire pour les tailles supérieures à 21 mm. En été, l'allométrie se maintien majorante en mer et devient isométrique en lagune. Le test de pente tpe supérieur à 1.96 montre une croissance différente entre les deux stations. La population de la lagune croit mieux que celle de la mer à partir d'une taille de 35 mm.

#### Relation poids de la chair sèche - Longueur

En automne, les valeurs du test de student reflètent une allométrie minorante pour la population lagunaire et majorante pour celle de la baie. Le test de pente révèle une différence très significative au niveau de la croissance entre les deux stations. La croissance de la chair sèche est meilleure en lagune quelque soit la longueur du bivalve. En été, l'allométrie est minorante pour les deux stations. Le test de pente n'a révélé aucune différence significative. Le test tpo montre une différence significative en faveur de la population lagunaire ayant une taille supérieure à 50 mm. Relation poids de la coquille sèche - Longueur

Les valeurs automnales de la pente révèlent une allométrie minorante dans les deux stations (tabl. 1). Le test tpe montre une différence significative entre les deux milieux en faveur de la population lagunaire quelque soit la taille du bivalve. En été, l'allométrie se maintien minorante. Les tests de pente et de position révèlent une différence significative en faveur de la population lagunaire et ce à partir de la taille 59mm.

Tab. 1. Coefficients de corrélation entre les paramètres suivants: longueur (L), largeur (l), épaisseur (Ep) de la coquille, poids de la chair sèche de la partie molle (Wch-s), poids sec de la coquille (Wcq-s).



#### Conclusion et discussion

La croissance en lagune des différents paramètres morphométriques est meilleure qu'en mer et ce pour les spécimens d'une taille supérieure à 20-25mm. S'agissant des paramètres pondéraux, la croissance, en automne, se maintien en faveur de la population lagunaire quelle que soit la taille, alors qu'en été, c'est à partir de la taille 50-60mm. Selon [1], la température et l'activité sexuelle constituent deux facteurs déterminants dans la croissance somatique et/ou gonadique de la datte de mer. [2] considèrent que la croissance est fonction également de la disponibilité ou non de nourriture dans le milieu environnant. Il est donc très probable que les conditions de la lagune de Bizerte sont plus favorables à la croissance. Reste à vérifier, parmi les travaux en cours, la qualité sanitaire et microbiologique de la chair dans les deux milieux.

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# A PRELIMINARY STUDY ON THE FISH COMMUNITY STRUCTURE AROUND GOKCEADA ISLAND, NORTH AEGEAN SEA, TURKEY Cetin Keskin \* and Muammer Oral

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# Abstract

This preliminary study was carried out in the mixed habitat (*Posidonia aceanica* and rocky) around Gokceada Island. Samples were collected with gill net and trammel net. A total of 2265 individuals were collected belonging to 44 species. *Chromis chromis, Spicara maena* and *Serranus scriba* were the most dominant species. Juvenile or sub-adult represented 16.6% of the total number of individuals. Diversity, species richness, evenness, and dominance had optimal values in May.

Keywords : Fishes, Biodiversity, Aegean Sea.

# Introduction

Nearshore seagrass beds (*Posidonia oceanica*, *Zostera* spp., *Cymodocea nodosa*) are important areas having higher diversity and abundance of fish than nearby bare substrata [1, 2]. High structural complexity of vegetated habitat provides shelter, food and refuge for resident and temporary species [2, 3]. This study provides preliminary data on the fish community structure in a mixed habitat (*P. oceanica* and rocky) around the Gökceada Island.

#### Materials and methods

The sampling was carried out from March to August in 2003 in a mixed habitat (*Posidonia aceanica* and rocky) around Gokceada Island. Samples were collected with gill nets (mesh size: 22 mm; 120 m x 2.4 m) and trammel nets (mesh size: 18 mm; 180 m x 0.9 m), which were set from 5 to 10 m depth. Sampling took place four times per month. The number of individuals per species was determined in the laboratory. Community structure was approached by estimating diversity (H), species richness (D), evenness (J), and dominance (C) [4].

# Results and Discussion

A total of 44 species were collected belonging to 24 families. This is a high value, considering also the short time of sampling, when compared with other studies in the same area [5]. The number of species was highest for the families Labridae (9 species) and Sparidae (8 species). *C. chromis* (23.2%), *S. maena* (18.8%) and *S. scriba* (10.6%) were the dominant species in terms of total number of individuals. *S. scriba* (seranidae), *Symphodus mediterraneus, S. tinca* (Labridae), *Diplodus annularis, D. vulgaris, Sarpa salpa* (Sparidae), and *Scorpaena porcus* (Scorpaenidae) were the most common and abundant species (Figure 1). These are typical in the Mediterranean coastal waters [3, 6]. Similar results were obtained in this study.



Fig. 1. Numerical percentage composition of most abundant species sampled around Gokceada Island from March to August in 2003.

Juveniles represented 16.6% of the total number of individuals, and their numbers increased from March to August. The number of species and individuals increased from March to May (Fig. 2). The diversity, species richness, evenness and dominance generally had optimal values in May (Fig. 2). Conclusively, the coastal waters of Gokceada Island represent

an inportant area with different habitat types for resident and temporary species.



Fig. 2. The number of individuals (N), number of species (S), evenness (E), species richness (D), diversity (H), and dominance (C) around Gokceada Island, March to August in 2003.

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# REPRODUCTIVE ASPECTS OF *MELICERTUS KERATHURUS* (DECAPODA: PENAEIDAE) FROM THE THERMAIKOS GULF (N. AEGEAN SEA)

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# Abstract

Aspects of the reproductive biology of *Melicertus kerathurus* were investigated in Thermaikos Gulf (N. Aegean Sea) from October 2000 to September 2002. Temporal variations in mated females percentage, gonad maturation and gonadosomatic index showed that reproduction begins in spring, peaks in summer and extends to October. Managerial measurements are discussed in relation to the present results. *Keywords : Aegean Sea, Reproduction, Decapoda.* 

## Introduction

The prawn *Melicertus kerathurus* is one of the most valuable resources for both the otter-trawl and artisanal coastal fisheries in the Thermaikos Gulf. Information on its catch rates, size structure and sex ratio has been published only recently [1]. The present work provides the first data on its reproduction.

#### Material and Methods

During two open fishing seasons (October to April 2000-01 and 2001-02) a monthly sampling schedule was followed on board commercial otter-trawlers. Due to unprofitable catches and consequently to fishermen's change of fishing target, samples were obtained from the artisanal fishery in May 2001 and 2002. During the closed season, experimental trawling was carried out (June and September 2001; July, August and September 2002), and additional samples were obtained from the artisanal fishery (June and July 2002). Female carapace length (CL, mm), body (BW, g) and gonad (GW, g) fresh weight, and spermatophore presence were recorded. The gonadosomatic index (GSI) was estimated as GSI = (GW/BW)x100. Ovary maturation was assessed using a five-stage ovary scale [2].

#### Results and Discussion

Out of the 7,206 females studied, about half (3,682) were found to be mated (size range 25.31 - 57.7 mm CL). Between April and July, more than 80% of the females were mated decreasing sharply in August-September (Fig. 1). Comparable maximum mating activity has been reported from Cadiz (Atlantic) [2] and Gabès (Tunisia) [3], while in Amvrakikos Gulf (E. Ionian Sea) maximum frequencies were much lower [5]. In contrast to the Gadiz and Amvrakikos populations, mating activity of the Thermaikos population was significant also during winter. The lowest monthly GSI was observed in winter, steadily increasing thereafter to a maximum in July, and sharply decreasing in August (Fig. 1). A slight increase was also observed in October. In general, GSI monthly values were much lower that those reported from the Atlantic [2].



Fig. 1. *Melicertus kerathurus* from the Thermaikos Gulf: temporal variations of mated females frequency (dashed line) and gonadosomatic index (GSI) (solid line).

In accordance with other geographical locations, the reproductive period of *M. kerathurus* extends from mid spring to early autumn with a June-July peak: high frequency (50-92%) of female maturity stages (ST) 3 and

4 coincided with that of mated individuals (April to July) (Fig. 2). The smallest spawning female had a size (32.24 mm CL) which was between those reported from Amvrakikos [4] and Smirni (Izmir) [6].



Fig. 2. *Melicertus kerathurus* from the Thermaikos Gulf: monthly percentages of ovary maturation stages; ST 1 = undeveloped, ST 2 = developing, ST 3 = early maturing, ST 4 = fully mature, and ST 5 = spent.

Regarding resource management, the trawl banning from June to September implemented in the Greek fishery seems to cover most of the prawn reproductive season. In that period, however, the artisanal fleet targets prawns in shallow waters, where it migrates for spawning. A closed period exists also for the artisanal fishery  $(10^{th} \text{ July-}10^{th} \text{ September})$ , but, according to the present results, it seems to be inefficient, as it covers only partially the main period in which females are functionally reproductive (May to July).

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# A NEW METHOD FOR THE INVASIVE WHELK (RAPANA VENOSA) FISHERY IN THE BLACK SEA

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# Abstract

A new method, utilising pots, was succesfully applied for the Rapa whelk fishery in the Black Sea. Blue mussel and fish offal were used as bait to attract whelks. In addition to food preference, additional experiments on whelk speed and pot attraction are conducted. A monthly sampling program has been set up to understand effectiveness of this new gear throughout the year. The advantages and disadvantages of this method are discussed.

Keywords : Gastropods, Fisheries, Black Sea.

# Introduction

The veined Rapa whelk, *Rapana venosa* (syn. *R. thomasiana*) is one of the most important species in the Black Sea after its introduction in 1946 [1] from the far-east. By voraciously feeding mainly on mussels, oysters and other bivalves, its damage on the benthic ecosystem of the Black Sea is devastating. from the Black Sea, it is believed to be transported to Cheaspeake Bay where it is also causing great ecological damage.

Ironically, because of its export value for the far-eastern countries, it became also an important fishery target, and there are regulations to protect its abundant stocks in the southern Black Sea. There are two main methods to catch this species: dredging and diving. The former method damages many other benthic species, and the latter is very risky for the fishermen's health.

We tested "Pots" to catch this species in the Black Sea. Pots were extensively used for the fishery of common whelk in the northern Atlantic [2]. Its use was first mentioned by the first author to local scientists in the 1993, however, its successful application in the Black Sea was realised first time in September 2003, in Sinop Harbour.

## Material and Methods

Since April 2006, monthly sampling using pot system has been performed in this region. Three sets of 10 pots are being used for this aim. The bait used includes bivalve, fish offal and mixture of these.

Each pot is basically a 30 lt hard, thick (4 cm) plastic container (32x28x42 cm) having cement weight in their bottom (10 cm high), to keep the pot always at upright position) and a sole opening at the top covered with an inward net to prevent exit of caught whelks (see Fig. 1).



Fig. 1. General view of the pot.

The walls of the pot has been drilled with tens of holes (12 mm in diameter) around, both to let the smell of bait and to let smaller individuals go. The distance between a set of 10 pots is 10 m. Further details on this gear will be given in the final report. The pots are generally left at sea for three days, at 15, 25 and 35 m depths simultaneously.

#### Results and Discussion

Whelks were successfully caught with the trap (Table 1). Attracted to the bait smell, whelks climbed up along the outside pots, and entered through the net.

Tab. 1. Monthly average numbers and weights of whelks caught during 2006.

|           | Depth (m) |    |    |     |     | Total \A/(m) | A ( )   |
|-----------|-----------|----|----|-----|-----|--------------|---------|
| Months    | 15        | 25 | 35 | ;   | т   | Total VV (g) | Avr (g) |
| April     | 170       | 38 | 7  |     | 215 | 13328        | 61      |
| May       | 87        | 50 | 15 | ; ; | 152 | 11769        | 77      |
| June      | 150       | 6  | 5  | 1   | 161 | 12372        | 76      |
| July      | 52        | 9  | 27 | 1   | 88  | 7866         | 89      |
| August    | 132       | 3  | 5  | 1   | 140 | 9942         | 71      |
| September | 271       | 40 | 91 |     | 402 | 23096        | 57      |
| Average   | 144       | 24 | 25 | ;   | 193 | 13062        | 72      |
| StdDev    | 75        | 19 | 32 | 2   | 110 | 5283         | 10      |

The smallest whelk caught was 12.8 mm in width, confirming that smaller ones were possibly able to get out. Average number of whelks caught monthly in April-September 2006 was 193 and about 13 kg from a total of 30 pots. Although this number is smaller than those caught by a daily diving and individual dredging operation (589 and 1618 ind. in August 2006), the new method has the advantage of (a) environmentally-friendly for the sea bottom (b) no risk to human life, (c) fishing of targeted whelk size and (d) very few by-catch individuals. However, lower catch rates and the use of bivalve as bait are the disadvantages of the pot method. Our efforts are continuing to overcome these disadvantages.

# Acknowlegements

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# DISTRIBUTION OF CAULERPA RACEMOSA (FORSSKÅL) J. AGARDH AND RELATIONSHIP WITH POSIDONIA OCEANICA (L.) DELILE IN DATCA BOZBURUN SPECIALLY PROTECTED AREA

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# Abstract

Present study reflected the general distribution of *Caulerpa racemosa* in Datça-Bozburun SPA. Results pointed out that the invasive *Caulerpa racemosa* is most frequently distributed below 38 m where the bottom limit for the distribution of *Posidonia oceanica* is. *Keywords : Algae, Posidonia, Marine Parks.* 

# Introduction

*Caulerpa racemosa* is described as an invasive species in Mediterranean Sea [1]. The main difference between *C. racemosa* and the other alien invasive species *Caulerpa taxifolia* in Mediterranean Sea is the opportunistic nature rather than the invasive characteristic, since success of *C. racemosa* depends on the failure of other species in the environment instead of the domination [2-3]. This study pointed out to the distribution of lessepsien and invasive marine algae *C. racemosa*, its sighting frequency depth dependency, the percentage of the species sighted within *C. racemosa* and relationship with *Posidonia oceanica* in Datça-Bozburun SPA.

# Materials and Methods

Data is collected by SCUBA divers, 831 SCUBA dives and 27 quadrate count were performed in 2002-2004. In quadrate studies, each group studied facieses at 10, 20, 30, 40 and 50 m depth using 1 m2 square quadrates divided into 400 cm2 (20x20) (a total of 25) squares.

### Results and Discussions

Under water observations indicated that the distribution of *C. racemosa* in the area is between 0.5-70 meters. Its distribution is higher on the sandy substratum between 40-50 meters. These depths are the bottom limits of *P. oceanica* (>40m). In the south of the Datca Peninsula, especially at the region between Datca town center and Knidos, *C. racemosa* was widely distributed at in almost all depths below 40 m. The *C. racemosa* distribution in the north of Datça Peninsula was very close to the southern region (Figure 1). Pollution and physical destruction (anchoring, fish farms) has negative effects on *P. oceanica* distribution and has caused serious facies loss. Important pollution load due to settlements and tourism activities was observed in some areas and negative effects of this pollution on *P. oceanica* meadows were detected [3].



Fig. 1. Distribution of Caulerpa racemosa.

Distribution of *C. racemosa* was detected in 17 quadrate stations out of 27. *C. racemosa* was detected only once between 10 and 20 m contours, 5 times at 30 m contour, 13 times at 40 m contour and 5 times at 50 m contour. *C. racemosa* was observed with *P. oceanica* in all contours except 50 m. Most frequent groups observed with *C. racemosa* were Thallophyta (39%) and Magnoliopyhta (24%) (Table 1).

Detailed studies performed pointed out that there is an important invasion threat by *C. racemosa*. At regions where *P. oceanica* is damaged the advantage is shifted to *C. racemosa*, *P. oceanica* is very sensitive to any kind of alterations in the ecosystem and physical destruction.

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Fig. 2. Frequency of species groups sighted with C. racemosa.

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# GAMETE RELEASE AND GONAD SIZE IN THE SEA URCHIN *PARACENTROTUS LIVIDUS* FROM FOCA, TURKEY

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# Abstract

Specimens of the edible sea urchin, *Paracentrotus lividus*, were collected monthly from Foca, on the Aegean coast of Turkey, between February 2003 and January 2004. The length and weight of the gonad lop was measured. *P. lividus* maximal gamete release occurs in late winter. A significant relationship was found between gonad lop length and weight ( $p \le 0.05$ ). *Keywords : Aquaculture, Echinodermata, Aegean Sea, Mollusca.* 

# Introduction

*Paracentrotus* (Lamarck) is the most abundant echinoid species in Mediterranean littoral community and plays an important role in the development of benthic macrophyties [1]. Sea urchin gonads, also know as roe or uni, are highly valued seafood commodities and are considered as delicacies in many parts of the world [2] thus they are popular. The aim of the present study was to determine peak time of gamete release and to observe the relationship between gonad lop length and weight.

#### Material and Method

*In situ*, specimens of *P. lividus* were collected from Foca between February 2003 to January 2004 (0380 43, 80, N; 0260 44, 00, E), Izmir. All individuals were dissected into two parts and five gonad lops were measured and weighted individually. The present study defines gamete release individuals as those with gametes that ooze from the gonads. The percentage of gamete releasing individuals were calculated using Microsoft Excel Program. Simple linear regression was applied to determine correlation between gonad lop length and gonad lop weight [3].

## Results

In March, gamete releasing of sea urchins was not observed. An increase in the occurence gamete release in September-January was found. In January, when the most active gamete releasing was observed, a maximum peak was found (52%) (Fig. 1).



Fig. 1. A number of individuals P. lividus released gametes.

The regression analyse showed that there was a significant relationship between gonad lop weight and gonad lop length (r= 0.7226) (Fig. 2). Estimated b value was determined as 0.5417.

#### Discussion

In *Paracentrotus lividus*, gonadal growth occurs during the coldest months [4] and males and females aggregate for spawning, simultaneously release their gametes [5]. Spawning of *P. lividus* has been reported to occur either once or twice in a year [6]. On the other hand, the gamete release of *P. lividus* differs by as much as 4 weeks between years in Ireland [6]. In our study, although little gamete monthly release from gonads were observed throughout the year, the gamete release peaked (52%) once in a year only in late winter (January). It was observed that spawning only occurs during spring and early summer [7]. According to [8], *P. lividus* gonad growth and gametogenesis occurred throughout the year.

In this study, it was determined a significant realitionship between gonad lop weight and gonad lop length. This suggests that there is a direct proportion between these values. Despite the rich literature on gonad size of sea urchins [2, 3, 5], very few studies concerned gonad lop size.

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Fig. 2. The relationship between gonad lop weight and gonad lop length of *P. lividus*.

# ICHTHYOFAUNA RECOVERY OF A NEWLY RE-FLOODED MEDITERRANEAN COASTAL LAGOON

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# Abstract

The ichthyofauna of the illegally drained Drana lagoon (NE Greece) was studied, with the lagoon's hydrographic and water quality characteristics, during pre- and post-restoration works leading to its re-flooding. The low diversity, compared with other lagoonal ichthyofauna, is probably due to the recent re-flooding and the limited sampling intensity. The reduced presence of the mugilids may be related to the prevailing tidal inlet dynamics.

Keywords : Fishes, Lagoons, Restoration, Eastern Mediterranean.

#### Introduction

Fisheries exploitation of coastal lagoons is been applied in Greece since the ancient years. Nowadays most of them are managed by Fishing Cooperatives with "traditional"permanent fish entrapment devices, combined with fish wintering channels. In northern Greece, the lagoons extent in 11500 ha and during the last decade their average landings are 600 t/year, with a clear decreasing trend.

Drana Lagoon, located at the NW site of the Evros River Delta (N.E. Greece), a fishery-exploited lagoon (fish production of 8 to 20 th during 1974-1986) was drained illegally in 1987 by local farmers, under the perception that the lagoon's saline water affects their adjacent cultivations (Figure 1). Lagoon's re-flooding (by the opening of a new 5 m wide entrance for the water), together with other restoration works, were carried out during June 2004. The project was funded by a LIFE-Nature project, aiming to: a) restore lagoon habitats structure and functions, b) conserve protected avifauna species, and c) upgrade the management effectiveness applied in the lagoon's broader area. It is expected that the lagoon's the local cooperative.

#### Materials and Methods

A sampling program to determine the pre- and post-flooding ichthyofauna distribution (in terms of species abundance and diversity) was conducted, in association to hydrographic and water quality studies. Three samplings were attained: one before re-flooding (January 2003) and two after reflooding (October 2004 and April 2005). Fish were collected using a nylon centre-bag seine net (3 mm bar mesh size) of 12 m length and 1.2 m height. The bag seine was hauled for 30-50 m in order to cover an area of 250 m<sup>2</sup>, approximately. The relative abundance was estimated by the Catch per Unit Effort method (CPUE: 1.000 m<sup>2</sup>). Fish samples were preserved in 6% formalin solution and later sorted and measured in the laboratory. Water flow, tidal elevation, water temperature, salinity and dissolved oxygen content were recorded at the lagoon's inlet during two consecutive tidal cycles (24 hrs) for each monitoring period. Nutrients and chlorophyll-a were also determined at 9 sites inside the lagoon, during the ebb and flood periods of each tidal cycle.



Fig. 1. Map of the Drana Lagoon (Evros Delta, Greece) indicating the sampling sites for fish fauna (black triangles) and oceanographic, physical and chemical water conditions (1-9).

## Results and Discussion

Results from all samplings depicted the presence of saline water (up to 41 psu) inside the lagoon, due to sea water intrusion and increased evaporation rate. Dissolved oxygen distribution appeared to be mostly influenced by the wind mixing, rather than by the advection of oxygenated sea water through the inlet. Nutrient and chlorophyll-a levels showed negligible spatial and temporal variability. A mean concentration of 50  $\mu$ gr/l for nitrates, 95  $\mu$ gr/l for phosphates and a mere 0.2  $\mu$ gr/l for chlorophyll-a was observed. Tidal variability at the mouth was approximately 0.2 m, producing tidal currents of up to 0.75 m/s.

Twelve species representing 8 families were caught during the 3 samplings. Seven species were caught during the pre-reflooding period at the entrance. Five new species were collected after re-flooding, while one species caught before re-flooding, was not found again ( Gambusia affinis). Among all species caught, 5 species were characterized as permanent residents of lagoonal ecosystems, 6 as marine migrants and 1 as straggler (Table I). The inner part was dominated by five species. Among them Atherina boyeri, a species that permanently inhabits coastal brackish ecosystems, showed the higher presence (50.8%), followed by Pomatoschistus marmoratus and Aphanius fasciatus, both residents lagoon species, and two migrants, Lithognathus mormyrus and Sygnathus abaster. Generally, reduced species diversity was observed, compared to other lagoon ecosystems, probably due to the recent lagoon re-flooding and the limited sampling intensity. The reduced presence of the Mugilidae family species inside Drana Lagoon (2.1%), which constitutes the higher proportion of the Greek lagoons' catches (60-80%), could be related to the prevailing tidal inlet dynamics (i.e. strong ebb flow at lagoon inlet).

Tab. 1. Relative abundance of the ichthyofauna of the Drana Lagoon (Evros Delta, Greece), before and after restoration (R= resident species, M=migrant species, S=straggler species).

| n  | Family          | Species                   | Life<br>history | Before | After |
|----|-----------------|---------------------------|-----------------|--------|-------|
| 1  | Atherinidae     | Atherina boyeri           | R               |        | 37.6% |
| 2  | Cyprinodontidae | Aphanius fasciatus        | R               | 0.4%   | 7.6%  |
| 3  | Gobiidae        | Pomatoschistus marmoratus | R               |        | 0.2%  |
| 4  |                 | Knipowitschia caucasica   | S               | 5.6%   | 31.7% |
| 5  | Mugilidae       | Mugil cephalus            | M               | 0.7%   | 2.9%  |
| 6  |                 | Liza ramada               | M               | 57.5%  | 0.6%  |
| 7  |                 | Liza aurata               | M               | 32.7%  | 0.2%  |
| 8  |                 | Liza saliens              | M               | 0.9%   | 1.2%  |
| 9  | Poeciliidae     | Gambusia affinis          | R               | 2.2%   |       |
| 10 | Soleidae        | Solea solea               | M               |        | 0.3%  |
| 11 | Sparidae        | Lithognathus mormyrus     | M               |        | 8.1%  |
| 12 | Syngnathidae    | Syngnathus abaster        | R               |        | 9.4%  |

Inlet dynamics characterized by strong flood currents and limited ebb duration were considered to affect the entry of juveniles into Drana Lagoon. An improvement in the design of the lagoon's inlet was suggested, by increasing its width and produce areas of low flow conditions. Lateral friction could be enhanced with the positioning of medium-sized stones at the sides of inlet's banks.

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# MACROBENTHIC COMMUNITY PATTERNS ACROSS THE MARINE BRACKISH GRADIENT

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# Abstract

Structure of four ecotonal environments consisted of lagoons, estuaries and marshes were investigated in comparison with their adjacent marine areas across Kalloni Gulf (Island of Lesvos, NE Aegean) for the first time. Significant differences were detected between and within ecotonal and marine ecosystems in terms of benthic community organization. Ecotonal areas were consisted of typical marine/estuarine and lagoonal species in a varying degree of numerical dominance. Observed differences concerning the prevailing environmental conditions at each ecosystem suggest a strong gradient from the sea towards the ecotones. Biocommunities seemed to experience a pronounced environmental stress only in the ecotones and not in the marine areas. Findings of this study support the role of confinement in the paralic domain in the Mediterranean as a function of a number of environmental factors governing biological communities' patterns. *Keywords : Zoobenthos, Brackish Water, Coastal Systems, Aegean Sea, Eastern Mediterranean*.

#### Introduction

Transitional coastal ecosystems, a term used for a variety of ecosystems such as lagoons, estuaries, semi-enclosed bays and saltmarshes, constitute areas of special ecological and economical interest since they are located to the inter-surface of land and sea (land/water ecotone). These ecosystems are characterized by their buffering role towards land effects at the coastal zone (e.g. eutrophication incidents) [1]. Kalloni Gulf (Lesvos Island, NE Aegean Sea, Greece) comprises a rich mosaic of wetland patches such as lagoons, estuaries and marshes along the coastline. The present research effort aims to investigate for the first time marine/land ecotones in various transitional ecosystems of the Kalloni Gulf, in comparison with their adjacent marine areas concerning the prevailing environmental conditions and the benthic biological structure.

#### Materials and methods

The study areas were four Kalloni Gulf wetlands [Polihnitos saltworks (stations Pol-Br and Pol-Mar), Vouvaris estuaries (stations Bou-Br and Bou-Mar), Kalloni saltworks (stations Kal-Br and Kal-mar) and Parakoila marshes (stations Par-Br and Par-Mar)]. Macrobenthic samples were collected in each one of the aforementioned coastal areas (marine site - Mar; ecotone site - Br), by means of a Van-Veen sampler during Spring 2006. Environmental variables either clear physicochemical ones or variables related with food availability (e.g. Salinity, Temperature, Chloroplastic pigments concentration, Inorganic Nutrients, Sediment Organic content) were also measured in the studied areas. Uni- and multivariate methods based on Bray-Curtis similarity index were employed to detect biological and environmental patterns [2].

#### Results

Marine and brackish areas presented pronounced differences concerning environmental conditions (ANOSIM test results Global R: 0.729, p<0.2%). Values of environmental parameters (e.g. Nutrients, Chlorophyll- a and Organic load concentrations) measured, were higher in the Brackish ecosystems (hypo-saline such as estuaries, marshes or hyper-saline areas such as saltworks) in relation to those in the adjacent marine environment. MDS plots of the environmental parameters revealed a strong environmental gradient from the sea towards the ecotones (Fig. 1). As far as the benthic communities are concerned, the most abundant species distributed along the ecotones can be divided into three groups: freshwater species such as the larvae of the Insecta Chironomus sp.; typical lagoonal species of marine ancestry such as the gastropods Hydrobia acuta and Pirenella conica; and marine/estuarine species such as the Molluscs Bittium reticulatum, Abra segmentum, the Polychaetes Hediste diversicolor, Capitella capitata, and the Amphipods Gamarus aequicauda, Microdeutopus gryllotalpa. On the contrary, the dominant species in the marine sites were typical marine species such as the Molluscs Gibbula albida, Pusillina radiate, Loripes lacteus, and typical marine/estuarine species such as the Mollusc Bittium reticulatum. Multivariate analysis (Fig.1) revealed a clear separation between the ecotonal and the marine areas (ANOSIM test results Global R: 0.7, p<0.5%). Application of ABC curves and Geometric class plots techniques on the macrofaunal data have revealed that only the Ecotonal areas constitute stressed ecosystems. Finally, results of the BIOENV analysis have revealed that the macrobenthic community distribution pattern was mainly governed by environmental factors related to food availability (i.e. Chl- a, Nutrients).



Fig. 1. Environmental (a) and Macrobenthic community (b) patterns across the Kalloni Gulf study sites produced from the multivariate analyses

#### Discussion

Comparison of the transitional water ecosystems and the adjacent marine area is a poorly explored issue in the NE Aegean coastline. The observed diversity within and between ecotonal and marine habitats seemed to be comparable denoting no diversity modification or even loss from sea to ecotones, a fact that supports the claim that land/water ecotones constitute habitats of substantial ecological value [3]. Furthermore, the observed diversity levels were similar with these recorded from other Transitional Coastal Ecosystems across the Hellenic coastline [4]. Dominance of certain species was the observed community mode thus confirming the hypothesis that the presence of only few keystone species can support ecosystem functions in ecotonal habitats [5]. The observed marine-brackish gradient in the Kalloni Gulf wetlands corresponds to the zonation model typical for the paralic domain [1]. Perturbation events detected in the ecotonal ecosystems should probably be attributed to the highly dynamic and severely fluctuating environmental conditions known to prevail in transitional ecosystems across the Mediterranean [3].

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# GROWTH OF MUSSELS (*MYTILUS GALLOPROVINCIALIS*) ON CULTIVATION RAFTS IN THERMAIKOS GULF (GREECE)

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# Abstract

The aim of this study was to investigate mussel growth of several cultured populations (Kalohori, Halastra and Makrygialos) in Thermaikos gulf. The results revealed that shell length and mussel weight were affected neither by the position where spat attached to the initial ropes nor by the different water culture depths. Reciprocal mussel transplantations between the culture areas of Halastra and Makrygialos revealed that all the populations, native and transplanted, showed a higher shell and weight growth and seemed to grow faster in the area of Halastra than in Makrygialos. The slope values of the length-wet weight and length-dry weight regressions were significantly higher for all populations cultured in the area of Halastra. The analysis of water physicochemical parameters revealed no significant differences between the two culture areas while a relatively small difference of the nutrients' content was observed. *Keywords : Bivalves, Growth, Aegean Sea.* 

#### Introduction

The blue mussel *Mytilus galloprovincialis* predominates in Thermaikos gulf in the Northern Aegean Sea where mussel cultivation has recently become increasingly important. It is a highly variable species and populations frequently differ in growth rate and size as well as in the morphology of shell and soft parts. A large part of this variation may be a result of environmental factors. Reciprocal transplantations are one way to examine the extent to which population differences in growth may be environmentally induced or inherited. The present study is part of a wider one, which aimed at describing the growth characteristics and genetic variation of three mussel populations from three different sites at Thermaikos gulf in the Northern Aegean Sea. In this paper we compare growth characteristics of mussels attached or cultured at different water depths and of mussels reciprocally transplanted among three sites within Thermaikos Gulf.

#### Materials and Methods

The study of mussel growth in suspended culture farms started in May 1995 and was completed by July 1996. Special ropes used for collection of spat, were placed at three stations in Kalohori, Halastra and Makrygialos areas, at 8 m water depth in February 1995. At each station, 30 bands were created and suspended in long-line mussel culture farms at 8 m water depth. In June 1995 reciprocal transplantation of mussels were carried out among the study areas. The mussel density of each unit was controlled and the mussels were spaced out at two months intervals.

Several physicochemical parameters, as well as nutrient content of the water were measured at two months intervals at 1 and 3 m water depths [1]. Comparison of their mean values between the two areas and between the different water depths of mussel culture was performed using Mann-Whitney test. For growth study 22.245 mussels were used, 12.879 from the Halastra and 9.366 from Makrygialos area. Growth was reconstructed by measuring shell length (mm) and the data obtained were formalized using the Von Bertalanffy [2] growth equation (VBGF). Shell lengths were related to weight according to the allometric equation:  $W=aL^b$ . Linear regression analyses on logarithmically transformed values of weight and length were carried out for each sample, followed by covariance analysis to compare estimates of b. For the weight study, 3.760 mussels were used, 2.146 from the Halastra and 1.614 from Makrygialos area.

#### Results and Discussion

Many authors have attempted to compare growth rates within a single species monitored at different water depths and concluded that growth rates differed according to cultivation raft position but not according to culture depth [3]. Our results revealed that shell length and weight of mussels were affected neither by the position where spat attached to the collector ropes nor by the different culture water depth (from 1 to 4 m below surface). Probably, such differences would be detected between moderate depths and depths greater than 6 m.

The most important finding is the fact that in Halastra culture site mussels seem to grow faster than in Makrygialos. Values of Von Bertallanfy K

were significantly higher (t-test p<0.001) for all subpopulations cultured in Halastra compared to the same subpopulations cultured in Makrygialos (mean K for Halastra:  $2.15\pm$ ' 0.04, for Makrygialos:  $1.62\pm$ ' 0.08). The same trend was seen for the values of  $\varphi$ , which represent the rate of shell growth (mean  $\varphi$  for Halastra: 2.09 $\pm$ 0.005, for Makrygialos 2.00 $\pm$ 0.007). This difference in growth rate of mussels between the two culture areas may be a result of more favorable environmental factors [4]. However, during our study, no significant differences were found in any physicochemical parameter measured between the two culture areas that could justify our results. Also, the effect of contamination by various metals on mussel growth has been recorded as high levels of metals have inhibitory effect on mussel filtration. Halastra and Makrygialos areas receive high quantities of agriculture outfall from Axios and Aliakmonas rivers respectively [5]. The difference in mussel growth observed between the two areas could be caused by a possible different metal concentration in the water outfall of the two rivers. However the available data on metal concentration in the two rivers during the experimental period do not show any significant differences (Kravva, unpublished data).

Mussel growth is largely influenced by the water nutrient content as it regulates the phytoplancton concentration, which in turn is the primary food source for mussels [6]. The nutrient concentration in both culture sites is influenced by the waters of the Axios and Aliakmonas rivers. The differences in nutrient concentration observed during our study, especially those in PO<sub>4</sub>-P content (mean value for Halastra: 47.6  $\mu g/l$ , for Makrygia-los: 32.6  $\mu g/l$ ) could justify the faster weight gain of mussels in the area of Halastra as this area receives water from Axios River. Water from this river has the highest nutrient concentration, mainly in phosphates, caused by anthropogenic processes.

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# SOFT BOTTOM LUMBRINERIDAE (POLYCHAETA) SPECIES IN IZMIR AND SAROS BAYS (AEGEAN SEA)

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# Abstract

The present study deals with Lumbrineridae species on soft substrate in Izmir and Saros Bays located in the Aegean Sea. Benthic samples were collected from 12 stations (20-69 m) in Izmir Bay between 1997 and 1998 and from 18 stations (8-135 m) in Saros Bay in 2000. A total of 13 species were identified, belonging to 6 genera, of which *Lumbricalus adriatica* and *Lumbrinerides* cf. *acuta* are new records for the marine fauna of Turkey. *Lumbrineris gracilis* and *L. latreilli* were the most abundant species in both areas. *Keywords : Polychaeta, Systematics, Aegean Sea.* 

## Introduction

Lumbrineridae Malmgren,1867 were represented by 250 species and 13 genera worldwide, 22 species and 7 genera in the Mediterranean and 11 species and 5 genera on the coasts of Turkey. On the Turkish coasts, 5 species were reported in the Sea of Marmara [1], 7 species in the Aegean Sea [2] and 8 species in the Levantine Sea [3].

The aims of this study are to determine lumbrinerid species in Izmir and Saros Bays and to investigate their distributional patterns in the areas.

## Material and Methods

Lumbrinerids were found a total of 56 samples collected at 30 stations in Izmir (20-69 m, in 1997-1998) and Saros (8-135 m in August 2000) Bays by a van Veen grab (Izmir Bay) and anchor dredge (Saros Bay) (Figure 1). Benthic samples were sieved through 0.5 mm mesh and the retained material was placed in separate jars containing 4% seawater formaldehyde solution. In the laboratory, samples were sorted according to taxonomic groups under a stereomicroscope and preserved in 70% ethanol. Lumbrinerids were separated from other worms, then identified and counted. The Jaccard's Similarity Index was used to assess species associations in the areas.



Fig. 1. Map of investigated area with location of sampling sites.

#### Results and discussion

The examination of materials collected on soft substrate in Izmir and Saros Bays revealed a total of 1829 specimens belonging to 12 species and 1 subspecies (Table 1). *Lumbricalus adriatica* and *Lumbrinerides* cf. *acuta* are newly added to the marine fauna of Turkey. The genus *Lumbrineris* was represented by four species and 1569 individuals (86% of the total individuals). The most dominant species in the areas were *Lumbrineris gracilis* (56% of the total individuals) and L. *latreilli* (24%). The densities of *L. gracilis* and *L. latreilli* reached up to 550 individuals/m<sup>-2</sup> and 370 individuals/m<sup>-2</sup> in Izmir Bay, respectively. As a result of Soyer's frequency (F) categorizations, 5 species can be classified as constant ( $F \ge 50$ ), 3 species as common ( $25 \le F \ge 49$ ) and 4 species as rare (F < 25) in Izmir Bay. When it comes to Saros Bay, 4 species can be classified as constant, 1 species as common and 7 species as rare. The most frequent species in the Bays were *L. gracilis*, *L. latreilli* and *Scoletoma impatiens*.

Tab. 1. The list of Lumbrinerid species found and their distribution on biotopes in the study areas (M: Mud, S: Sand, P: *Posidonia oceanica*, Ms: Muddy sand, Sm: Sandy mud).

| Study area                                          |        | Saro | s Bay | 3     | 12    | zmir Ba | У     |
|-----------------------------------------------------|--------|------|-------|-------|-------|---------|-------|
| Biotopes                                            | M      | P    | Ms    | Sm    | M     | S       | Ms    |
| Depth (m)                                           | 12-135 | 8-24 | 22    | 20-63 | 28-62 | 38      | 20-69 |
| Number of species                                   | 6      | 8    | 6     | 7     | 8     | 7       | 9     |
| Lumbrineris gracilis (Ehlers, 1868)                 | 460    | 98   | 76    | 155   | 36    | 23      | 177   |
| Lumbrineris latreilli (Audouin&Milne-Edwards, 1834) | 116    | 33   | 14    | 81    | 26    | 40      | 131   |
| Lumbrineris nonatoi Ramos, 1976                     | 13     | 3    | 2     | 10    | 5     | 6       | 29    |
| Lumbrineris coccinea (Reiner, 1804)                 | 8      | 1    | 4     | 2     | 7     | 1       | 12    |
| Scoletoma impatiens (Claparède, 1868)               | 79     | 19   | 14    | 31    | 10    | 13      | 31    |
| Scoletoma fragilis (O.F.Müller, 1776)               |        |      | 4     | -     |       | 3       | 8     |
| Scoletoma funchalensis (Kinberg, 1865)              |        | 4    |       |       |       |         | 2     |
| Scoletoma emandibulata mabiti (Ramos, 1976)         |        | 4    |       |       |       |         | -     |
| Lumbrinerides amoureuxi Miura, 1980                 |        |      |       | 4     | 1     | 1       | 8     |
| Lumbrinerides cf. acuta (Verrill, 1875)             |        |      |       |       | 1     |         |       |
| Lumbrineriopsis paradoxa (Saint-Joseph, 1888)       |        | 11   |       | 1     |       |         |       |
| Lumbricalus adriatica (Fauvel, 1940)                |        | 2    |       |       |       | 20      |       |
| Nince armoricana (Glèmerec, 1968)                   | 3      |      |       |       | 5     |         | 1     |

According to Jaccard's Similarity Index analysis, three mean species associations were found. The first association consisted of the species *Lumbrinerides* cf. acuta and Ninoe armoricana, which were found only in deeper waters (62-69 m). The species Scoletoma funchalensis, S. emandibulata mabiti, Lumbrineriopsis paradoxa and Lumbricalus adriatica were grouped at a similarity level of 38%. These species seemed to prefer Posidonia oceanica meadows in Saros Bay. The other association included the species Lumbrineris gracilis, L. latreilli, L. nonatoi, L. coccinea, S. impatiens and S. fragilis, which were frequent and dominant species on soft bottoms (without phanerogames) in Izmir and Saros Bays. Lumbrinerides amoureuxi was grouped with the latter association at a similarity value of 25%.

A detailed study on lumbrinerids, which was performed along the coast of Crete Island in the Aegean Sea, reported 11 species [4]. *Lumbrineris* gracilis was the most abundant species on the coasts of Crete and Turkey but *Scoletoma emandibulata mabiti* was represented by high number of individuals on the coast of Crete and lower number of individuals on the coast of Turkey. The present study included two species (*Lumbrinerides amoureuxi* and *Lumbrinerides* cf. *acuta*) which were not found on Crete Island. Furthermore, this study provides some information on Lumbrineridae fauna distributed along the Turkish coast of the Aegean Sea. In order to better understand of the distributional and ecological features of Lumbrineridae species in the area, more samples including different depths and habitats should be collected and investigated.

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# DIVERSITY AND DISTRIBUTION OF MACROPHYTES ALONG THE COAST OF LEBANON ( LEVANTINE BASIN, EASTERN MEDITERRANEAN)

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# Abstract

A total of 243 taxa of macroalgae were found along the coast of Lebanon. They include: 25 Cyanophyta, 58 Chlorophyta, 29 Phaeophyta, 127 Rhodophyta, 3 Phanerogams and 1 Xantophyta. Brown algae are very sensitive to organic pollution, on the contrary of green algae which tolerate polluted sites. Several phaeophyte species from the genera: *Cystoseira, Sargassum, Corallina, Laurencia* and *Padina pavonica*, are good indicators of unpolluted coastal seawater, while, *Ulva, Enteromorpha, Colpomenia* and *Cladophora* thrive in organic polluted coastal waters. High taxonomic diversity and biomass occurred in spring and summer; while most of the algae are qualitatively and quantitatively poor during fall and winter. Several introduced species of Indo-Pacific origin were found, many of them have established stable populations.

Keywords : Algae, Coastal Waters, Levantine Basin, Biodiversity, Biomass.

## Introduction

Marine flora of the Levantine Basin, including the coast of Lebanon belongs to the Atlanto-Mediterranean province. However, the occurrence of several introduced Indo-pacific species, attribute to this region a certain tropical and subtropical characteristics .Few data are available regarding the phytobenthos of the Lebanese coast [1-2] 75% of the occurring species inhabit the western Mediterranean [3], whereas many others considered as Lessepsian were introduced in the Levantine Basin, where they established permanent populations. Most Phaeophytes are very sensitive to organic pollution whereas chlorophytes are very tolerant to polluted coast. These circum-tropical species present along the Lebanese coast may be either endemic or relicts from the period of the Tethys, or migrant species introduced, directly, or indirectly, through the Suez Canal into the Mediterranean. In this paper we present the spatio-temporal distribution of macroalgae along the Lebanese coast, focusing on their relation to environmental factors.

## Material, methods and investigated area

Samples were made during 2000 and 2004 at a frequency of two times a year: in spring and in summer, at six sites along the coast of Lebanon. (33°50'-34 55' N and 35°30' E), covering polluted and unpolluted soft and rocky shores. Five sampling points were chosen on each transect, covering the supralittoral, mediolittoral and infralittoral zones [4]. A 0.04 m<sup>2</sup> metallic quadrat was used for quantitative and qualitative sampling. Temperature, salinity, dissolved oxygen and pH were measured in situ, and water samples were collected from surface for chemical analysis, namely ammonia, phosphate and nitrite-nitrate. In the intertidal zone, samples were collected directly, while in sub-tidal, scuba diving was used for collecting algae. In addition to the biomass, the % of algal coverage was estimated. Semi-diurnal tide amplitude along the Levantine coast is very small (15-20 cm.). Hydrology is characterized with two thermal phases: 1) a cold phase during winter (December-March), characterized with cool seawater (min 16°C in February) and moderate salinity (S=39.25psu ), and marked with vertical isothermal conditions in the water column; 2) a warm phase during summer-fall (May-November) characterized with high surface temperature and salinity ( max in August-September T= 30°C and S=39.75psu), accompanied with sharp thermocline in the layer 35-75 m, and with water layer stratification. The Lebanese seawater is highly oligotrophic as in all Levantine Basin.

#### Results

In total 243 taxa were found, in all sites, including 25 Cyanophyta, 58 Chlorophyta, 29 Phaeophyta, 127 Rhodophyta, 3 Phanerogams and 1 Xantophyta. The bathymetric distribution is not very clear since the limit between two adjacent zones is not well defined, due to sea level variability. Many overlaps among species distribution are always observed. In all sites, the supralittoral is the poorest zone, while the infralittoral is the richest in diversity and in algal biomass. The sites St1,St3 and St6 situated in unpolluted coast, are the most rich , while St4 (near thermo-electric power plant) and St5 (near big urban sewer) are very poor; except in green algae. Sciaphile algae, mostly from rhodophytes, are the most important in the mediolittoral. The brown algae grow only in the intertidal zone and are not as tolerant as the green algae, they are very sensible to pollution (St4 and St5).

Supralittoral - Most of the species in this zone are tolerant to changing environmental conditions such as moistening, dryness, dumping of freshwater and organic pollution. *Cyanophycaea* are dominant along with some benthic diatoms. 13 species characterizing this zone were recorded, namely *Hormatonema sphaerica*, *Hyella caespitosa*, *Anabena* sp., *Oscillatoria nigroviridis*, *Chrococcus turgidus*, *Hydrocoleus lyngbyaceus*, *Phromidium ambiguum*, *Rivularia mesenterica* and *R. atra*. The sites St1,St2, St3 and St6 show similar species associations, different from those of polluted sites St4 and St5.

Mediolittoral - The maximum number of species found in all mediolittoral sites was approximately 148. In upper mediolittoral at all sites dominant species are: *Porphyra leucostica, Enteromorpha compressa, E. flexuosa, E. aragoensis, Nemalion helmintoides, Polysiphonia sertularoides, P. tenerrima, Calothrix aerugina.* Several accompanying species from Cyanophyta and Chlorophyta are also present. Lower mediolittoral is dominated by *Neogoniolithon notarisii, Laurencia papillosa, L. pinnatifida, L. obtusa, Cladophora* spp., *Enteromorpha* spp., *Jania rubens* and *Corallina mediterranea*, with 26 accompanying species.

Infralittoral - The subtidal level which is always covered with the seawater, is the richest and the most diversified. The species in this zone grow within stable environmental conditions. About 190 species were recorded in the subtidal at all the investigated sites, St3 being the richest with 115 species. Several species from the mediolittoral are also present in the infralittoral. Cystoseira spp. and Sargassum vulgare are good indicators of the infralittoral low-water tide. Upper infralittoral extending to depth -10 m is dominated by many species such as: Jania rubens, Bryopsis mucosa, B. hypnoides, Liagora farinose, Anadiomene stellata, Lophocladia lallemandii, Hydroclathrus clathrus, Sargassum vulgare, Bryopsis sp., Corallina elongata, Padina pavonica, Udotea patiolata, Dasycladus vermicularis. Several accompanying species are present with less abundance. Lower infralittoral is dominated by sciaphile algae, namely: Acanthophora delilei, Rityphlaea tinctoria, Siphonocladus pusillus and Phanerogams growing on soft bottom: Zostera noltii, Cymodocea nodosa and Halophila stipulacea. On sediment seafloor we also record the caulerpales: Caulerpa scalpelliformis, C. prolifera, C. racemosa. Many accompanying species grow in this level such as: Valonia utricularis, Bryopsis hypnoides, B. pinnata, Lithophyllum incrustans, L. lenormandii, etc.

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# CONTRIBUTION TO THE STUDY OF ZOOPLANKTON COMMUNITY IN ISKENDEROUN BAY (NORTH-EASTERN MEDITERRANEAN)

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# Abstract

Based on samples collected seasonally in coastal Iskenderoun Bay, the zooplankton community has revealed high biomass contrasting with low taxonomic diversity. Major Mediterranean groups are present in Levantine Basin, including Iskenderoun Bay. 20 groups were reported, the copepods being the most important, forming between 50% (August) and 96% (January) of the total zooplankton community. Cladocerans in swarming patches, are abundant in summer, whereas Thaliaceans dominate in summer-fall. Winter assemblage is characterized with relative high diversity. Some Lessepsian species were reported in the area, namely from copepods. *Keywords : Biodiversity, Coastal Waters, Levantine Basin, Copepoda, Zooplankton.* 

#### Introduction

Recent studies indicate that hydrobiological changes have happened in the Levantine Basin, including Iskenderoun Bay since the opening of Suez Canal and the construction of Aswan High Dam [1], [2]. Few data with this respect to species composition and dynamicsof zooplankton of the northeastern Levantine Basin are available [3], [4]. More research on taxonomy and distribution of copepods of the area were achieved by [5], [6], [7]. In the present work we describe the composition and the structure of zooplankton community of the coastal Iskenderoun Bay.

#### Material and methods

Seasonal cruises during 2002, were carried out at five coastal stations in north-west Iskenderoun Bay (Fig.1). Vertical hauls were towed at 20 m and 30 m depth using plankton nets of 200 microns of mesh size. Identification up to species level was carried and counts of individuals were reported as number of individuals per sample.

#### Results

The Bay of Iskenderoun covers a relative large area of the continental shelf less than 100 m depth. The annual thermohaline cycle is resumed in two phases: a cold phase in winter characterized with isothermic structure in the water column, with minimum temperature and salinity in February (16°C; 37-38 psu). The warm phase in summer-fall is characterized with a water layer stratification and a heavy thermocline in the depth 30-75 m. Temperature averages reach 29 °C at surface and 19 °C at the bottom in July-August. The primary production estimated from chlorophyll data was higher in the central part of the Bay (annual average 60 g C/m<sup>2</sup>/year) and lower in the eastern Mediterranean (25 g C/m<sup>2</sup>/year) [8]. Most of the zooplanktonic groups found in the Bay are of Atlanto-Mediterranean the copepods constituting the major group, either in diversity and in biomass. Ecological cycle of the planktonis is marked with three seasonal assemblages: winter (January), spring (April) and summer-sall (August-October). During the cold period, the main common groups are: the copepods dominated by Calocalanus spp., Calanus minor, Oncaea spp. and Oithona spp., the Hydromedusae, Siphonophorae, Sagitta friderici and Oikopleura cophocerca. In spring the plankton community is dominated by herbivorous species developing after the spring phytoplankton bloom; the zooplankton is rich and diversified, the copepods being the most common, namely: Paracalanus parvus, Acartia clausi and Centropages kröyeri, Ichtyoplankton (eggs and fish larvae), crustacean decapod larvae, Lamellibranch and Prosobranch larvae, Echinoplutei, Pteropods and Siphonophores. During summer zooplankton is abundant and marked with by swarming cladoceran patches, namely Evadne spinifera and E. tergestina and abundance of Centropages kroyeri, Acartia clausi, A. latisetosa and exotic introduced species Labidocera pavo. Early autumn, advanced stages of decapod larvae, (Zoe and Megalopes) are very common. Larval stages of stomatopods are also present in few number; whereas larvae of Leucosiidae such as: Ilia nucleus, Phylira globulosa are common during the hot and dry season. Some calanoids appear in high number, namely: Temora stylifera, Paracalanus parvus and Clausocalanus furcatus. The hydro-climate seasonality induces a bimodal annual profile of the plankton similar to that existing in other Levantine regions [9] and the Cilicean Sea. Annual cycle is characterized with a peak in abundance of zooplankton in May after the spring phytoplankton, and a break down of the abundance in summer. This is due may be to the circulation and current system in Iskenderoun Bay. The ingression

of oceanic deep water masses inside the Bay. However the zooplankton community is characterized with low species diversity contrasted with high biomass. It is well known that the Levantine Basin is a the most oligotrophic water body in the Mediterranean, excluding the Nile Delta area and the Iskenderoun Bay, where nutrients input from Seyhan and Ceyhan rivers in the sea. Contribute to high productivity.



Fig. 1. Location of zooplankton sampling stations in Iskenderoun Bay.

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# HOW HUMAN FORCINGS AFFECT ECOLOGICAL PROPERTIES OF LARGE PELAGIC FISH IN THE MEDITERRANEAN? HISTORICAL GENETIC CHANGES IN THE OVEREXPLOITED BLUEFIN TUNA ( *THUNNUS THYNNUS*)

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# Abstract

Based on a comparative analysis of genetic diversity at 7 microsatellite loci in ancient (archived skeletal specimens) and modern (freshly collected individuals) samples of *Thunnus thynnus* collected in the Mediterranean Sea, we assessed temporal changes and spatial variation of genetic and demographic (genetically-related) features in the overexploited Mediterranean stock of bluefin tuna. From the analysis of more than 300 individuals, a temporal stability of genetic diversity over about 90 years but significant changes in the genetic structure of the stock were achieved. Such results argue for an evidence that, in the Mediterranean, stock overexploitation has not yet corrupted the genetic potential of such living resource and that bluefin tunas are not fully pannicite.

Keywords : Biotechnologies, Conservation, Genetics, Fisheries, Western Mediterranean.

The estimation of genetic variability and the identification of temporal variation in genetic structure of a population is crucial for the conservation of endangered species undergoing dramatic ecological and demographic changes linked to strong overexploitation [1], such as the Atlantic bluefin tuna *Thunnus thynnus*. Fishery is having strong impact on bluefin tuna population abundance and serious consequences on genetic potential of Mediterranean populations may occur [2].

Tab. 1. Genetic variation at the 7 microsatellite loci in ancient and modern Mediterranean samples of *Thunnus thynnus*. A<sub>r</sub>, allelic richness; H<sub>o</sub>, observed heterozygosity; H<sub>e</sub>, unbiased expected heterozygosity; P, Hardy-Weinberg equilibrium test: \*\* P <0.01, \* P <0.05. <sup>a</sup> For each genetic diversity estimator, the statistical difference between ancient and modern bluefin tunas was tested by one-way ANOVA (not significant) and pairwise Chi<sup>2</sup> (not significant)

| Lœus              |         | Ancient   | Modern |
|-------------------|---------|-----------|--------|
| Ttho-4            | $A_r$   | 13.8      | 18.0   |
|                   | Ho      | 0.383     | 0.797  |
|                   | $H_{e}$ | 0.721     | 0.814  |
|                   | P       | **        |        |
| Tth-5             | A,      | 3.0       | 3.0    |
|                   | Ho      | 0.769     | 0.400  |
|                   | He      | 0.542     | 0.488  |
|                   | P       | **        | *      |
| Tth-10            | A,      | 8.9       | 6.9    |
|                   | Ho      | 0.681     | 0.482  |
|                   | He      | 0.523     | 0.486  |
|                   | P       | * *       | * *    |
| Tth-34            | A,      | 14.0      | 17.9   |
|                   | Ho      | 0.674     | 0.769  |
|                   | He      | 0.736     | 0.833  |
|                   | P       | * *       |        |
| Tth 1-31          | A,      | 15.9      | 19.9   |
|                   | Ho      | 0.757     | 0.813  |
|                   | $H_{e}$ | 0.861     | 0.897  |
|                   | P       | * *       |        |
| Tth 208           | Ar      | 25.0      | 28.9   |
|                   | H       | 0.775     | 0.708  |
|                   | He      | 0.910     | 0.920  |
|                   | P       | * *       | * *    |
| Tth 112           | Ar      | 9.9       | 13.0   |
|                   | H       | 0.715     | 0.927  |
|                   | He      | 0.697     | 0.853  |
|                   | P       | * *       | * *    |
| Mean <sup>a</sup> | A,      | 12.9      | 15.4   |
|                   | H       | 0.710     | 0.669  |
|                   | He      | 0.713     | 0.756  |
|                   | P       | alja alja | **     |

Owing to i) the general interest in assessing and predict historical changes in fish communities of the Southern European Seas (henceforth SES) to develop ecological and socio-economic models for an integrated management of the marine ecosystems at the regional scale [3], ii) the specific interest for the conservation, ownership and sustainable management of bluefin tuna stocks [2], it becomes critical to resolve structure and dynamics of the SES populations of this large pelagic fish over time.

A molecular approach becomes fundamental to unlock ancient genetic features of populations and for genetic comparisons to modern populations. This can be decisive for assessing genetic and demographic changes in fishery resources overexploited since decades [4, 5]. The demonstration of loss of genetic variability in wild populations is empirically limited by lack of samples before heavy overexploitation started. Although rare, archived samples represent a unique opportunity to access ancient populations [4, 5]. In the framework of an Italian PRIN 2005-2007 research project (TUNING; http://:www.dipartimentobiologia.it/tuning/index.htm) and of the EU-FP6 2006-2010 Integrated Project (SESAME), a comparative analyses of genetic diversity at 7 microsatellite loci in ancient (skeletal records collected from 1911 to 1926 by Massimo Sella) and modern samples (from fishing vessels) of Mediterranean bluefin tunas have been carried out to infer historical changes of genetic and demographic properties.

The analysis of about 300 bluefin tunas revealed a temporal stability of genetic diversity over about 90 years and more than 50 years of industrial exploitation of the stock (Table 1). On the other hand, significant changes in the genetic structure of Central Mediterranean bluefin tuna samples were detected. In addition, the results of such work argue for an evidence that, in the Mediterranean, stock overexploitation has not yet corrupted the genetic potential of such relevant fishery resource and that bluefin tunas are not fully pannictic [2, 6]. In general, the results did outcome from the analysis of temporal genetic variation in fishery resources that include comparisons between ancient unexploited and modern (over)exploited populations can really contribute to assess the conservation of fish stocks, based on quantitative genetic data sets that were obtained independently from fishery and tagging data.

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# SOME BIOLOGICAL ASPECTS OF SERRANUS HEPATUS L., 1758 IN IZMIR BAY (AEGEAN SEA, TURKEY)

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# Abstract

A total of 2304 specimens of brown comber *Serranus hepatus* (Linnaeus, 1758) were collected with bottom trawl from Izmir Bay (Aegean Sea, Turkey) between January 2005-December 2005, monthly. Total length (TL) and weight (W) ranged from 4.4 to 11.7 cm and 1.16 to 25.49 g, respectively. The estimated length-weight relationship for all fishes had a slope of 2.8896. *Keywords : Aegean Sea, Teleostei.* 

### Introduction

Brown comber, *Serranus hepatus* (Linnaeus, 1758), is a small, demersal serranid species distributed in coastal waters, occurring along the coasts of the Eastern Atlantic Ocean from Portugal to the Canaries and the Mediterranean Sea [1]. It is common in *Posidonia* beds, sandy and muddy bottoms down to 100 m depths [2]. Because of its small size, *S. hepatus* has not commercial value in Turkish fisheries. This paper presents some biological parameters of brown comber caught in Izmir Bay.

#### Materials and methods

Samples were monthly obtained from three stations (station I 38° 28'N 26° 46'E; station II 38° 33'N 26° 43' E; station III 38° 32'N 26° 40' E) by R/V Egesüf (27 m LOA, 500 hp) between January 2005 to December 2005 around Uzunada Island, in the western part of Izmir Bay (Figure 1). In the samplings, a traditional bottom trawl net was used to capture small size fish species by a 24 mm strecthed mesh size codend. The towing duration was 30 min for all hauls and the average towing speed was 2.4 knots (ranging between 2.0 and 2.8 knots). Length-weight relationship (W=a \* L <sup>b</sup>) and length-weight frequencies of samples were calculated based on 2304 individuals. Total and standard lengths were measured to the nearest mm and weights were taken using a digital balance with a precision of 0.01 g.



Fig. 1. Izmir Bay and bottom trawl sampling stations.

Results and discussion

The depth range of the sampling stations varied from 40 to 50 m, 55 to 65 m and 15 to 50 m, respectively. Stations I and II have silt sediment, and station III sandy bottom type with dense *Posidonia* meadows.

The total length of all measured specimens ranged from 4.4 to 11.7 cm (9,5  $\pm$  0.8 cm, mean  $\pm$  SD) and weight from 1.16 to 25.49 g (13.42  $\pm$  3.2 g, mean  $\pm$  SD). The length and weight frequencies exhibited peaks between 9.00-10.50 cm (68 %) and 12.00-16.00 g (46 %), respectively (Figure 2).

There was a strong relationship between total length and standard length:  $SL = 0.8625 \text{ TL} - 0.4723 \text{ (n} = 259, r^2 = 0.971).$ 

Length-weight relationship was W = 0.0196 TL<sup>2.8896</sup> (n = 2304, r<sup>2</sup> = 0.8937, SE of slope = 0.020). Negative allometric growth was observed for all fish (t-test, t = 0.54 <tool{0.05}, n > 500 = 1.65). The value of parameter a was lower than that in Iberian Peninsula and Balearic Sea, Spain (a = 0.0044, n = 22, r<sup>2</sup> = 0.928) [3] and Alexandria, Egypt (a = 0.025, n = 153, r<sup>2</sup> = 0.948) [4], and higher than those in Adriatic (a = 0.0112, n =

87,  $r^2 = 0.977$ ) [5] and Thracian Sea, Greece (a = 0.0113, n = 1739,  $r^2 = 0.960$ ) [6]. Our parameter *b* value was lower than those in other areas, *b* = 3.5681 [3], *b* = 3.123 [5] and *b* = 3.157 except for that in Alexandria waters, Egypt (*b* = 2.84) [6]. This study was supported by Ege University, Scientific Research Project Foundation.



Fig. 2. Observed length and weight frequencies of *Serranus hepatus* in Izmir Bay (sexes combined).

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# ZOOPLANKTON FROM COASTAL SALT LAKES OF THE CRIMEA (UKRAINE)

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# Abstract

The fauna of 5 coastal hypersaline lakes of the Crimea has been studied for the first time. Species assemblages were differently structured according to the season and the lake. *Artemia* sp. was the most common organism, but the population of the Koyashskoye lake is probably a species that is different from those occurring in the other lakes. The species assemblage of the Feodosiyskoye lake was surprisingly dominated by *Onychodiaptomus* sp., a taxon endemic to North America.

Keywords : Black Sea, Zooplankton, Salinity.

Some salt lakes of the Crimea have already been considered for studies on Artemia sp., which is present with both parthenogenetic and bisexual populations in this region [1; 2]. But a complete survey of the Crimean salt-lake fauna has never been carried out. A total of 55 samples were collected from April 2004 to September 2006 (in different seasons) in 5 different salt lakes along the Black Sea coast. The organisms collected were grouped according to 35 categories (11 at the level of species orgenus). The lowest number of categories (6) was typical of the most saline lake (Koyashskoye, 160-300psu). The highest number of categories (20) was found in the only lake (the Bakalskoye) which was affected by a marine ingression during the study period. Artemia sp. was the only ubiquitous organism (at least as eggs, it has been found in all the lakes). On the contrary Mesopodopsis slabberi (Mysidacea), and Acartia tonsa (Calanoida) were present in only one lake. The communities of coastal salt lakes were dominated by Artemia during summer and by Cletocamptus sp. (Harpacticoida) or Moina salina (Cladocera) during spring, in different lakes. The Feodosiyskoye lake had not a stable population of Artemia (only eggs were found) and it was dominated by Onychodiaptomus sp. (Calanoida) during summer, and Brachionus sp. (Rotifera) during spring. It was noted that the plankton showed a benthos-derived composition related to the increase of water salinity. This is probably affected either by the sampling (the reduced water depth deriving from a decrease of water volume forces the net to collect closer to the bottom), and from the floating facilitation that organisms receive from the more salty (and more dense) water. The low number of species of lake Koyashskoye was attributed to its extremely high salinity (never below 160psu in all the study period). The lake was never considered in previous studies, and the Artemia which has been found was never observed before. The Koyashkoye Artemia is evidently dissimilar from all the other Artemia that have been reported from other Crimean lakes [3; 2] and even according our records in the present survey. The Koyashskoye Artemia population is bisexual (contrary to the other populations of the present study, which were parthenogenetic). Many morphological characters [4; 5] allowed us to consider the Koyashskoye population as belonging to a species different from other Crimean Artemia. The most evident differences are the long abdomen, the absence of the furca, and the exceptionally large antennae (A1) of the males. It is known that the morphology of Artemia salina is variable and affected by salinity [6], but the morphology of the Kojashskoye population probably deserves a deepest study.

The typical species composition of the Feodosiyskoye lake allowed us toconsider it as not completely marine derived. Although it is located at 50-70m from the sea-shore, its salinity is probably more affected by continental supplies. The presence of *Branchinella* and *Artemia* eggs suggests that both these anostracans (which were not found as adults), could represent an allochthonous contamination. Otherwise they probably occurred as active organisms in the past (and they probably will occur in the future) under environmental conditions different from the present ones. In the same lake, the Calanoida (which dominated alternatively with Rotifera) were recognised as *Onychodiaptomus* sp., a genus endemic to North America [7] at the present state of knowledge. Feodosiyskoye lake is surrounded by a densely populated area, and a role played by man is the main suspect to explain the presence of a *taxon* never recorded outside of its native area until now. This adds elements to the discussion about the Black Sea area as a sink site for allochthonous bio-invaders [8].

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# DETERMINATION OF FISH COMPOSITIONS AT ARTIFICIAL REEFS DEPLOYED THREE DIFFERENT DEPTHS (20, 30 AND 40M) IN AEGEAN SEA COAST OF TURKEY: PRELIMINARY RESULTS

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## Abstract

Studies aimed at determination of fish assemblages around artificial reefs were conducted mainly 10-25m depths in Mediterranean and Aegean Sea. The goals of this study are determine and compare of fish compositions around artificial reefs which deployed 20, 30 and 40m depths. Underwater visual census technique was used to determine fish species and to record number of individuals. The result shows that fish species number and abundance around artificial reef sets are decrease by increase of depth. *Keywords : Artificial Reefs, Biodiversity, Aegean Sea.* 

## Introduction

Artificial reef researches in Turkey were started at 1991 and mainly took place in the Aegean Sea Coast [1]. Coastal municipalities and fisheries cooperatives showed intensive interest to artificial reef projects after 1995. Ten artificial reef projects were carried out by coastal municipalities between 1995 and 2002. But artificial reef studies improved very slowly during this period.

Monitoring and assessment of artificial reefs to evaluate their effectiveness had gained great importance in recent years [2]. Researches on artificial reefs also increased in Turkey after 2002. The most of the studies related to biological aspects. Limited studies were made on engineering aspects such as stability of reefs [3], effects of waves and currents.

Aim of the present study is to determine and to compare the fish composition around artificial reefs which deployed three different depths (20m, 30m and 40m).

#### Materials and Methods

Gümüldür is a coastal village located in Gulf of Kuşadasi, 60km south of Izmir. Sea bottom between 0-5m is sandy; 5-15m is covered by P. oceanica meadows and than muddy zone extending to deeper areas. Concrete culverts which have 30cm diameter and 105cm long were used to artificial reef unit. Six units, for construct a reef set, were formed like a pyramid (3-2-1). Nine pyramid shape reef sets were constructed and three sets were deployed at each depth (20, 30 and 40m) in April 2006 (Figure 1). The distance between sets was approximately 25m. Underwater visual census technique was used to determine fish species richness and abundance. Three artificial reef sets in each depth were visited during to all observations. Fish species were determined and number of individuals counted. Statistical analyzes consists of 20 and 30 meters, because of few number of species and low abundance records of 40 meters were excluded. Species number and abundance data were compared with One Way ANOVA using SPSS 11.0. Jaccard similarity index was used to measure of the similarity of the structure of fish communities at artificial reef sets in three different depths.

Tab. 1. Frequency of occurrence (%) of species in relation to depths.

| Species               | 20m  | 30m  | 40 m   |
|-----------------------|------|------|--------|
| Conger conger         |      |      | 33.3   |
| Serranus cabrilla     | 100  | 100  | 100    |
| Ephinephelus costae   | 16.7 |      |        |
| Mullus barbatus       |      | 16.7 |        |
| Diplodus annularis    | 16.7 | 16.7 |        |
| Chromis chromis       | 83.3 | 16.7 |        |
| Gobius niger          | 16.7 | 16.7 |        |
| Parablennius rouxi    | 100  | 66.7 |        |
| Scorpaena porcus      | 16.7 |      |        |
| Scorpaena scrofa      | 33.3 | 16.7 |        |
| Balistes carolinensis | 16.7 | 402  | 0.0100 |
| Total no. of species  | 9    | 7    | 2      |

Results

A total of 11 species (126 fishes) belonging to 9 families were recorded in 6 census during September-October 2006 period (Table 1).

The three reef sets in 20m were recorded 9 species (87 fishes), 7 species (28 fishes) at 30m and 2 species (11 fishes) at 40m. *S. cabrilla* was only species which recorded all depths and it was recorded all observations (Table 1). *C. chromis* at 20m and *S. cabrilla* at 30m and 40m were dominant species.

There were no statistically significant differences in fish abundance (p >0.05), however, species richness differ significantly between 20 and 30 meters (p <0.05). The values of Jaccard index between depths were found 50% between 20m and 30m, 10% between 20m and 40m, 14.3% between 30m and 40m.

# Discussion

These preliminary results show that there is a major change in fish composition around 40m depth. But, long-term observations should necessary to make this kind of suggestion. The reason for the absence of many species in this depth may be lack of critical resources such as food. Depth also affects temperature. Thermoclines can be barrier to some organisms [4]. To consider of this kind of result will be important to success of artificial reef projects.

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# UNDERSTANDING THE EFFECTS OF FISHING ON FISH BIODIVERSITY : A CHALLENGE FOR THE ECOSYSTEM APPROACH TO FISHERIES MANAGEMENT

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## Abstract

Maintaining species diversity has been recognised internationally as a priority for sustainable fisheries. An appropriate indicator of fish diversity trends resulting from fishing exploitation is still lacking. To shed light on underlying mechanisms of fish communities' responses to fisheries in terms of biodiversity, we analysed predator-prey interactions within demersal fish communities. In particular, we contrasted size-based fish diversity patterns with the spatial distribution of commercial fishing in the Central Tyrrhenian Sea. *Keywords : Biodiversity, Demersal, Fisheries, Trophic Relations, Tyrrhenian Sea.* 

Following the emphasis given to biodiversity within international agreements for sustainable development (Rio 1992 CBD, Jakarta Convention) and in line with the recent shift towards an ecosystem-based approach to fisheries management (EAFM), biodiversity protection has been adopted as a specific objective within fisheries policies (FAO Code of Conduct For Responsible Fisheries, 1995). Fisheries researchers are asked to provide indicators of ecosystem health to underpin such ecosystem-based management approaches [1]; however the way that fish assemblages respond to fishing exploitation in terms of diversity remains poorly understood available studies show contradictory or inconclusive results [e.g. 2]. As a consequence, indicators of fish biodiversity are considered unsatisfactory metrics for management purposes [3], raising concerns regarding the adequacy of scientific support to these political commitments [4]. In particular, the Mediterranean basin, where phenomena such as climate change-driven tropicalization enhanced by Lessepsian immigrations of southern species, are compounded with over-harvesting effects, understanding biodiversity changes represents a crucial challenge for future environmental protection and human activities management.

We argue that an ecologically meaningful approach to the study of fisheries-driven species diversity changes is required. In this view we suggest that diversity should not be measured considering fish assemblages as a whole, as commonly done, but should instead be estimated within each trophic level present within the fish community, since diversity (i.e. species evenness) is known to be related to competition/predation interactions [5]. In marine ecosystems, trophic level scales with size and fishing is also a size-selective activity, generally targeting larger individuals. Thus fishing disturbance, while affecting the size distribution of fish communities, is also affecting their trophic structure [6]. Based on all these observations, we propose that an appropriate indicator of fishing effects on fish species diversity should be size-based.

The analysis of the distribution of biomass or diversity versus individual body size (size-spectra) provides a method to detect the differential response of large versus small size classes to fishing disturbance [7]. It has been frequently observed in strongly exploited marine communities that a reduction of top-predators, compounded with a positive selection induced by fisheries for smaller faster growing species, has triggered an increase in abundance of smaller fish. Based on Huston's Dynamic Equilibrium Model [5], we hypothesized that a further consequence of this is that a few dominant prey species, no longer kept under control by predatory pressure, expand at the expense of other species sharing the same resource, causing diversity to decline within this size-range. Our previous results from a case-study based in the North Sea [8] suggest that over-fishing of large piscivorous fish has indirectly caused a decline of species evenness of smaller forage fish through a predatory-release mechanism. However, the particular character of the Mediterranean basin, where an oligotrophic regime is expected to result in stronger bottom-up limitation than seen in the highly productive North Sea waters and stronger competitive interactions [9]. The fish community spans a smaller size-range, thus showing a lower degree of piscivory than northern regions, and harvesting strategies are more prevalently mixed fisheries. Therefore, different mechanisms are to be expected and call for specific testing of our hypothesis in the area. We present here diversity and biomass size-spectra of demersal assemblages from the Central Tyrrhenian sea, sampled during routine trawl surveys from 1985-2005 (GRUND) and 1994-2005 (MEDITS) (for details see [9]). To detect fishing effects on these communities we compared the diversity patterns of fish assemblages from an area that suffered intense commercial fishing exploitation with those from an area where disturbance has been less intense. Furthermore, in an attempt to disentangle changes in smaller size-classes due to predatory release effects from fisheries-driven positive selection of smaller fast-reproducing individuals, we estimated the predator-prey size ratio for piscivores, based on stomach-content analyses, and explored life-history characteristics of the component of the fish assemblage at the lower end of the size spectrum.

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# CAULERPA RACEMOSA ON THE MONTENEGRIAN COAST

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# Abstract

The invasive algae *Caulerpa racemosa* was first recorded from the Montenegrian coast in 2004, and eradication was attempted. Our survey identified three new localities for the alga in 2005, and two more in 2006. *Keywords : Adriatic Sea, Algae.* 

## Introduction

Since beginning of the 1990s the invasive variety *C. racemosa* var. *cylindracea* has been recorded on many localities on the coast of 11 countries around the Mediterranean [1] and the first report for the Adriatic Sea was in 2000 on the Pakleni archipelago (Croatia). [2] The aim of this work is to present the data about its spread along Montenegrian part of the Adriatic coast.

#### Materials and methods

The field research was done by SCUBA diving on 52 localities between 2004 and 2006. Collected material was conserved in 4% formaldehyde solution and photo documentation was done as well.

## Results and discussion

The first record of Caulerpa racemosa for the coast of Montenegro was in August 2004 near Budva (Fig. 1) and in that time algae was growing on 3m depth covering 2m<sup>2</sup> of dead matte substrate. Regarding it was the small patch and in that time the only one known on the Montenegrin coast attempt of eradication was carried out. Eradication was done in September by manual collecting of algae, as much as possible and by covering the colony with black pvc foil. Also, before placing the pvc foil the solution of copper-sulphate and lime were sprinkled. [3] Although during the winter and spring colony of Caulerpa racemosa almost disappeared, in summer 2005 reappearance of algae occurred. The local diving club repeated eradication process in autumn 2005 but the algae is growing still now. On the first known location now we have the oldest patch with 11m in diameter and few smaller patches around. Since first record three new localities were found in 2005 and two localities in 2006. All together six populations on the Montenegrian coast create around 864m<sup>2</sup> of covered and 3,8 ha of affected area with 560m of affected coastline.



Fig. 1. Localities were *Caulerpa racemosa* was found (1. Budva; 2. Island Mala Gospa; 3. Žanjice; 4. Mirište; 5. Cove Veslo and 6. Budva-2).

It should be noted that we registered reticulated depigmented thalii of fertile algae in October 2006 and by microscope observation we noted male and female gametes, but further analysis of gamete conjugations were not done. Also it should be noted that length of fronds on all localities in October 2006 was significantly shorter than last year in same period.

#### Conclusion

Although *Caulerpa racemosa* is spreading on the Montenegrian coast with threat to have a significant impact to autochthonous biocenoses we should say that a few positive outputs emerged. Mapping of *Caulerpa* in this year was project funded by three Ministries together, campaign for public awareness probably helped to reduce man-made dissemination and the most important output, interest for protection of marine environment in general is increased.

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# SPECIES ABUNDANCES OBSERVED IN AN ICHTYOPLANKTONIC ASSEMBLAGE IN THE GULF OF IERISSOS (THRACEAN SEA, GREECE)

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# Abstract

A series of fish larvae species from the Ierissos Gulf were collected using a bongo-net during three expeditions, in June, September and November 2004. After identifying and analysing the samples, seasonal variations of species characterizing the ichtyoplanktonic assemblages were found. The European anchovy (*Engraulis encrasicolus*) was the dominant species in June and September. *Keywords : Ichthyoplankton, Aegean Sea, Biodiversity.* 

## Introduction

The coastal marine ecosystem of Strymonikos Gulf, is one of the richest fisheries grounds in Greece and major source of income for the local fishermen. The area of Ierissos, a small bay in the eastern side of Strymonicos, is known for its richness in ichtyoplankton [1] due to the local rivers inflow and the strong influence of Black sea water [2]. Trawl fishing is banned in the area of Ierissos Gulf, creating good conditions for the local spawning and nursery grounds. The main objective of this work is to identify characteristic species of the ichtyoplanktonic assemblage and its seasonal changes in the Ierissos Gulf.

## Material and methods

Specimens were collected with a bongo-net (mesh size: 250 and 500  $\mu$ m). Samplings took place in 2004 during three daily surveys carried out in June, September and November. A flowmeter determined the water volume filtered. The sampling grid consisted of 14 stations placed in transects perpendicular to the coast. The larvae were identified to the lowest possible taxonomic level, counted and measured. Maximum tow depth and volume of water filtered were used to standardize abundance in number of larvae per 10 m<sup>2</sup> [3]. PRIMER v5 software [4] was used for the data analysis as well as STATISTICA v7 statistical software. A matrix of taxa abundance per station was constructed and the Bray-Curtis similarity matrix was generated which was subjected to cluster analysis (using forth root transformation in order to give weight to less abundant species). The characteristic species in each month were determined with SIMPER, using forth root transformation (species with contributed less than 10% were not considered in the analysis). Furthermore, differentiations between months was tested with ANOSIM (pairwise test). Samples from stations 1, 11, 13 and 14 during the November survey were omitted because they had less than 6 taxa.

#### Results

A total of 2697 larvae were collected and identified. The species characterizing the larval assemblage in each month and their order according to their percentage contribution were: *Engraulis encrasicolus* (23.97% contribution), *Sardinella aurita* (16.71%) and *Serranus hepatus* (15.79%) in June; *E. encrasicolus* (27.44%), *S. hepatus* (20.04%) and *Cepola macrophtalma* (17.76%) in September; and *C. macrophtalma* (26.45%), *Ceratoscopelus maderensis* (20.13%), *E. encrasicolus* (16.10%) and *Sardina pilchardus* (14.13%) in November.

Cluster analysis (Fig. 1) showed an evident similarity of samples within each month and defined two groups: one for June and September (Summer) and another one in November (Autumn). The pairwise test showed a significant dissimilarity between months (June-September: R=0.84; June-November: R=0.84; September-November: R=0.77).



Fig. 1. Dendrogram of similarities (cluster analysis, group-average linkage, fourth root transformation) of the 36 stations sampled in June, September and November in 2004 in Ierissos Gulf.

#### Discussion

The study showed seasonal changes in fish larval assemblage. The main factors for this differentiation were the predominance of E. encrasicolus in June and September, the presence of S. aurita in June and S. pilchardus in November. E. encrasicolus picked in September, in accordance to Koutrakis et al. [1] and had a long-lasting presence of larval stage in the gulf covering almost six months. C. macrophtalma percentage contribution in the assemblage increased by months: in June was 7.84% while in September was 17.76% and in November 26.45%, when it achieved the maximum abundance. S. hepatus was one of the characteristic species of the assemblage during the warm season, and was completely absent in November, as observed by Koutrakis et al. [1]. Species diversity remained constant although its two components, species richness and evenness showed a shift of their relative importance: June was characterized by a larger species richness and a lower equitability, due to the dominance of E. encrasicolus, in contrast to November, when a lower species richness and a more balanced distribution of individuals between all species were found.

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# TAXONOMIC AND FUNCTIONAL STRUCTURE OF SESSILE MACROBENTHOS IN THE LAGOON OF VENICE

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# Abstract

The sessile benthos colonizing the wooden piles of the lagoon of Venice was sampled in July 2005 in stations characterized by different types of disturbance, in order to investigate the taxonomic and functional structure of the community. The most unexpected result was the high taxonomic richness observed in stations affected by industrial and urban discharges, that could be related to the environmental changes occurring in the lagoon.

Keywords : Adriatic Sea, Lagoons, Zoobenthos.

## Introduction

We present the results of a recent survey on the sessile zoobenthos colonizing artificial hard-bottoms in the lagoon of Venice. This community has been considered a good indicator of environmental change and used in monitoring programs over the last decades [1, 2]. In this study we analyse both taxonomic and functional composition of the community, in the attempt to identify characteristic species and functional traits related to different environmental conditions.

## Materials and Methods

Biological samples were collected in July 2005 in 12 stations, located in the central and northern sub-basins of the lagoon of Venice and selected as representative of different environments: F1, F2 at the continental margin, influenced by freshwater and agriculture discharges; I1, I2 in the industrial area of Marghera, where a refinery complex is located; U1, U2, U3, U4 in the urban canals of Venice; L1, L2, L3, L4 in the typical lagoon context. Sampling methods of the sessile organisms colonizing artificial hard substrates (wooden piles) are described in [2].

Two different matrices were created, i.e. a matrix of taxa  $\times$  stations (average abundance over three replicates), plus a matrix of functional traits  $\times$  stations, calculated according to [3]: (i) seven functional traits were selected and sub-divided into several categories, for example the trait "body form" included the categories "flat", "mound", "erect"; (ii) individual taxa were scored from 0 to 3 for their affinity to each trait category, using a "fuzzy coding" procedure; (iii) for each taxon its relative abundance was multiplied for the trait category scores, that were then summed over all taxa present at each station. Finally, the Bray-Curtis similarity between couples of stations was calculated for both matrices, and non-metric multidimensional scaling (nm-MDS) plots were generated.

### Results and Discussion

A total number of 44 taxa was identified. The most frequent and abundant taxa were: Didemnidae, Ostreidae, *Mytilus galloprovincialis, Pileolaria militaris, Tricellaria inopinata* and *Ventromma halecioides*. The ascidians Didemnidae, probably of exotic origin, showed invasive character, having never been observed with such high frequency and abundance in all the previous surveys. Conversely, species once characteristic and abundant in the lagoon, in July 2005 were collected only in a few stations, suggesting that the zoobenthos is experiencing deep changes in its taxonomic composition.

Taxa richness evidently varied among stations, with minimum values at the two freshwater stations (mean richness:  $5.8 \pm 2.22$ ) and maximum values at the lagoon and industrial stations ( $15.0 \pm 3.02$  and  $15.0 \pm 2.53$ , respectively). Within the group of urban stations (mean richness:  $10.7 \pm 4.81$ ), over 15 taxa were observed in each replicate of U1 and U2. This is in contrast with the observations of past studies: all the urban stations in the 1990s were characterized by very simplified communities, with only a few opportunistic species [1]. Such a high taxonomic richness in stations affected by industrial and urban discharges was unexpected. The contribution of non-indigenous species has to be taken into account: invasive organisms like the bryozoan *T. inopinata* and the ascidians Didemnidae, being able to colonize even industrial and urban stations, have locally increased the taxonomic richness, but their presence is a symptom of other types of disturbance affecting the lagoon of Venice.

Fig. 1 shows the results of similarity analysis: 4 groups of stations can be detected both from the taxonomic (fig. 1a) and functional (fig. 1b) point of view. However, the constant presence of a few opportunistic species in

most samples influences the results of the similarity analysis: the disturbed urban and industrial stations are no longer clearly separated from the more pristine lagoon stations, as in the past [1].

The urban stations, although being geographically close and having a relatively similar taxonomic composition (fig. 1a), display high functional dissimilarity within themselves and among other groups (fig. 1b), showing an unpredictable pattern. On the contrary, the most characteristic community is observed in stations F1 and F2, which present a set of species with peculiar traits (e.g. erect form, low protection, asexual reproduction by budding).

The environmental changes occurring in the lagoon of Venice, in particular the lowered nutrient discharge from the drainage basin and the increased frequency of the "high water" events, could be responsible for the reduction in differences of sessile benthic communities within the lagoon.



Fig. 1. Similarity analysis: nmMDS plots obtained from the taxa x stations matrix (a) and functional traits x stations matrix (b).

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# TAILLE À LA MATURITÉ SEXUELLE DE *SQUALUS BLAINVILLEI* (RISSO, 1826) DU GOLFE DE GABÈS (TUNISIE)

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# Résumé

Dans le golfe de Gabès (côtes sud-est de la Tunisie), la maturité sexuelle de l'aiguillat coq, *Squalus blainvillei*, s'installe chez les mâles et les femelles respectivement à 52 et à 62 cm.

Mots clès : Gulf Of Gabes, Fishes, Reproduction.

## Introduction

*Squalus blainvillei*, est un requin à affinité atlanto-méditerranéenne, se rencontrant sur les deux versants du cadre maritime tunisien [1, 2]. Les études se rapportant à sa biologie ont concerné principalement les populations de la Méditerranée occidentale et centrale [3, 4]. Dans la Méditerranée orientale, les informations concernant sa biologie sont limitées [5, 6]. Dans ce travail, nous estimons la taille à la maturité sexuelle du *S. blainvillei* dans le golfe de Gabès.

#### Matériel et méthodes

La présente étude a porté sur 152 individus (81 femelles, 71 mâles) ayant une longueur totale allant de 34 à 100 cm et provenant d'un échantillonnage étalé sur une année (mai 2004-mai 2005) dans le golfe de Gabès. Les individus ont été classés en trois catégories (juvéniles, subadultes et adultes) selon les critères suggérés par Stehmann [7]. Pour les mâles, la taille de la première maturité sexuelle a été estimée par le suivi de la croissance relative des ptérygopodes (Lpty.) par rapport à la longueur totale (LT). Pour les deux sexes, la taille de la première maturité sexuelle est donnée par le calcul de la proportion des matures par classe de taille qui sera ajustée grâce à un logiciel FSAS [8]. La taille de la première maturité sexuelle est la taille à laquelle 50 % de la population sont matures.

#### Résultats et discussion

La croissance relative des ptérygopodes en fonction de la taille révèle la présence de trois groupes.



Fig. 1. Evolution du pourcentage des femelles et des mâles matures en fonction de la LT chez *S. blainvillei.* 

Les individus dont LT est inférieure à 38 cm présentent des ptérygopodes courts et flexibles. Les individus ayant une LT comprise entre 38 et 56 cm

ayant des ptérygopodes calcifiés. A partir de LT supérieure à 56 cm tous les individus possèdent des ptérygopodes très rigides.

La taille à laquelle 50 % des mâles sont matures est égale à 52 cm (Fig.1). Tous les mâles ayant une LT supérieure à 59 cm sont matures. Ces résultats corroborent ceux de Sion et al. [6] dans les eaux grecques.

La taille à laquelle 50 % des femelles sont matures est égale à 62 cm (Fig.1). A partir de 70 cm, toutes les femelles sont matures. Les différents résultats obtenus par divers auteurs en Méditerranée [4, 6] montrent que la taille de la première maturité sexuelle des femelles du *S. blainvillei* est de l'ordre de 60 cm. Ces résultats reflèteraient que la LT à la maturité de cette espèce ne diffère pas en fonction des secteurs maritimes méditerranéens.

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# FIRST RECORDS OF THE RARE STARFISH *MARGINASTER CAPREENSIS* (GASCO, 1876) (ECHINODERMATA, ASTEROIDEA, PORANIIDAE) IN THE STRAIT OF SICILY AND FURTHER INFORMATION ON ITS RECENT FINDING IN THE IONIAN SEA

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# Abstract

First records of the rare starfish *Marginaster capreensis* (Echinodermata: Poraniidae) for the Strait of Sicily are reported. Two specimens were collected in 2004 at 87m and 136m depth on the off-shore African shelf. Detailed information on the first specimen, recently reported in literature from the Ionian Sea, is also given. It was collected in 2000 at 707-742 m depth off the Corfù island (Eastern Ionian). *Keywords : Echinodermata, Sicilian Channel, Ionian Sea, Eastern Mediterranean, Western Mediterranean.* 

*Marginaster capreensis* (Gasco, 1876) is a small sized starfish living in a wide depth range (between 50 and 2500m) [1]. It is considered as "one of the rarity of the Mediterranean fauna" [1], where it was found in the Gulf of Naples (Tyrrhenian Sea), between 70 and 84m [2], in the Southern Aegean Sea (597m) [3] and in the Levant Sea (315m) [1]. Recently the species was reported on the bathyal bottoms of the Eastern Ionian Sea [4]. The two specimens of *M. capreensis* from the Strait of Sicily were collected during the 2004 trawl survey (Italian GRUND program). The specimen from the Ionian Sea was collected during a campaign carried out within the Italian-Greek INTERREG program [4]. The main information on catch data and biometries of the two individuals found in the Strait of Sicily and of the specimen from Ionian Sea [4] are reported in Table 1.

Tab. 1. Main information related to the findings of *M. capreensis*. R and r according to [1].

| Area          | Date       | Appr. Lat. | Appr. Lon. | Depth (m) | Diameter (mm) | R/r | Weight (g) |
|---------------|------------|------------|------------|-----------|---------------|-----|------------|
| Sicily Strait | 19/09/2004 | 34°30.00'  | 12°49.00'  | 87        | 23            | 1.2 | 1.15 (wet) |
| Sicily Strait | 12/10/2004 | 34°21.50°  | 13°23.50'  | 135-137   | 21            | 1.2 | 1.15 (wet) |
| Ionian Sea    | 22/7/2000  | 39°18.00'  | 19°55.00'  | 707-742   | 25            | 1.3 | 0.41 (drv) |

Biology of this species is unknown and the information on biogeographical distribution is scanty both in Eastern Atlantic and in Mediterranean. Including the new records from the Strait of Sicily, only eight individuals were reported for the Mediterranean. The specimen from the Eastern Ionian Sea was the deepest record of the Mediterranean. According to available data, the species in the Eastern basin seems to prefer habitats deeper than those of the Tyrrhenian Sea and the Strait of Sicily.

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# THE INFLUENCE OF OCEANOGRAPHIC SCENARIOS ON THE POPULATION DYNAMICS OF DEMERSAL RESOURCES IN THE WESTERN MEDITERRANEAN: HYPOTHESIS FOR HAKE AND RED SHRIMP OFF BALEARIC ISLANDS

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## Abstract

We analysed the relationships between climatic indices, population parameters (abundance, recruitment and spawning stock) and catchability of hake and red shrimp in the trawl fishery off Balearic Islands (western Mediterranean). *Keywords : Demersal, Recruitment, Fisheries, Hydrography, Balear Islands.* 

As in other areas of the western Mediterranean, the hake (*Merluccius merluccius*) and the red shrimp (*Aristeus antennatus*), two target species for the trawl fishery off Balearic Islands, exhibited inter-annual fluctuations in landings during the last decades. Within the IDEA project (www.ba.ieo.es/idea) we have studied relationships between some climatic indices and parental stock, recruitment and accessibility to trawl fishery for these two species.

Available annual catch per unit effort (CPUE; as kg/HP) data series for the period 1960-2004 were used as a proxy for the abundance of these species. Their population parameters recruitment (R) and spawning stock biomass (SSB) could be obtained (for 1980-2004 for hake and for 1992-2004 for red shrimp) from assessments developed within the framework of the General Fisheries Commission for the Mediterranean. As environmental data, the meso-scale IDEA index was used [1]: higher and lower values indicate minor and major presence of WIW for the Ibiza channel, the following spring respectively, which determine the spring-summer oceanographic scenarios around the Balearic Islands. Other large-scale climate indices, North Atlantic Oscillation (NAO) and Mediterranean Oscillation (MO). were also used. These indices could determine the climatic conditions where Mediterranean intermediate waters which could affect hake and red shrimp (WIW and LIW, respectively) are formed. Data series of environmental variables (NAO, MO and IDEA indices) and population dynamics parameters for hake and red shrimp (CPUE, R and SSB) used are shown in Figure 1. To analyse possible links between large- and meso-scale indices with the population dynamics of both species, two approaches have been used: (i) stock-recruitment relationships (SRR) from Ricker and Beverton-Holt models, by incorporating sequentially environment factors; (ii) generalized additive modelling, both classical general and threshold non-additive models were considered, which simulate an abrupt change in explicative variables across different phases (time periods or climatic index values). The strategy of analysis has been to consider the influence of two climatic indices for each species: the regional IDEA index and one global index (NAO for hake and MO for red shrimp). MO index values were considered with a -5 years time lag, because available information estimates that LIW requires up to 5-6 years for reaching the western basin. To avoid the influence of trends in CPUE, R and SSB, these population parameters have been conveniently detrended.

A negative significant relationship between NAO index and abundance (modelled by CPUE) and SSB of hake were found, being this effect more evident during the period 1960-1980. Results also suggest that density-dependent and environmental factors affect its R, both SSB and IDEA index improving our ability to simulate R from SRR Ricker and GAM formulations. The best model for R was obtained from the negative effect of SSB, influenced by NAO index, and IDEA index during 1980-1995. For red shrimp, a positive effect of the global MO index on its abundance and SSB was detected. Results also suggest that density-dependent and environmental factors affect R of this species. A direct positive effect of SSB and negative effect of IDEA index on R have been detected, while MO index also affects R, but indirectly through SSB.

The results indicate that macro and meso-scale climate regimes can influence the population dynamics of hake and red shrimp around the Balearic Islands. Specially for recruitment, which seems to be enhanced during low NAO and IDEA indices periods, when colder-than-normal winters, producing high generation of cold Winter Intermediate Waters in the Gulf of Lions, which flow southwards and reach the Balearic Islands channels in spring, increasing the productivity in the area. This oceanographic scenario could also be favourable to the distribution of hake on the fishing grounds where trawl fleet target to this species, increasing its accessibility to the fishery. Both spawning stock and abundance of red shrimp seems to be also enhanced by high MO index periods, which could reflect the major presence of the saline and warm Levantine Intermediate Waters (LIW) in the study area, which extends over the fishing grounds of this species.

These proposed interactions between external and internal variables on hake and red shrimp populations can be useful to assess and manage these important demersal resources in the Balearic Islands: (i) allowing the identification of reliable environmental indices and their integration into stock assessment models; (ii) and enhancing our ability for recruitment forecasting.



Fig. 1. Data series of environmental variables (NAO, MO and IDEA indices, represented by three years running averaged) and population dynamics (CPUE: catch per unit effort; R: recruitment; SSB: spawning stock biomass) of hake and red shrimp in the Balearic Islands used in this study.

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# NOUVELLES DONNÉES SUR LA DISTRIBUTION GEOGRAPHIQUE DE ZEBRUS ZEBRUS POISSON GOBIIDAE (RISSO, 1826) AU NIVEAU DES CÔTES MÉDITERRANÉENNES MERIDIONALES

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# Résumé

Dans ce travail, nous fournissons de nouvelles données sur la distribution de Zebrus zebrus (Risso, 1826), poisson gobiidé, dans les eaux tunisiennes et mentionnons sa présence, pour la première fois, sur les côtes libyennes. Les caractères méristiques et morphométriques relevés sur les spécimens colletés ont permis de vérifier qu'ils présentent les mêmes caractéristiques que ceux déjà décrits en Méditerranée et en Atlantique.

Mots clès : Biodiversity, Fishes.

## Introduction

La distribution géographique de *Zebrus zebrus* (Risso, 1826), l'unique espèce de son genre, n'est pas clairement délimitée jusqu'à présent [1-2]. En effet, ce poisson est réputé pour son endémisme en Méditerranée [3]. Cependant, Miller [4] a suggéré la présence de ce gobie dans les eaux chaudes de l'Atlantique. Son hypothèse a été par la suite confirmée par la capture de l'espèce sur les côtes sud ouest de l'Espagne [2]. Cette mention a changé radicalement les connaissances sur la distribution géographique de ce gobie et par conséquent son statut de poisson endémique a été remis en cause [5].

En Méditerranée, le gobie zébré a été signalé dans quelques localités des côtes européennes et Est levantines [1, 6]. En 2000, cette espèce a été pêchée dans cinq sites tunisiens qui sont : la lagune de Bizerte, la lagune d'El Biban, le littoral de Tabarka, ainsi que sur les côtes Est allant de Salakta à Sfax [7]. Récemment, la prospection de nouveaux sites en Tunisie à savoir la Lagune Sud de Tunis, la lagune de Lella Hadria (Jerba), Sidi Rais dans le Golfe de Tunis, le littoral de Sousse, nous a permis de capturer des spécimens de ce poisson gobiidé. De même des investigations réalisées dans une lagune libyenne (la lagune de Farawah), située près de la frontière tunisienne, ont révélé la présence de Zebrus zebrus dans ce site.

## Matériel et Méthodes

Les individus collectés de Zebrus zebrus ont été pêchés au moyen d'un mini chalut benthique constitué de deux demi-cercles de 0,85 m de diamètre reliés entre eux par une charnière. Le filet de cet engin est de 0,85 m de large, 4 m de long et 2 mm de maille. En Tunisie, les pêches réalisées sont mensuelles et ont été effectuées durant la période allant de janvier à octobre 2006. En revanche, en Libye, nous avons entrepris une seule campagne de pêche au cours du mois de Mars 2006. Les échantillons ont été identifiés et sexés, en se référant à la forme externe de leurs papilles urogénitales [1]. Sur chaque individu, nous avons prélevé six caractères méristiques (Nombre des rayons de la première nageoire dorsale "D1", nombre des rayons de la deuxième nageoire dorsale "D2", nombre des rayons de la nageoire anale "A", nombre de rayons de la nageoire pectorale "P", nombre des écailles en série longitudinale de l'aisselle de la pectorale jusqu'à la caudale "LL" et nombre de vertèbres "Vert"), et seize caractères morphométriques (Longueur totale "LT", longueur standard "LS", longueur de la tête "T", diamètre de l'oeil "O", distance interorbitaire "IO", hauteur du corps "H", distances prédorsales "PD1 et PD2", distance pelvienne "PV", distance prépectorale "PP", distance préanale "PA", longueur de la base de la première nageoire dorsale "LD1", longueur de la base de la deuxième nageoire dorsale "LD2", longueur de la base de l'anale "LA", longueur de la pectorale "LP").

# Résultats et discussion

Les caractères méristiques relevés sur les spécimens collectés sont D1 : V-VI, D2 : I+10-11, A : I+9-10 et P : 14-16. Le nombre des écailles sur la ligne latérale est compris entre 29 et 32, alors que le nombre des vertèbres est compris entre 26 et 27. Les intervalles de variation de ces caractères sont similaires à ceux cités par Miller [1], Nieto & Alberto [2], Tortonese [6] et Menif [7] sur les côtes Méditerranéennes et Atlantiques.Les données morphométriques des poissons examinés ainsi que leur coloration corporelle, la distribution de leurs papilles sensorielles et de leurs pores céphaliques sont en concordance avec ceux rapportés dans la littérature [1, 6]. Celles-ci confirment qu'il s'agit effectivement de l'espèce *Zebrus zebrus*, poisson gobiidé.Conclusion : Selon ces nouvelles données, nous supposons que *Z. zebrus* est commun le long de toutes les côtes tunisiennes. Quant aux côtes libyennes, d'autres investigations sont nécessaires pour apprécier l'ampleur de la répartition de cette espèce dans cette région.

#### Remerciements

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# ALIEN FORAMINIFERS ALONG THE AEGEAN AND SOUTHWESTERN COASTS OF TURKEY

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# Abstract

Many Indo-Pacific originated foraminifer species have been recorded from the Eastern Mediterranean. In the framework of this study, sediment samples collected from various depths in the Aegean and Southwestern Mediterranean coasts of Turkey have been analysed. 26 genera and 32 species of recent benthic foraminifera, commonly known from Indo-Pacific or Atlantic have been identified. 27 of these alien species are observed only on the Turkish coastline in the Mediterranean Sea and 18 of them are new records for the Mediterranean fauna.

Keywords : Aegean Sea, Eastern Mediterranean, Foraminifera, Migrant Species.

Several hundred marine alien species in the Eastern Mediterranean are of Indo-Pacific origin. Alien algae, fishes, molluscs and crustaceans are intensively studied, but little is known about the alien microfauna of the Mediterranean, though some alien foraminiferan species have already been recorded from the Eastern Mediterranean [1, 2]. In the framework of this study, sediment samples from various depths (3-30 m) of the Aegean and southwesternMediterranean coasts of Turkey were analyzed and the composition as well as the distribution of the alien foraminifers were determined.

Twenty-six genera and 32 species of recent alien benthic foraminiferans with various distribution patterns in the eastern Aegean and Mediterranean coasts ofTurkey were recorded. These taxa include; Haddonia spp., Edentostomina cultrata (Brady), Clavulina angularis d'Orbigny, C. cf. multicamerataChapman, Nodopthalmidium antillarum Cushman, Spiroloculina cf .angulata Cushman, S. antillarum d'Orbigny, Schlumbergerina alveoliniformis (Brady), Hauerina diversa Cushman, Quinquemosharrafai Said, Miliolinella cf. hybrida (Terquem), loculinacf. Pseudomassilina reticulata (Heron-Allen and Earland), Pyrgo denticulata (Brady), Triloculinacf. fichteliana d'Orbigny, Articulina alticostata Cushman, Peneroplis arietinus (Batsch), Cycorbiculina compressa (d'Orbigny), Amphisorus hemprichii Ehrenberg, Sorites orbiculus Ehrenberg, S. variabilis Lacroix, Pyramidulina catesbyi (d'Orbigny), P. perversa (Schwager), Astacolus insolitus (Schwager), A. sublegumen (Parr), Entosigmomorphina sp., Cymbaloporetta plana (Cushman), C. squammosa (d'Orbigny), Acervulina inhaerens Schultze, Planogypsina acervalis (Brady), P.squamiformis (Chapman), Amphistegina lobifera Larsen, Elphidium charlottense (Vella), E. striatopunctatum (Fichtel and Moll) and Heterostegina depressa d'Orbigny. 27 of these alien species are observed only along the Turkish coastline in the Mediterranean Sea, whereas, Haddonia sp., Clavulina angularis, C. cf. multicamerata, Schlumbergerina alveoliniformis, Quinqueloculina cf. mosharrafai, Miliolinella cf. hybrida, Pseudomassilina reticulata, Pyrgo denticulata, Triloculina cf. fichteliana, Peneroplis arietinus, Cyclorbiculina compressa, Amphisorus hemprichii, Sorites variabilis, Pyramidulina catesbyi, P. perversa, Cymbaloporetta plana, C. squammosa, Elphidium cf. charlottense aren ew records for the Mediterranean fauna.

Most of the alien foraminiferan species are rare, represented by 1 to 100 individuals per 5gr of sediment. However, *Amphistegina lobifera* Larsen forms dense populations along the southwestern coasts of Turkey with up to 230.-310 individuals/m<sup>2</sup>. The high ratio of tests in the sediment (3.75 grams) results in large amounts of sand formation.

The majority of these alien species are only known from the Indo-Pacific, while some species are recorded both in the Atlantic and the Indo-Pacific (i.e., *C.angularis, N. antillarum, S. antillarum, S. alveoliniformis, H. diversa, C. compressa, A. hemprichii, P. catesbyi, C. squammosa, A. inhaerens, P. acervalis, P. squamiformis, Amphistegina spp., H. depressa)* [3-6]. But since, with the exception *S. orbiculus*, these species have yet to be found in the westernMediterranean, it is suggested that the populations in the eastern Mediterranean most likely originated from the Indo-Pacific.

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## BIOECONOMIC SIMULATION ANALYSIS OF HAKE FISHERY IN THE GULF OF SARONIKOS (GREECE)

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## Abstract

European hake (*Merluccius merluccius*) is one of the most important species in Greek fisheries due to its high commercial interest. It has been reported to be overexploited and in need of management to preserve its exploitation. The MEFISTO bioeconomic simulation model is proposed in order to test the effect of effort reduction in the bioeconomic indicators of the trawl hake fishery. Two alternative policy scenarios are analyzed compared to the *status quo* scenario. The trends of the biological and economic indicator variables through time are displayed for each scenario.

Keywords : Aegean Sea, Demersal, Fisheries, Models, Population Dynamics.

#### Introduction

European hake, *Merluccius merluccius* is one of the most important resources for the bottom trawl fleets in the Greek territories, both in terms of catch and economic value. The stock has been reported as overexploited [1]. The Saronikos Gulf's trawling fleet is composed of eighteen vessels that operate from October to the end of May, a total of eight months per year. The landings of hake represent 4.5% of the total catches in Saronikos Gulf and 45.5% of the total Greek hake landings and the 5% of the total revenues [2].

## Material and Methods

The objective of the MEFISTO simulation model is to reproduce the bioeconomic fishing conditions of the Mediterranean [3]. The model includes the age-structured dynamics of the target species and a relationship between landings of target and secondary species. This particular instance has been run with constant recruitment and catchability. The prices of target and secondary species are assumed to be constant. The simulations are performed through a vessel level analysis. Vessels are characterized through their technical characteristics including catchability and costs. The fishermen will choose a fishing strategy based in yearly profits obtained after discounted an appropriate cost structure to their revenues [3, 4]. The simulation carries out projections starting from the current situation forwards into the future at a yearly scale with the purpose of analyzing the trends of different indicators of the fishery under different scenarios that represent alternative management actions. The simulations presented here are run deterministically through a fifteen year horizon.

The data source: Biological parameters such as the growth parameters [5], the length-weight relationship parameters [1], the fraction of mature individuals at age [1], the natural mortality [1] assumed as constant and initial populations' data [1] as derived by VPA run assuming steady state [6] are shown in Table 1. Economic data were collected by Karlou-Riga (unpublished data).

The scenarios: *Scenario 0.* The control or *status quo* scenario, represents the outcome of the fisheries biological and economic indicators projecting the situation of 2004 (year t=0 for the simulation).

Tab. 1. Biological parameters (a, b,  $L_{inf}$ , k,  $t_0$ , Mat, M) and initial population data (N, F) at age for hake (a, b: parameters from the length-weight relationship;  $L_{inf}$ , k,  $t_0$ : growth parameters as derived from the von Bertalanffy equation; Mat: maturity fraction at age; M: natural mortality; N: initial number of individuals at age; F: fishing mortality at age).

|     | a= | 0.006   | L <sub>int</sub> = | 73.12 cm  |
|-----|----|---------|--------------------|-----------|
|     | b= | 3.13    | k=                 | 0.2725    |
|     | M= | 0.43    | $t_0 =$            | -0.15 yrs |
| Age |    | N       | Mat                | F         |
| 0   |    | 5908005 | 0.019              | 0.298     |
| 1   |    | 2854163 | 0.167              | 1.828     |
| 2   |    | 298545  | 0.511              | 1.463     |
| 3   |    | 44988   | 0.905              | 0.842     |
| 4   |    | 12614   | 1                  | 0.085     |
| 5   |    | 7533    | 1                  | 0.016     |
| 6   |    | 4825    | 1                  | 0.101     |
| 7   |    | 2837    | 1                  | 0.5       |

*Scenario 1.* The effect of an effort reduction in trawlers activity is tested reducing their legal period of fishing by 12% (1 month) at year t=5 of the simulation.

*Scenario* 2. The effect of an effort reduction in trawlers activity is tested through a reduction of their legal period of fishing by 24% (two months) at year t=5 of the simulation.

### Results

The two scenarios tested bring positive results both for conservation (increase in biomass, fig. 1) and economic objectives (increase in profits, fig.1) after two years of the management action. A short-term (one year) crisis after the implementation of the management measure is noted for hake biomass, which however recovers getting values higher than before the management action. The current overexploitation level of this species suggests that a decrease in its fishing mortality would bring positive results for the fishery. However, it should be noted that even with 24% reduction in fishing time (scenario 2), the stock remains overexploited (i.e. it is still beyond the  $Y_{max}$ ) and needs more drastic management measures (i.e. improvement of selectivity).



Fig. 1. Bioeconomic indicators for two effort control scenarios against the base or *status quo*.

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## MEDITERRANEAN MONK SEAL SIGHTINGS IN ITALY THROUGH INTERVIEWS: VALIDATING THE INFORMATION (1998-2006)

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## Abstract

Despite the fact that the monk seal has been defined as absent from Italian coasts during the last decades sightings are still reported. The present paper illustrates the methodology used to validate monk seal sightings reported along Italian coasts since 1998. The presently outlined sighting validation procedure suggests that a small presence of individuals may still be occurring for short periods throughout Italian coasts.

Keywords : Conservation, Monitoring, Sampling Methods.

The Mediterranean monk seal (*Monachus monachus*) is considered extinct from Italian shores since the mid 1980s, in light of the absence of a stable resident population and of known reproductive activities. The sightings occurring over the last decades have been attributed to vagrant individuals originating from groups of nearby countries [1]. The Italian Central Institute for Marine Research (ICRAM) has collected information on seal observations, recorded by seafarers along the Italian coasts as of 1998, so as to monitor and evaluate the phenomenon. This information is shared with Gruppo Foca Monaca-Italia. Sighting observations are reported following a specific information campaign directed at the wide public (mass media comunications) and involving institutional bodies (Coast Guard, Maritime officers, Marine Protected Area).

The present paper illustrates the data collected by ICRAM for the period 1998-2006 and the methodological approach used to differentiate observations of seal sightings from unattendible incomplete observations. Monk seal observations are recorded through verbal interviews of the observers with a standard interview format aimed at collecting the technical details of the sighting itself taking care not to provide the interviewee with any technical hints on the species' characteristics. The format involves information on: the observer's general details, weather conditions, date and location, distance from the coast and from the sighted animal, number of animals, estimated length, pelage colour, physical characteristics (i.e. description and shape of any body parts), swimming characteristics, general behavior, photographic documentation. To provide a validation of the observations, a score of 1 was given for each of the following phocid physical/behavioural characteristics [2] reported by the observer: 1) rotund head, held out of water during swimming, 2) large ocular orbits, 3) presence of vibrissae/fur, 4) compressed snout/presence of nasal slits, 5) edge of posterior flippers trailing along water surface during surface swimming, 6) lateral oscillations of posterior body trunk during swimming, 7) round head smaller than round shape of body 8) shape and position of flippers with respect to body. The total score was tallied for each observation and those scoring 4 or more, for situations in which the observer was out of the water, were considered acceptable (validated observations). This total value was lowered to 3 for underwater observations because of the reduced visibility under water. Furthermore, sightings having acceptable photographic documentation were automatically considered validated. One or more validated observations occurring in the same location and time were considered as a single seal sighting. Selected features of the validated observations were analysed.

On the overall, 59 observations were recorded of which 38 are validated observations and correspond to 27 sightings. Figure 1 illustrates their distribution. Only two sightings had photographic documentation. The highest number of validated observations was reported by professional and recreational fishers (32 and 24%), followed by boaters (18%), scuba divers (16%) and locals (11%). Only 16% of the observations occurred underwater. Almost 75% of the observations occurred within 20 meters of the seal and almost 48% lasted less than 1 minute. The majority of observed individuals (79%) were estimated as being <1.5 meters long while only 18% of individuals surpassed 1.5 meters.

The concerned sighting areas regard the southernmost continental and insular locations that are most proximate to populations of nearby countries such as Greece and Tunisia [1]. Given the estimated lengths provided by the observers, it is likely that the individuals transiting through Italian coasts are composed principally of juveniles, a size class known to disappear from its original birthsite for unknown destinations for prolonged periods of time [1], followed by a minor amount of adult sized individuals. The generally limited duration of the observations appears to be sufficient in guaranteeing an adequate perception of the principal seal characteristics necessary for sighting validation, this is also probably determined by the close proximity of most seal encounters. The seafarer's typology analysis suggests that information campaigns geared at future data collection on monk seal sightings should address all of the typologies involved so as to guarantee an efficient sighting monitoring. The applied approach allows to screen indirect information in order to distinguish the most accurate seal sightings occurring along the Italian coasts, an aspect that is crucial given the species' rarity.



Fig. 1. Distribution of sightings and dates (number of sightings in parenthesis; stars indicate photographic documentation)

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## BIOLOGICAL CHARACTERISTICS OF MALTESE LONGLINING BLUEFIN TUNA (*THUNNUS THYNNUS*) LANDINGS 2005

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## Abstract

This document provides an analysis of the biological characteristics of a sample of bluefin tuna landed by Maltese longliners during 2005. Data collected included length, weight, sex, maturity stage and age, and it can be considered as a sample of the longline fishery in the central Mediterranean. The Maltese longline fishery mainly targets adult specimens in excess of 200cm in length. *Keywords : Fisheries, Monitoring, Pelagic.* 

## Introduction

Due to the annual periodicity and representativeness of the sample, the biological data collected are of great relevance for the assessment of the state of the population exploited by the Maltese longline fishery. Length, weight, age, sex and maturity stage were collected between May and July during the fishing season.

#### Material and Methods

Bluefin tuna specimens were sampled at the landing port by field recorders. Length measurements (n=192) were carried out and spines (n=77) were collected for age reading. Length and weight parameters are collected concurrently. The weight (n=192) was raised to live round weight by a factor of 0.16 (ICCAT conversion factor).

Sex and maturity stage parameters (n=78) were collected through a scheme in collaboration with fishermen (Bluefin tuna is normally gutted at sea) consisting on fishermen taking photos of the gonads of each specimen at sea (specimens were tracked in the fish market by means of numbered tags) [1]. All samples were collected from commercial catches as part of the market sampling programme.

## Results and discussion

The Maltese bluefin tuna fisheries mainly targets mature individuals in excess of 200 cm, which differs from other fisheries in the Mediterranean, which on average catch smaller specimens.

The average length of fish caught in May, June and July were 223, 213 and 210 cm respectively. The size of tuna landed decreased steadily with time. The average length at maturity stages 2, 3 and 4 were 208, 205 and 222 cm respectively.

The length-frequency distribution of the landings of the three months combined showed that the bulk of the specimens landed was found to be within 210 and 230 cm length range.



Fig. 1. Length-Weight relationship of a sample of bluefin tuna landings in 2005.

The length-weight relationship equation obtained using all the 2005 data (Figure 1) shows a coefficient of determination  $(\mathbb{R}^2)$  of 0.6446 which indicates a positive correlation between length and weight of the specimens. The analysis of the L-W relationship by sexes showed a higher coefficient of determination (0.86) in the case of males which indicates a strong positive correlation between length and weight. For females the coefficient was also positive (0.43) but showing a weaker correlation very likely due to the fact that they reach higher weights at same length in the reproduction period.

The study of the length-at-maturity stages showed that the majority of specimens examined presented maturity stages 3 or 4 which indicates that they are mature and ready for spawning. There were no specimens

showing stage 5 (spent). Most males were at stage 4 of maturity and most females at stage 3. The maturity stage is not directly related to size, since during the season, individuals progress in maturity stage whilst length is practically constant. Moreover, large/older individuals could be at an early maturity stage whilst younger specimens could be at a more advanced maturity stage [2].



Fig. 2. von Berthalanffy growth curve and equation ( $L_t = L\infty \cdot (1-\exp(-K \cdot (t - t_0))))$ ) for bluefin tuna data 2005.

The analysis of length-at-age graphs showed that the sampled bluefin tuna were represented by specimens ranging from 6 to 12 years of age (Figure 2). The majority of tuna landed were aged 9 ranging from 160 to 240 cm FL. Male specimens were found to be all of age 9 or 10, while females ranged from 6 to 9 years of age. Size does not seem to increase with age, most likely because this set of data is composed by samples that fit within the plateau of the growth curve (von Berthalanffy growth equation [3]). The parameters L $\infty$ , K and t<sub>0</sub> of the von Berthalanffy equation (y=L $\infty$  ·(1-exp (-k ·(x- t<sub>0</sub>)))) were estimated through the non-linear regression (minimum squares calculated thought the Newton method within Solver-Excel) obtaining, a L $\infty$  = 228.48 cm, K = 0.2316 and t<sub>0</sub> = -7.22 (using 2005 data only).

#### Conclusions

The Maltese longline fishery mainly targets adult specimens in excess of 200 cm in length. Male specimens showed a better length-weight correlation than females, with the former composed mainly of individuals in maturity stage 4 and aged 9 or 10 years whilst the latter was composed mainly of individuals in maturity stage 3 aged 6 to 9 years.

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## DO WE PROTECT BIOLOGICAL ORIGINALITY IN PROTECTED AREAS? THE CASE OF THE BONIFACIO STRAIT MARINE RESERVE

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## Abstract

Nowadays the question is no longer whether protected areas are able to maintain species richness but whether protected areas are able to protect other overlooked facets of biodiversity against erosion. Our study aims at evaluating the ability of protected areas to maintain viable populations of the most "original" species on a biological point of view. This question was investigated using a long-term monitoring programme in the Bonifacio Strait Marine Reserve. As a result, our study provides a clear example of how protection against human impact in coastal areas benefits preferentially to the most original fish species in terms of ecomorphological characters. *Keywords : Biodiversity, Trawl Surveys, Strait Of Bonifacio, Marine Parks, Coastal Management.* 

In a natural world increasingly transformed by human activities, it is now widely accepted that biodiversity is being lost rapidly in both terrestrial and marine ecosystems. For aquatic ecosystems, the most important factors are certainly climatic change, biotic exchange and overfishing; the latter being the most direct human disturbance to all coastal ecosystems [1]. If the causes of biodiversity loss seem established, the consequences of such dramatic declines or alterations have spurred considerable research and tremendous debate. Indeed biodiversity should be preserved not only for aesthetic reasons and for its direct usefulness, but also for its indirect benefits. For instance, it has been experimentally demonstrated locally that species richness per se positively influences ecosystem functioning and some fundamental ecosystem properties such as productivity, resistance to invasion, stability and resilience (e.g. [2]). Given the uncertainty of the future, preserving local biodiversity would maximize the probability of a viable response at the community level and would increase the variability of possible alternative types of ecological organization to disturbance and changing environmental conditions [3]. Thus, as alterations of biodiversity may disrupt ecological functions performed by species assemblages, it is urgent to carefully examine the implications of biodiversity loss not only in terms of pure conservation purposes but also in terms of sustainability of ecosystem services upon which human welfare depends.

Protected areas are indisputably the primary tool for in situ biodiversity conservation across the world [4] with more than 100,000 sites covering nearly 11.7 per cent of the land surface of the planet and about one per cent of the marine environment. However protected areas have been set up for reasons which are more based on species and habitat considerations rather than on knowledge and understanding of ecological systems. For instance biodiversity is almost exclusively assimilated to species richness in protected areas (the number of species coexisting on a site) while the definition of biodiversity includes various facets of the diversity of life. It is thus ironic that the main measure of biodiversity ignores what makes species different in an assemblage: their relative abundances and their biological attributes. In addition the two diversity facets of biodiversity, which are closely related to the differences among species, are known to influence ecosystem functioning. Evenness, which measures the relative distribution of abundance among species, is positively related to the resistance against invasion [5]. Functional diversity, which measures the value and range of the functional traits of the organisms, is now widely recognized as a main driver of ecosystem processes in aquatic environments [6]. Thus the question is no longer whether protected areas are able to maintain species richness but whether protected areas are able to protect other overlooked facets of biodiversity against erosion.

When considering the differences among species to assess the biodiversity of an assemblage we can assume that the species that contributes the more to the biological diversity of this assemblage is the one with the more original biology, i.e. the one with the highest average rarity of its features or characters [7]. Consequently the loss of such original species is more likely to provoke the loss of some unique biological features which can be life-history traits, morphological structures or behaviours. This is particularly true for some species-poor families on Earth (rhinos and kiwis) because extinction of species belonging to these families would inevitably lead to the loss of their unique biological characters [8]. Moreover, the degree of originality of species within an assemblage determines the strength and the shape of the relationship between taxonomic and functional diversity [9]. Extinction of species which are functionally equivalent to some others in the assemblage has less impact on functional diversity than the extinction of original species. Thus measuring the biological originality of a species gives insight into its conservation importance in the light of the conservation of ecosystem functioning. Then, a crucial question arises: do protected areas contribute to protect biological originality? In other words our article aims at evaluating the ability of protected areas to maintain viable populations of the most "original"species on a biological point of view. This question was investigated using a long-term monitoring programme in the Bonifacio Strait Marine Reserve. As a result, our study provides a clear example of how protection against human impact in coastal areas benefits preferentially to the most original fish species in terms of ecomorphological characters.

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## ASPECTS REPRODUCTIFS DE SPONDYLIOSOMA CANTHARUS (LINNAEUS, 1758) DES CÔTES TUNISIENNES

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## Résumé

La période de ponte de *Spondyliosoma cantharus* se déroule de mars à mai sur les cotes tunisiennes; la présence de gonades bisexuées, le déséquilibre marqué du sex-ratio en faveur des femelles et la nette supériorité de la taille moyenne des mâles confirment la protogynie de la dorade grise. La taille à la première maturité sexuelle des femelles est de 17,78 cm. *Mots clès : Fishes, Reproduction, Spawning.* 

#### Introduction

Le genre *Spondyliosoma* Cantor, 1849 comprend une seule espèce en Méditerranée; il s'agit de la dorade grise *Spondyliosoma cantharus* (Linnaeus, 1758). Ce Sparidae est présent dans l'Atlantique oriental, de la Scandinavie à l'Angola, dans la Méditerranée, la mer Noire, à Madère, dans les îles Canaries et du Cap-Vert [1]. Les études concernant la biologie de la reproduction de la dorade grise se limitent à l'Atlantique oriental [2, 3, 4, 5, 6]. Par ce travail préliminaire, nous nous proposons d'apporter une contribution à la connaissance des caractéristiques reproductives de la dorade grise des cotes tunisiennes méditerranéennes.

#### Matériel et méthodes

L'échantillonnage a été réalisé, à partir du marché central de Tunis, de janvier 2005 à juin 2006. Pour chaque spécimen nous avons mesuré la longueur totale (LT) au mm prés, le poids éviscéré (Pe) au g prés et le poids des gonades (Pg) au 0,01g prés. Les proportions numériques des sexes sont exprimées sous forme d'un ratio (M : F) et évaluées au moyen du test du  $\chi^2$ . L'analyse des fluctuations mensuelles de l'indice gonadosomatique (IGS = Pg / Pe x 100) et des pourcentages d'individus matures (stades de maturation et de ponte) a permis de délimiter les différentes périodes du cycle sexuel. Enfin, la taille à la première maturité sexuelle a été estimée en utilisant une fonction logistique reliant les proportions d'individus matures aux longueurs totales correspondantes.

## Résultats et Discussion

L'échantillonnage est composé de 330 spécimens de taille comprise entre 13,4 et 36,6 cm (19,0 ± 0,2 cm). La longueur totale moyenne des mâles (26,10 ± 1,48 cm) est très significativement supérieure à celle des femelles (18,70 ± 0,18 cm) (p = 0,00). Le sex-ratio global est nettement en faveur des femelles avec 1: 19,67 ( $\chi^2 \ge 3,84$ ; p <0,05); cette disproportion a aussi été rapportée dans les travaux réalisés en Atlantique [4, 5, 6].



Fig. 1. Variations mensuelles de l'IGS et des pourcentages des individus matures de *S. cantharus*.

La maturation des gonades s'étend de décembre à février (Fig. 1); le frai a lieu de mars à mai alors que le repos sexuel s'étale de juin à novembre. La période de ponte de la dorade grise s'étend d'avril à juin dans la Manche [2, 3], de février à avril sur les cotes sud ouest du Portugal [6], de janvier à février dans les îles Canaries [5] et de mai à août dans le Banc saharien [4]. Ce décalage temporaire de la période du frai est du à des différences locales des paramètres environnementaux qui agissent sur le déclenchement de la ponte. La dorade grise présente en Tunisie un dichromatisme durant la période de ponte; les mâles ont une robe plus sombre que celle des

femelles; cette particularité a également été relevée dans les populations des îles de Canaries [5] et des cotes sud ouest du Portugal [6].

La taille à laquelle 50 % des femelles sont matures est de 17,78 cm (Fig. 2); elle est assez voisine à celle observée sur les cotes canariennes (17,3 cm) [5] mais inférieure à celle des cotes sud ouest du Portugal (20,1 cm) [6] et de la Manche (23 cm) [3].

La présence d'individus présentant des ovotestis (1,82%), le déséquilibre du sex-ratio et l'antagonisme de la répartition des sexes en fonction de la taille suggèrent une modalité d'expression de sexe principalement protogyne. Ce type d'inversion sexuelle a déjà été signalé [7] puis ultérieurement confirmé [4, 5, 6, 8].



Fig. 2. Courbe de la maturité sexuelle de S. cantharus.

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## SIGHTING FREQUENCIES OF FIN WHALES (*BALAENOPTERA PHYSALUS*) ON A PREVIOUS SIGHTINGS POSITION: IMPLICATIONS FOR WHALE WHATCHING DATA

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## Abstract

Whale-watching activity performed in the Ligurian Sea (off Imperia-Savona) from 2004 to 2006 is analysed to access to the sighting probabilities of fin whale on previous sighting positions, during 7 days time-window. On 62 km<sup>2</sup> area, 15 % of the fin whale sightings occurred near a previous sighting position.

Keywords : Cetacea, Ligurian Sea.

## Introduction

Since nearly 20 years, the whale watching activity has grown considerably in the Ligurian Sea especially to watch fin whales. Indeed, in the early spring and during the summer, fin whale are aggregated in function of the food availability [1]. The implantation of this tourism activity provides also opportunistic research platforms to conduct study on cetaceans habitat [2]. However, it is not clear how results obtained by whale-watching surveys may be biased by the re-sightings of one single individual on a particular position. This work analyse the quantity of fin whale sightings occurring on near one sighting position during the 7 following days.

## Materials and Methods

3 years of the main whale-watching operator in the Ligurian Sea are analyzed. During 362 days of whale-watching aboard the two vessels (the *Corsara* and the *Stenella*), 186 fin whale sightings occurred. To establish the frequency of  $2^{nd}$ -sightings on  $1^{st}$ -sighting positions, we first fix the time-window to 7 days. This window can considered to be representative of the relative oceanographic stability in the Mediterranean Sea. Moreover, it is not expected that a whale remains on a static position during more than 8 days because of obvious changes of oceanographic configuration. In contrast, it is expected that a whale remains quasi-static when its prey is abundant. Therefore the 7 days window should fit for this study. Then, for each  $1^{st}$ -sighting position represented on a grid with a resolution of  $1/60^\circ$ , we calculate the sightings (called later  $2^{nd}$ -sightings) that occurred on surrounding grid-cells during the time-window. 4 different resolution scales were tested: 3, 5, 7 and 9 pixels.

## Results and discussion

In general, the whale-watching boat realized 4 days of "survey" after one fin whale sighting (Table 1). This result indicates indirectly the favourable meteorological condition for surveys, considering that operators in this area exploit all possible occasion when the weather is good enough.

Tab. 1. Sightings results on different extension of areas (I, II, III, IV).

| Туре                                         | Ι     | II    | III   | IV    |
|----------------------------------------------|-------|-------|-------|-------|
| Width (km)                                   | 5     | 8     | 11    | 14    |
| Area (km <sup>2</sup> )                      | 22    | 62    | 122   | 201   |
| Sighting frequency                           | 0.04  | 0.15  | 0.32  | 0.53  |
| Sighting success frequency by return         | 0.05  | 0.11  | 0.19  | 0.28  |
| Effort (NM) by return                        | 298   | 1011  | 1956  | 3049  |
| Encounter rate at the 2nd-sightings position | 0.027 | 0.028 | 0.031 | 0.032 |
| Effort (NM) on the 1st-sightings position    | 395   | 774   | 1081  | 1587  |
| Encounter rate at the 1st-sightings position | 0.471 | 0.240 | 0.172 | 0.117 |

Because daily horizontal pattern of movement of fin whale is not yet known, we have tested different space scale. On the more restricted area, representing about  $22 \text{ km}^2$ , (see Table 1, I), fin whale are not often sighted; the  $2^{nd}$ -sighting frequency is 0.04. However the boat did return a lot of times (153). The success of  $2^{nd}$ -sighting is of 0.05 by return. This results is quite unexpected considering that generally it was supposed to re-find more easily fin whales on previous positions. The relative encounter rate, expressed as the number of sightings divided by the number of the nautical miles done in the area, is quite low 0.027 comparing to the one obtained with casual encounters (0.48) on the even area. This demonstrates that even if the boat is looking for whales in the restricted area,  $2^{nd}$ -sightings are not numerous. Extending the area, on 62 km<sup>2</sup>, the frequency of  $2^{nd}$ -sightings grows to 0.15 (with 28  $2^{nd}$ -sightings on the 1<sup>st</sup>-sightings position) with the success frequency by return of 0.11. In this situation,

the encounter rate is 0.028. Extending then to 122 km<sup>2</sup>, the frequency of  $2^{nd}$ -sightings becomes 0.32 with a relative success frequency 0.19 by return; here, the encounter rate on the delimited area is 0.031. On the most extended area tested (201 km<sup>2</sup>), the frequency of  $2^{nd}$ -sightings reaches 0.53. But the area is extended on the usual features where fin whale is abundant. In the Ligurian Sea, fin whale habitat is characterized by deep water (average 2136 meters), by gentle bottom slope (average of 26m/km) and daily sea surface temperature of 21.8°C [3].

This work gives access to results on whale watching data. The analysis on a restricted area (over 22 km<sup>2</sup>) indicates a low quantity of sightings on a previous position. But on 62 km<sup>2</sup> area, 15 % of the fin whale sightings occurred near a previous sighting position. Extending the area, the quantity of sightings grows indicating that fin whales may move around their primary position during the 7 following days and so may be re-sighted. This study would be greatly improve by photo-identification results, in order to determine the proportion of re-sightings of the same whale.

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## INDICATIONS OF A POSSIBLE CHANGE IN THE FISHERY EXPLOITATION PATTERN IN IONIAN SEA LAGOONS

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## Abstract

Continuous daily fishery landings (1977-2003) from four adjacent lagoons of Amvrakikos Gulf (Western Hellas; Ionian Sea) using barrier traps were analyzed herein. During the last 30 years, the general area has been subjected to a high degree of human impacts that might influence the fish and fisheries dynamics. Two of the studied lagoons indicated an alteration in their seasonal pattern that marked by an increase of spring landings and a great reduction of autumn-winter ones. *Keywords : Lagoons, Coastal Management, Ionian Sea, Fisheries.* 

#### Introduction

In lagoons, landings from barrier traps are based on the species-specific inshore-offshore seasonal or ontogenic fish migrations [1]. In this context, we analysed a 27-year (1977-2003) fisheries landings series derived from four lagoons of Amvrakikos Gulf (Western Hellas; Ionian Sea) using barrier traps. Although fishery exploitation is limited during spring (traps are opened), in the studied lagoons the traps are remaining active (closed) allowing only the entrance of juveniles and small-sized fish. Hence, the aim of the study was to detect changes in seasonal species composition though time and to determine possible causes of this pattern.

## Materials and Methods

Fishery exploitation took place by the same fisher cooperation during the study period, a fact that guaranteed data validity, homogeneity and stability of fishing effort variability. Fishing period was considered to start at March, till the end of next February, as there is not any fishery legislation that regulates fishing period inside the lagoons. Data-series were composed by landings per species or group of species. To investigate similarities and/or dissimilarities in seasonal species composition for each lagoon separately, we constructed matrices comprising the percentages of the seasonal composition per year using the Bray-Curtis coefficient [2].

#### Results and Discussion

Multivariate analyses of season landing percentages revealed a quite good separation in time for each different lagoon (Figure 1). Hence, two major year-groups were formed consisted, with some exceptions, by the first 20 years of data-series (Group A: 1977-1999, for Mazoma and Tsopeli; 1977-1998 for Pogonitsa; and 1977-1997 for Vathi) and the most recent ones (Group B: 2000-2003 for Mazoma and Tsopeli; 1999-2001 for Pogonitsa; and 1998-2003 for Vathi). In Group A, summer, autumn, and winter were the seasons with the highest contribution representing more than 85% of annual landings in Mazoma, 68% in Tsopeli, 41% in Pogonitsa and 60% in Vathi. In contrast, for Group B in Mazoma and Vathi, landing percentages indicated a different seasonal pattern marked by an increase in spring landing percentages, especially after 2001 (>21\% of the total annual landings). Subsequently, in Vathi, season landings, except the autumn ones that have been reduced to almost zero level, showed a high fluctuation of its values: in spring they ranged from 0% to 72%; in summer from 0% to 45%; and in winter from 15% to 100%. However, in Tsopeli and Pogonitsa seasonal alterations in landings were not so evident due to lower spring landings (from 0% to 13% and from 0% to 9%, respectively) compared with the other seasons.

Eventually, despite the close geographic proximity among the four lagoons (<15 km) and the presence of the same fishers cooperation, each lagoon indicated different seasonal landing patterns during recent years (after 1997) than before. This could be attributed to the decline in fishery landings due to the combined effect of anthropogenic impacts both on inland and marine environment (e.g., pollution, overexploitation, absence of fishery regulation) [3] accompanied by the influence of global climatic change [4]. Even though the latter needs a better approach, however, it has been shown that climatic shifts was responsible for the loss of several species [4], a fact that it has been also observed in the studied lagoons (Fish. Dep. of Preveza unbl. data). Moreover, the degradation of lagoon biodiversity impacted on fisher's exploitation tactics. Thus, due to low fish prices during autumn-winter, fishers limited the exploitation and thus, the economic costs, in order to land more fish during spring when the prices are getting higher. In this context, it is important the existence of artificial deep channels (wintering channels) where fishers could maintain the trapped fish (especially eels, under-sized Mugilidae and *Sparus aurata*) during the cold months (late autumn and winter) and to land the catches in the next harvest season. Consequently, these phenomena had a significant social effect in the general region as fisher's cooperation forced to reduce the number of fishers that worked in the lagoons (from 10, 9, 6 and 5 in 1980, to 5, 4, 4 and 3 after 1999, in Mazoma, Tsopeli, Pogonitsa and Vathi, respectively) in order to limit the economic loss. Concluding, it is evident that the application of an integrated managerial scheme including marine environment (both coastal and inland ecosystems) together with a socioeconomic approach could be the primary perspective towards ecosystem sustainability.



Fig. 1. Dendrogram for group-average clustering based on Bray-Curtis similarities (double-square root transformation) between seasonal species composition per year for the four studied lagoons (Amvrakikos Gulf, 1977-2003).

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## FOULING ASSEMBLAGES FROM TWO MALTESE PORTS STUDIED AS PART OF THE PORTAL PROJECT

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## Abstract

Within the context PORTAL project, which was initiated by CIESM in 2003, a wharf in the Grand Harbour, and a fuel jetty and buoy in Marsaxlokk Harbour were sampled to collect baseline data on alien species. 86 species belonging to 7 targeted taxa were collected, with Crustacea being the dominant taxon in terms of both species richness and individual abundance. The highest species richness and evenness values were recorded at 3 m at both sites. Multivariate analyses and SIMPER showed that the degree of separation of fouling assemblages between the two sites was minimal. The fouling assemblages investigated are broadly similar to those occurring in Italian waters. The only alien species found in the samples was a single juvenile of the grapsid *Percnon gibbesi*. *Keywords : Biodiversity, Coastal Waters, Fouling.* 

### Introduction

PORTAL is a research programme of the International Commission for the Scientific Exploration of the Mediterranean Sea (CIESM) that aims at implementing a Mediterranean-wide port and port-proximate survey using standardized protocols to collect baseline data on alien species, particularly those which might be introduced by shipping. The Valletta harbours (Marsamxett Harbour and Grand Harbour) and Marsaxlokk Bay are the major harbours of the Maltese Islands. Information on fouling assemblages within the Maltese harbours and harbour-like environments is very scarce. Practically, the only work carried out has been a preliminary study of fouling organisms in oyster cultures in three Maltese bays, including at Rinella within the Grand Harbour [1].

#### Methods

Pinto Wharf in Grand Harbour, a fuel jetty and a buoy at Birzebbuga in Marsaxlokk Bay were sampled using the PORTAL standard methodology. Fouling biota was collected from three replicate 0.1  $m^2$  quadrats at each of three depths (0.5 m, 3 m, 7 m), on the vertical wall of the wharf or jetty at three different stations, while on the buoy three replicates were sampled at 0.5 m.

#### Results and discussion

A total of 86 species belonging to the taxa targeted by the PORTAL project and to some other taxa for which good taxonomic knowledge was available (Algae: Chlorophyta, Rhodophyta, Phaeophyta; Cnidaria; Polychaeta; Sipuncula; Crustacea: Cirripedia, Amphipoda, Tanaidacea, Isopoda, Mysidacea, Decapoda; Mollusca: Polyplacophora, Gastropoda, Bivalvia; and Ascidiacea) were recorded from the two sampling sites: 77 species from Birzebbuga (73 from the fuel jetty and 21 from the buoy) and 43 species from Pinto Wharf. In terms of individual abundance, Crustacea was the most abundant taxon, followed by Polychaeta and Ascidiacea, whilst in terms of species richness, Crustacea was the most important taxon (25 species), followed by Mollusca (23 species) and algae (17 species). The melitid amphipod Elasmopus sp. was overall the most abundant species, followed by the sabellid polychaete Sabellidae sp. Other species of the targeted groups were collected, but they have not yet been identified, in particular Bryozoa, while species belonging to groups other than those targeted were present. Surprisingly, no Hydrozoa were found in the samples. Only one alien species of the targeted taxa was present: a single young juvenile of the grapsid crab Percnon gibbesi was collected from the Birzebbuga fuel jetty at 3 m depth; dense populations of this species are now found in suitable habitats all along the Maltese coast [2]. At both sites, the abundance of ascidians, polychaetes, molluscs and algae decreased with depth whilst that of crustaceans and sipunculans increased. The highest species richness and evenness values were recorded at 3 m at both sites; this suggests that in the localities sampled, this depth provides the most favourable conditions for fouling assemblages. The majority of species were recorded in both harbours. In addition, the fouling assemblages from the two sites were not significantly different from each other in terms of species richness and individual abundance. Mean species richness at Birzebbuga was 6.5 (s.d. 1.8) at 0.5 m, 7.9 (2.0) at 3 m; 6.8 (1.2) at 5 m, and 3.4 (0.8) for the buoy, while mean species richness at Pinto Wharf was 3.3 (s.d. 1.17) at 0.5 m, 4.3 (1.3) at 3 m; and 3.4 (1.18) at 7 m. The mean Shannon-Wiener Index (H') was 1.08 (s.d. 0.13) for the Birzebbuga jetty and buoy, and 0.93 (s.d. 0.1) for Pinto Wharf, whilst the mean Pielou's Evenness was 0.25 (s.d.0.03) for the Birzebbuga jetty and buoy and 0.21 (s.d.0.02) for Pinto Wharf. Multivariate classification (group average linkage hierarchical cluster analysis and nMDS) of species-abundance data separated out the Pinto Wharf samples from the Birzebbuga ones (jetty and buoy), however, the degree of separation was low. nMDS also indicated a bathymetric separation of the Birzebbuga samples; the samples from 0.5 m depth and the buoy were different from those at 3 m and 5 m depths. This suggests that for this site, depth, rather than site-specific environmental conditions, is the most important physical factor influencing the distribution of fouling assemblages. There was also a weak separation between the samples from Birzebbuga buoy and the jetty at 0.5 m depth. SIMPER analysis confirmed the low degree of separation between assemblages from the two harbours. The present results are broadly similar to those obtained for fouling assemblages in Italian waters [3,4], although there are some differences in the dominant taxa. The complete absence of hydroids in the present samples is surprising, especially since, along with barnacles and oysters, hydroids are amongst the first organisms to colonise man-made structures and are common in ports [5]. The absence of alien species, except for Percnon gibbesi, was somewhat unexpected in view of the large volumes of marine traffic that passes through Malta ports and their strategic geographic location in the central Mediterranean. Although not recorded in the present study, a number of alien species have been recorded from Malta ports, including the bryozoans *Celleporaria pilaefera* and *C. aperta* [1], the slipper limpet Crepidula fornicata [6,7], the oyster Crassostrea gigas [8], and the echinoid Eucidaris tribuloides [9].

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## MORPHOMETRIC AND MERISTIC CHARACTERISTICS OF THE SARDINE, *SARDINA PILCHARDUS* (WALB., 1792), IN THE MIDDLE EASTERN ADRIATIC SEA

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## Abstract

A total of 1,219 specimens of sardine, *Sardina pilchardus* (Walbaum, 1792) were obtained from the Middle Eastern Adriatic Sea during the period from March, 2004 to February, 2005. Sardine specimens were caught by purse seine. Total length ranged from 13.0 to 19.0 cm, and weights ranged between 16.72 and 51.45 g. Negative allometry was established (b=2.5538) in the length-weight relationship. *Keywords : Adriatic Sea, Biometrics, Fishes.* 

## Introduction

The aim of this paper is to present the morphometric and meristic characteristics of the sardine, *Sardina pilchardus* (Walbaum, 1792). Based on the differences in gill raker numbers and migratory patterns, it was supposed that two subpopulations of sardine exist in the Adriatic Sea [1]. Results of these studies give the basis for comparisons between sardine biometric characteristics from the Adriatic Sea with other regions. The length-weight relationship is essential in stock assessment models and in estimations of the weight from length observation, as well as in an estimate of fish population condition [2,3] and comparisons among populations of the same species from different habitats or regions [4].

#### Material and methods

Sardine specimens were caught with purse seine in the coastal and open Middle Eastern Adriatic Sea during the period from March 2004 to February 2005. Total length of analysed specimens ranged from 13.0 to 19.0 cm, and weights ranged between 16.72 and 51.45 g. A total of 1219 specimens were analysed for the length-weight relationship and for the morphometric characteristics, whereas 122 specimens were used for the analysis of meristic characteristics. Eight morphometric (LT, LS, LF, LH, LF, H, PE and Ed) as well as two meristic parameters (RD and Vert.) were used for biometry. All lengths were measured to the nearest mm and weights to the nearest g.

The length-weight relationship was determined according to the equation:  $W=aL^b$ 

where *W*=fish weight in g; *L*=total length in cm; *a*=proportionality constant and *b*=regression coefficient. In order to check for isometric growth, the *t* test was used.

#### Results

Overall morphometric and meristic characteristics are presented in Table 1. Mean total length was  $16.03 \pm 0.88$  cm and mean weight was  $31.49 \pm 5.32$  g. All length-length relationships were linear. The relationships *LT-LS*, *LT-LF* and *LF-LS* are: *LS* = 14.019-0.0006 *LT* ( $R^2$  = 0.0817); *LF* = 14.017+0.0003 *LT* ( $R^2$  = 0.0078); *LS*= 14.019-0.0006 *LF* ( $R^2$ =0.0817).

Tab. 1. Morphometric and meristic characteristics of sardine caught in the Middle Eastern Adriatic Sea during the period March, 2004 to February, 2005.

| Characteristics                   | Range (cm)  | $\overline{x} \pm SD$ |
|-----------------------------------|-------------|-----------------------|
| Morphometric:                     |             |                       |
| Total length (LT)                 | 13.0 - 19.0 | $16.03 \pm 0.88$      |
| Standard length (LS)              | 11.5 - 16.2 | $13.65 \pm 0.76$      |
| Fork length (LF)                  | 11.5 - 17.3 | $14.35 \pm 0.77$      |
| Head length (LH)                  | 2.3 - 3.9   | $3.08 \pm 0.19$       |
| Length of dorsal fin base (DF)    | 1.2 - 2.9   | $1.81 \pm 0.35$       |
| Maximum body height (H)           | 1.8 - 3.6   | $2.69 \pm 0.24$       |
| Preorbital length (PE)            | 0.7 - 1.2   | $0.98 \pm 0.07$       |
| Eye diameter (ED)                 | 0.6 - 1.1   | $0.82\pm 0.07$        |
| Meristic:                         |             |                       |
| Number of rays in dorsal fin (RD) | 17 – 19     | 18.11 ± 0.51          |
| Number of vertebrae (Vert.)       | 48 - 52     | $50.02 \pm 0.97$      |
|                                   |             |                       |

The length-weight relationship for sardine caught in the study area was:  $W = LT^{2.5538}$ ; ( $R^2 = 0.6976$ ; SE = 0.0009) and is shown in Figure 1.



Fig. 1. Length-weight relationship of sardines from catches in the Middle Eastern Adriatic Sea during March, 2004-February, 2005.

#### Discussion

Vertebral numbers ranged from 48 to 52 ( $\bar{X}$ =50), whereas Mužinić [5] found that they ranged from 49 to 54 ( $\bar{X}$ =51) in the Middle Eastern Adriatic Sea. According to Sinovčić [6] the sardine from the coastal Middle and North Eastern Adriatic Sea has 50-53 vertebrae ( $\bar{X}$ =51). The lengthweight relationship for the sardine from the Middle Adriatic Sea showed negative allometry (b=2.5538) (Fig.1). Alegria [7] reported negative allometry for the sardine length-weight relationship for the Middle Adriatic (b=2.851). The same results were also found in the length-weight relationship for sardines from the Ionian Sea in 1995 (b=2.75) [8] and 2003 (b=2.75) [9].

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## RECENT DISTRIBUTION OF GELATINOUS ORGANISMS IN THE SOUTHERN BLACK SEA

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## Abstract

Since introduction of *Beroe ovata* in 1999 into Black Sea, two cruises in June and October 2006 have determined the distributions of both invading *Mnemiopsis leidyi* and *Beroe ovata*, and the resident *Aurelia aurita* and *Pleurobrachia pileus* in the southern Black Sea. Total biomass of *M. leidyi* in the entire Black Sea was 22.00 and 11.00 million tons, 35.96 and 14. 81 for *P. pileus*, 169.20 and 33.84 for *A. aurita* in June and October 2006, respectively and 3.81 million tons for *B. ovata* in October 2006. As compared to the biomasses in June when no individual of *B. ovata* was caught by the net, the biomasses and abundances of the former species decreased in October when individuals of *B. ovata* were observed.

Keywords : Zooplankton, Biomass, Black Sea.

Spatial distributions of gelatinous organisms (*A. aurita, P. pileus, M. leidyi* and new exotic species, *B. ovata*) in the southern Black Sea (the Turkish EEZ) were studied in June and October 2006. All species were collected using the Hensen plankton net (0.7 m mouth opening and 300  $\mu$ m mesh size). Samples were obtained by vertical hauls from a depth of H<sub>2</sub>S layer at 65 stations in June and 72 stations in October 2006. The gelatinous organisms were sorted out, numerated and weighed with a hand balance on board. In June, individuals of each species found at each station were frozen in a nylon bag for comparison for weight measurements with onboard hand balance and e-balance in the laboratory. Size measurements of the individuals were performed to compare biomasses in the other ways.

Three methods to estimate biomass were used: hand balance, e-balance of frozen specimens and length-weight relationship ([1], [2], [3]). This was purposed for inter-calibration of biomass estimation conducted with different methods. Pairwise of the methods were subjected to the t-student test. No significant differences in the biomasses were found at a level of p<0.05.

Spatial distributions of *M. leidyi* were followed by hydrographic features of the Black Sea. High biomasses ( $150 > gm^{-2}$  in June and  $>50 gm^{-2}$  in October) were found on the rime current between the coastal cyclonic eddies. The maximum abundance and biomass of *M. leidyi* were 13 ind  $m^{-2}$  and 390 g $m^{-2}$  with averages of 1.7 ind  $m^{-2}$  and 52 g $m^{-2}$  in June, and 23 ind  $m^{-2}$  and 130 g $m^{-2}$  with 7 ind  $m^{-2}$  and 26 g $m^{-2}$  in October. Mean biomass and abundance of *M. leidyi* were not however significantly different in the eastern area (51 g $m^{-2}$  and 1.9 ind  $m^{-2}$ , n= 32 stations) than in the western area (53 g $m^{-2}$  and 1.9 ind  $m^{-2}$ , n= 33) of the Turkish Black Sea in June they were significantly higher in the east ( $27 gm^{-2}$  and 10 ind  $m^{-2}$ , n=31) than in the west ( $22 gm^{-2}$  and 5 ind  $m^{-2}$ , n=36) in October (U test, p<0.05). No significant differences in the biomass and abundance were found between inshore (bottom depth<200m) and offshore (>200 m) waters in June (39 g $m^{-2}$  with 1.2 ind  $m^{-2}$ , n=13 and 55.4 g $m^{-2}$  with 1.8 ind  $m^{-2}$ , n=52) and in October (25 g $m^{-2}$  with 6 ind  $m^{-2}$ , n=18 and 26 g $m^{-2}$  with 7 ind  $m^{-2}$ , n=54).

Main concentrations of *P. pileus* were found at the northern peripheries of the anticyclonic eddies. The mean wet weight of *P. pileus* never exceeded 100 g m<sup>-2</sup> (84 g m<sup>-2</sup> in June and 35 g m-2 in October) while the maximum wet weights were recorded to be 234 g m<sup>-2</sup> in June and 91 g m<sup>-2</sup> in October. In contrast to the summer distribution, the mean and abundance were significantly higher in the southeastern (40 g m<sup>-2</sup> and 154 ind m<sup>-2</sup>) than southwestern (30 g m<sup>-2</sup> and 21 ind m<sup>-2</sup>) Black Sea in autumn. A significant difference between inshore (19 g m<sup>-2</sup> with 100 ind m<sup>-2</sup>) and offshore (40 g m<sup>-2</sup> with 151 ind m<sup>-2</sup>) areas was found only in October.

In June 2006 *A. aurita* was found to be mainly distributed in the southwestern Black Sea. The locations of dense patches (>600 g m<sup>-2</sup>) were well correlated with peripheries of the western main gyre. Patches of *Aurelia* occurred in Kizilirmak and Batumi eddies. The density in the central Black Sea was virtually low. Overall, the distribution of individuals and biomass did not differ significantly between the western (498 g with 19 ind m<sup>-2</sup>) and eastern (298 g with 11 ind m<sup>-2</sup>) areas, and between inshore (383 g with 19 ind m<sup>-2</sup> and offshore (404 g with 15 ind m<sup>-2</sup>) waters. Maximum abundance and biomass were 91 ind m<sup>-2</sup> and 3380 g m<sup>-2</sup> with averages values of 16 ind m<sup>-2</sup> and 400 g m<sup>-2</sup> in the southern Black Sea. In October, mean abundance and biomass were 2.5 and 5 times lower than those in June. No statistical differences in abundance and biomass were found either between the western 6.2 ind m<sup>-2</sup> with 106 g m<sup>-2</sup>) and eastern (5.2 ind m<sup>-2</sup> with 55 g m<sup>-2</sup>) areas or between inshore (6.2 ind m<sup>-2</sup> with 113 g m<sup>-2</sup>) and offshore (5.6 ind m<sup>-2</sup> with 69 g m<sup>-2</sup>) areas. *B. ovata* was not found in the entire southern Black Sea during a cruise in June 2006. Mean biomass and abundance of *Beroe* was 8.9 g m<sup>-2</sup> and 1.4 ind m<sup>-2</sup> in October 2006. Individuals of *Beroe* were generally observed in area where *Mnemiopsis* and *Pleurobrachia* were not found, except in the Batumi eddy. Maximum abundance and biomass were recorded to be 16 ind m<sup>-2</sup> and 57 g m<sup>-2</sup>. There was no significant difference in biomass and abundance between the areas. The coastal water yielded little higher biomass (12 g m<sup>-2</sup>) than open waters (8 g m<sup>-2</sup>) with the similar areas shared equal abundance (1.4 ind m<sup>-2</sup>) while the biomass was little higher (11 g m<sup>-2</sup>) than that in the eastern area (7 g m<sup>-2</sup>).

On the board, an experiment was performed to observe visually food choice of *B. ovata*. Specimens in various sizes of *Mnemiopsis* and *Pleurobrachia* and small-sized *Aurelia* were served to *Beroe* in 201 jar. *Beroe* investigated the food at the surface in order presumably to seek existence of *Mnemiopsis*. If there is no *Mnemiopsis* at the surface, *Beroe* dived down to the bottom to catch *Pleurobrachia*. *Beroe* however did not feed on *Aurelia*. *Beroe* swallowed more than one individuals of *Pleurobrachia* at once and the zipped the mouth to start digestion. A few individuals of *Calanus* were observed inside *Beroe*.

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## PRELIMINARY RESULTS ON BENTHIC IMPACT OF CAGE FISH FARMING IN A SEMI ENCLOSED GULF OF EASTERN MEDITERRANEAN

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## Abstract

The impact of cage culture of marine fish species on the benthic environment was investigated seasonally at two fish farms of Pagasitikos Gulf, between July 2004 and April 2005. The polychaete *Capitella capitata* was the most dominant species in both farm sites (37% and 65% of the total abundance, respectively), whilst the most dominant species at the control sites of two fish farms was the polychaete *Nephthys hystricis* (11% of the total abundance in both sites). Furthermore, *Nephthys hystricis* was found at the control sites and the 50 m stations, but never at 0 m stations which located under the center of the cages. In all cases structure of macrobenthos in the immediate vicinity of the farms changed, but the spatial extent of this effect was quite limited. *Keywords : Aquaculture, Zoobenthos, Pollution, Aegean Sea.* 

Introduction

The impact of fish farming on macrobenthos gradually gains interest in the Mediterranean [1 - 4], where fish farming of marine species, particularly sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*), has grown exponentially during the last 25 years. The objective of this study was to assess the impacts of site specific aquaculture on macrobenthos structure of Pagasitikos Gulf, a semi-enclosed gulf of Eastern Mediterranean where otter trawling is prohibited.

## Materials and methods

Four seasonal samplings were carried out from July 2004 to April 2005 (July and October 2004, January and April 2005) from the two marine fish farms (AS: 39<sup>0</sup>07'38" N 23<sup>0</sup>09'17" E, BS: 39<sup>0</sup>07'13" N 22<sup>0</sup>57'53" E). At the area of each fish-farm, three stations were sampled, one was located in the centre of fish farm, the other at a distance of 50 m from the centre and the last one at a distance of 300 m from the fish farm center, taken upstream from the main current direction in each fish farm. Henceforth these are referred to as AS<sub>1</sub>, AS<sub>2</sub> and AS<sub>3</sub> for the first fish-farm and BS<sub>1</sub>, BS2 and BS3 for the second fish farm. Furthermore, AS1, AS2, BS1 and BS2 stations were the farm sites while AS3, BS3 stations were the control sites. At each sampling station, samples were collected by means of a grab sampler (Eckman-Birge) with an area of 0.0225 m<sup>2</sup>. From all sampling stations, three replicate samples were taken during all seasons, in order to determine natural variability within replicates (72 total samples). Samples were sieved through a 0.5 mm mesh sieve and each sample was placed in plastic vials in 10% formaldehyde. Calculations were done by means of PRIMER software package.

#### Results

A total of 1 193 individuals, belonging to 90 species were identified. In terms of community structure (Table 1), the two areas showed a pattern of spatial change with distance from the cages. The polychaete *Capitella capitata* was the most dominant species in both farm sites (37% and 65% of the total abundance, respectively), whilst the most dominant species at the control sites of two fish farms was the polychaete *Nephthys hystricis* (11% of the total abundance in both sites). Furthermore, *N. hystricis* was found at the control sites and the 50 m stations, but never at the 0 m stations, which were located under the center of the cages.

#### Discussion

The additional food resource supplied by the farms is likely to be exploited by opportunistic species. The polychaete *Capitella capitata* is an opportunistic macrofaunal species, which is commonly found in polluted marine sediments [2]. A number of authors have reported the presence of this species under fish cages [2, 4, 5]. In some cases *C. capitata* reached almost 75% of the total abundance at the farm sites [2]. In our study, *C. capitata* does not exceed 65%. On the other hand, polychaete *Nephthys hystricis* was present only at the control sites and 50 m stations, but was absent at 0 m stations. This finding may imply that *N. hystricis* is an indicator of not polluted marine sediments, which is in agreement with other authors [2]. In all cases the benthic assemblages in the immediate vicinity showed symptoms of disturbance, but the spatial extend of this effect was quite limited.

Tab. 1. Average relative abundance (%) per station of macrofaunal species comprising more than 1% of the total abundance at any one station over all sampling cruises (+: presence <1%; C: Crustacea, E: Echinodermata; M: Mollusca; P: Polychaeta; S: Sipunculida). Species are arranged by decreasing average abundance at the stations in proximity to the cages and increasing average abundance at the control sites.

| Species                        | Phylum | AS <sub>1</sub> | $AS_2$ | $AS_3$ | $BS_1$ | $BS_2$ | $BS_3$ |
|--------------------------------|--------|-----------------|--------|--------|--------|--------|--------|
| Capitella capitata             | Р      | 37              | 13     | +      | 65     | 33     | 2      |
| Tharyx dorsobranchialis        | Ρ      | 5               | 7      | 6      | 4      | 7      | 5      |
| Harpinia dellavallei           | С      | 6               | 5      | 5      | 2      | 5      | 5      |
| Paraonis gracilis gracilis     | Р      | 3               | 7      | 8      | 3      | 5      | 8      |
| Lumbrinereis gracilis          | P      | 3               | 3      | 2      | 2      | 3      | 3      |
| Ampelisca diadema              | С      | 2               | 4      | 4      | 3      | 5      | 5      |
| Podarke pallida                | P      | 3               | 3      | 3      | 2      | 1      | 3      |
| Glycera convoluta              | P      | 3               | 3      | 5      | 1      | 2      | 5      |
| Chaetozone setosa              | P      | 2               | 4      | R+     | 2      | +      | 1      |
| Apseudes latreilli             | С      | 3               | 3      | 1      | +      | 2      | 2      |
| Onchnesoma steenstrupi         | S      | 3               | 3      | 4      | +      | 2      | 3      |
| Turitella triplicata           | М      | 2               | 1      | +      | +      | 1      | 2      |
| Aricidea fragilis mediterranea | P      | 1               | 1      | 2      | 1      | 1      | +      |
| Oweria fusiformis              | Р      | 2               | 1      | 1      | +      | 2      | 2      |
| Mytilus galloprovincialis      | м      |                 |        |        | 2      | 4      | 1      |
| Corbula gibba                  | м      | 1               | 1      | 4      | +      | +      | 4      |
| Amphiura filiformis            | E      | 1               | 1      | 3      | +      | +      | 2      |
| Prionospio ehlersi             | Р      | 1               | 2      | 2      | +      | +      | 1      |
| Dentalium sp.                  | м      | +               | 2      | 3      | +      | 1      | 3      |
| Notomastus latericeus          | P      | +               | 2      | 2      | +      | 1      | +      |
| Nephthys hystricis             | P      |                 | 2      | 11     |        | 2      | 11     |
| Total                          |        | 80              | 67     | 68     | 92     | 81     | 72     |

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## PARTICLE FLUXES UNDERNEATH FISH FARMS IN A SEMI-ENCLOSED GULF OF EASTERN MEDITERRANEAN

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## Abstract

A field study was carried out at two fish farms of Pagasitikos Gulf in October 2005 in order to determine particle fluxes during feeding. Sediment trap deployments revealed that sedimentation fluxes of particulate matter (PM) and organic carbon (OC) were higher below the farms compared to the control sites located 300 m away. PM fluxes underneath fish cages ranged between 6.51 and 7.33 g m<sup>-2</sup> day<sup>-1</sup>, while OC fluxes ranged between 0.74 and 1.46 g m<sup>-2</sup> day<sup>-1</sup>. In all cases, the spatial extend of this effect was observed to be relatively limited.

Keywords : Aquaculture, Particle Flux, Aegean Sea.

#### Introduction

Little is known of the fish farming impacts in the Mediterranean [1, 2], where fish farming of marine species, particularly sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*), has grown exponentially during the last 25 years. The most widely documented process associated with intensive mariculture is the accumulation of PM on the seabed due to the deposition of solid waste from undigested feed [3, 4, 5]. The objective of this study was to determine particle fluxes underneath two fish farms of Pagasitikos Gulf, a semi-enclosed gulf of the Eastern Mediterranean.

#### Materials and methods

The study was carried out in the Pagasitikos Gulf, central Greece, at two marine fish farms (AS: 39°07'38" N 23°09'17" E, BS: 39°07'13" N  $22^{\circ}57'53''$  E) between the  $11^{th}$  and  $26^{th}$  of October 2005. Sea bream (Sparus aurata) and sea bass (Dicentrarchus labrax) are intensively cultivated in these farms by using pelleted and extruded diets. The average annual standing stocks were 130 t and 92 t, while the Food Conversion Ratio (FCR) was 1.7 and 2.0 for the AS and BS farms, respectively. Sampling was carried out at two stations, in each fish-farm area. The first station was located in the centre of the fish farm and the second at a 300 m distance from the fish farm center, upstream from the main current direction. Henceforth, these stations are referred as Cage and Control, respectively. At each sampling station, particulates sinking to the seabed were collected with a sediment trap, for a 15 day-period time, in order to determine PM and OC fluxes. Each sediment trap consisted of a PVC tube (diameter = 13 cm; height = 76 cm) with a detachable particle collector at its lower end. The sediment trap was attached to a floating buoy vertically oriented in the water column by means of an anchor. The opening of the sediment trap tube was situated 5 m above the seabed. This depth was chosen in order to measure particle fluxes as close as possible to the seabed and yet prevent artifacts from sediment re-suspension [4]. Sample analysis was performed according to the protocol described in [4].

## Results and discussion

PM and OC results are shown in Figure 1. These results show that both PM and OC fluxes were higher at the farm sites compared to the control ones. The above indicated that a considerable amount of uneaten food and faeces reached the seabed, contributing significantly to the overall solid waste production from fish cage systems. The accumulation of uneaten food and faeces below the fish cages may result in organic enrichment [6], thereby affecting the benthic community regarding macrofaunal succession with large differences in the spatial and temporal extend of the impacts [2]. Similar studies have shown that the environmental impacts of fish cage farming vary greatly, according to the site-specific characteristics [3]. During the course of this study, we concluded that the spatial extend of this effect was observed to be relatively limited.



Fig. 1. Sedimentation fluxes of particulate matter (PM) and organic carbon (OC) recorded in two fish farms (AS and BS).

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## PRELIMINARY STUDY ON THE BIVALVIA ASSEMBLAGES OF THE NORTHERN ADRIATIC SOFT BOTTOMS

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## Abstract

Present study is a part of comprehensive investigation on the soft bottom benthic communities in the northern Adriatic circalittoral zone. It aimed to compare and characterize the assemblages structure and seasonal dynamics of Bivalvia associated with three different benthic communities, i.e. biocoenoses of coastal detritic (DC), muddy detritic (DE) and shelf-edge detritic bottom (DL). The structure of bivalves fauna was determined by distinctive dominance of families Nuculidae, Tellinidae and Veneridae; species *Tellina donacina* and *Nucula nitidosa*, outstanding position of 5-6 species (>5%) per site, and diversity ranged 23-27 species or 3,18-3,68 bits./ind. *Keywords : Adriatic Sea, Bivalves*.

## Introduction

Benthic communities represent powerful tools for detection of natural and anthropogenic disturbance, but also for assessment of marine ecosystems stability. This study dealt with communities experienced heavy disturbance due to oxygen crisis in 1989 [1]. On that occasion Bivalvia were proved to be an excellent indicators of disturbance and ecosystem instability. The results of biennial post anoxic monitoring indicated partial recovery of benthic communities as well as Bivalvia assemblages [1, 2]. In the meantime the anoxic conditions were not repeated. Thus, we expect that recovery of benthos within investigated area is achieved. To test hypothesis on the resilience of benthic communities, assemblages structure and dynamics of Bivalvia were investigated.

## Materials and Methods

Sampling was performed seasonally from March to December 2005 on three permanent sites SJ005 (45°18.4'N: 13°08.0'E). SJ007 (45°17.0'N: 13°16,0'E) and SJ107 (45°02,8'N; 13°19,0'E). All sites characterized by similar environmental features (depths of 30-36 m, silty-sand type of sediment) and close macrobenthic composition [1]. Benthic biocoenoses are classified according Pérès and Picard [3] as: biocoenosis of muddy detritic bottom (SJ005), biocoenosis of shelf-edge detritic bottom (SJ007) and biocoenosis of coastal detritic bottom (SJ107) [1]. At all sites sediment was classified as poorly sorted silty sand (phi=2,38-3,05), and it was distinguished by high participation of sand (57-69%) dominated by fine and very fine fractions [4]. Samples were collected with 0,1m<sup>2</sup>Van Veen grab. The material was treated according to standard field and laboratory procedure: sieving (2 mm and 1 mm mesh), fixation (neutralized 4%formalin and 70% ethanol), counting and classification of macrofauna [5], as well as taxonomic determination of Bivalvia retained on 2 mm sieve [6]. The data were subjected to multivariate and distributional statistical analyses [7].

#### Results and Discussion

A total of 43 species, belonging to 33 genera and 24 families were identified. Faunistic composition were characterized by dominance of *Tellina donacina* and *Nucula nitidosa*, relatively high abundance (>5%) of 5-6 species and lower single participation of all others (Fig. 1a, 1b, 1c). Bray-Curtis similarity coefficients pointed out moderately high faunistic affinity between sampling sites ( $Q_{SJ005:SJ107}$ =38%,  $Q_{SJ005:SJ007}$ =57%,  $Q_{SJ007:SJ107}$ =53%,). The results of ANOSIM (global R=0,762; T=999, p<0, 1) suggested differences in Bivalvia assemblages structure between SJ107 and two other sites ( $R_{SJ005:SJ107}$ =0,969,  $R_{SJ007:SJ107}$ =0,938), but no difference between SJ005 and SJ007 were found.

Mutual intersection of k-dominance curves belonging to particular seasons suggested the same trend of distribution of individuals per species suggested no differences in diversity pattern within sites (Fig. 1d, 1e, 1f). A general shape, position and elevation of k-dominance curves indicated higher diversity and evenness at SJ107, related SJ005 and SJ007 (Fig. 1g). Compared with results of the previous investigations our results point out relatively high stability of Bivalvia assemblages and indicate resilience of benthic communities.



Fig. 1. Species composition and relative abundance of dominant (d>5%) Bivalvia species (a-c); k-dominance curves for Bivalvia assemblages (d-g).

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## ALLOMETRIC SOMATIC GROWTH PATTERNS AND OTOLITH SHAPE CHANGES IN *DIPLODUS SARGUS* (LINNAEUS, 1758) DURING METAMORPHOSIS

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## Abstract

A mean length at metamorphosis (Ljuv) is defined for *Diplodus sargus* using a multivariate analysis of morphometric characters. The Ljuv corresponds well to significant changes in relative otolith growth and otolith shape (coefficients of Elliptic Fourier Analysis). *Keywords : Biometrics, Fishes, Larvae, Ionian Sea.* 

## Introduction

In comparative studies of fish development an ontogenetic index is usually used, OL=log(L)/log(Ljuv), where L is the larval length and Ljuv the length at which the species completes metamorhosis [1]. However the definition of metamorphosis is debatable. Recently, a multivariate approach, taking into account a large set of characters has been proposed as more appropriate [1]. In this study, we determine morphometrically a mean length at metamorphosis (Ljuv) in *Diplodus sargus* and compare its consistency with changes in otolith relative growth and shape.

## Materials and Methods

A sample of 145 settled Diplodus sargus individuals was collected using a hand-net at depths ranging from 0.5 m to 1 m at a coastal site in the Ionian Sea, in May 2006. Fishes were anesthetized and individually photographed under a stereomicroscope. Morphometric measurements (Pre-orbital length, Eye diameter, Head length, Pre-pelvic length, Predorsal fin length, Pre-anal length, Pre-anal fin length, Post-dorsal fin length, Post-anal fin length, Standard length, Fork length, Eye depth, Head depth, Body depth, Caudal peduncle depth) were taken as defined in [2]. Logarithmic values of measurements were subjected to Principal Components Analysis (PCA) using the covariance matrix [3]. According to the analysis of [3], in an ontogenetic series where shifts in allometric growth patterns between sequencial stages exist, these shifts would be reflected in a multi-stage PCA as divergent PC2 trajectories (changes in oblique orientation). This point during metamorphosis (inflection point) was defined by plotting PC2 on fish standard length (SL) and fitting of a piecewise regression. The right sagitta was removed from each fish, photographed and measured for otolith area (OA) and perimeter (OP). The outlines of the otoliths were also extracted from the digital images and their 2D shape was studied with Elliptic Fourier Analysis (EFA) (invariant of size, position and rotation) [4]. Canonical Variate Analysis of the coefficients corresponding to the first 24 harmonics was used to study otolith shape changes during metamorphosis. Otolith size - fish size relationships were compared with ANCOVA models for the stages before and after the inflection point defined by the analysis of body morphometrics.

#### Results and Discussion

The plot of the second component of the multi-stage PCA on SL (Fig. 1) showed a marked change in orientation during metamorphosis. The inflection point defined by fitting the piecewise regression was 15.11 mm SL. This length was considered as the mean length at metamorphosis (Ljuv) of D. sargus [5]. The slopes of the OP-on-SL and OA-on-SL relationships differed significantly before and after the Ljuv (F=44.74, p<0.001 and F=19.23, p<0.001, respectively). Furthermore, otolith shape differed significantly for fish smaller (Group 1) and larger (Group 2) than Ljuv (Wilk's  $\lambda = 0.25$ , p<0.001). The results presented here, show a good correspondence between allometric changes defined with the multivariate approach and changes in relative otolith growth and shape in D. sargus, which furthermore support the use of morphometrics for defining a mean size at metamorphosis. Good agreement has also been observed between morphological-osteological changes (not presented here) and Ljuv [5], which provide additional support to the approach used. The definition of a mean length at metamorphosis is useful for comparative studies which express development as a logarithmic function of Ljuv.

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Fig. 1. Plot of PC2 of morphometric characters on log(SL). -: piecewise regression model.



Fig. 2. OA-on-SL, OP-on-SL relationships and their respective piecewise regression models for fish smaller (Group 1) and bigger (Group 2) than Ljuv.

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## CYCLES SEXUELS DES SARS (SPARIDAE) DU GOLFE D' ANNABA (EST ALGÉRIEN)

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## Résumé

Les poissons du genre *Diplodus* (Rafinesque, 1810) constituent une ressource halieutique non négligeable sur les côtes est algériennes d'où leur intérêt économique indéniable. Ces espèces occupent une partie considérable dans les apports des pêcheries d'Annaba et constituent une partie importante du régime alimentaire des habitants. Malgré les nombreux travaux consacrés à la biologie des poissons du golfe d'Annaba, les informations concernant la reproduction de ces espèces ne sont pas encore disponibles. Cette étude vise à fournir ces informations pour gérer de façon efficace cette ressource

Mots clès : Algerian Basin, Fishes, Reproduction, Spawning.

## Introduction

En Méditerranée, le genre *Diplodus* est représenté par 5 espèces; le sparaillon *Diplodus annularis* (Linnaeus, 1758), le sar à tête noir *D. vulgaris* (Geoffroy Saint-Hilaire, 1817), le sar à museau pointu *D. puntazzo* (Cetti, 1777), le sar à grosses lèvres *D. cervinus cervinus* (Lowe, 1838) et le sar commun *D. sargus sargus* (Linnaeus, 1758). Ces espèces coexistent en Méditerranée en milieu peu profond sur des fonds rocheux, seul *D. annularis* se trouve sur des fonds sableux et d'herbiers de posidonies. Ces espèces sont importantes dans les apports des pêcheries du golfe d'Annaba. Ce pendant leur reproduction n'a pas été étudié.

Ainsi, nous avons abordé le cycle sexuel des 4 premières espèces dans le golfe d'Annaba pour orienter leur exploitation.

#### Matériels et Méthodes

Notre échantillon provient du golfe d'Annaba. Au total 719 *D. annularis* (104  $\leq$  Lt  $\leq$ 188 mm ; 17  $\leq$  Pt  $\leq$ 118 g) ; 380 *D. vulgaris* (114  $\leq$  Lt  $\leq$ 288 mm ; 11,39  $\leq$  Pt  $\leq$ 220 g) ; 220 *D.* puntazzo (126  $\leq$  Lt  $\leq$ 418 mm, 27,04  $\leq$  Pt  $\leq$ 1188 g) et 254 *D. cervinus* (11,7  $\leq$  Lt  $\leq$ 532 mm, 24,5  $\leq$ Pt  $\leq$ 2200 g) ont été pêchés par filets maillant. Afin de déterminer la périodede reproduction, l'évolution mensuelle du rapport gonado-somatique a été étudiée

RGS = [(Poids de gonades)/(Poids du poisson éviscéré)] \* 100

#### Résultats et Discussion

Le suivi mensuel des valeurs moyennes des rapports gonado-somatique montre que la période de reproduction de *D. annularis* et *D. cervinus* et printano-estivale. Elle s'étend d'avril à juillet chez le sparaillon, elle est plus précoce en Atlantique où elle s'étend de janvier à mai [1; 2]. La valeur maximale du rapport gonado-somatique est enregistrée en mai (RGS = 5,787) indiquant la maturation des gonades. Le cycle sexuel de *D. cervinus* se déroule entre mars et août (fig. 1).



Fig. 1. Le cycle sexuel de D. cervinus se déroule entre mars et août.

L'activité sexuelle du sar à museau pointu du golfe d'Annaba se déroule entre août et novembre. La valeur maximale du RGS est enregistrée en septembre (3,202) marquant la maturation des gonades. Cette période est identique à celle déterminée dans le golfe de Tunis [3]. (fig. 2)



Fig. 2. Marquant la maturation des gonades entre août et novembre, cette période est identique à celle déterminée dans le golfe de Tunis.

Chez *D. vulgaris*, la période de reproduction est hivernale et s'étend de décembre à février. La valeur maximale du RGS est enregistrée en janvier (2,159). (fig. 2). Sur les côtes Sud-ouest du Portugal, la période d'activité sexuelle s'étend jusqu'à mars [4].

Les espèces de sars présentent une succession temporelle de leurs périodes de ponte qui semble être influencées par le réchauffement ou le refroidissement de l'eau de mer. Ainsi les larves qui fréquentent les mêmes nourriceries s'installent à des périodes différentes.

## Conclusion

L'évolution temporelle du rapport gonadosomatique, pour chacune des 4 espèces étudiées nous a permis de déterminer les différentes périodes du cycle sexuel. Il s'avère que la période de reproduction de *D. annularis* et *D. cervinus* est essentiellement printano-estivale. Elle est estivo-automnale pour *D. puntazzo* et hivernale pour *D. vulgaris*.

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## LE SAR *DIPLODUS ANNULARIS* (L., 1758) DU GOLFE D'ANNABA: CROISSANCES LINÉAIRE ET PONDERALE

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## Résumé

Le sparaillon *Diplodus annularis* (L., 1758) est un petit sparidé commun aux fonds d'herbiers à posidonie. Son aire de distribution s'étend sur l'ensemble des eaux atlanto-méditerranéennes. Dans le golfe d'Annaba, cette espèce constitue une ressource non négligeable. Ainsi, nous avons étudié son âge et sa croissance par scalimétrie afin d'orienter sa gestion. Les croissances en longueur et en poids sont décrites par le modèle de von Bertalanffy. *D. annularis* du golfe d'Annaba est caractérisée par une croissance lente et allométrique. La relation taille poids varie au cours de l'année et en fonction de l'état physiologique des géniteurs.

Mots clès : Algerian Basin, Fishes, Growth, Population Dynamics.

## Introduction

Le sparaillon *Diplodus annularis* (L., 1758) est un petit sparidé commun aux fonds d'herbier à posidonie. Son aire de distribution s'étend du golfe de Biscaye au Gibraltar et entre Madeira et les îles Canaries, il est également présent en Méditerranée et en Mer noire. Cette espèce constitue une importante ressource commerciale sur les côtes algériennes. Cependant, son âge et sa croissance n'ont pas été abordés, bien que ces données soient des informations clés pour les modèles exploités en dynamique des populations et en écologie halieutique. Ce travail constitue la première étude traitant l'âge et la croissance de cette espèce dans le golfe d'Annaba (Nord est algérien).

## Matériel et méthodes

L'échantillon ayant servi à cette étude se compose de 648 poissons pêchés dans le golfe d'Annaba par filet maillant. La détermination de l'âge a été réalisée par scalimétrie. Pour chaque poisson, 10 à 15 écailles ont été prélevées sous la nageoire pectorale gauche, nettoyées puis placées entre deux lames et ont été observées sous microscope en lumière transmise. Les mesures du rayon de l'écaille et des rayons des différentes marques d'arrêt de croissance ainsi que l'accroissement marginal sont prises par un micromètre. La période de formation de marques d'arrêt de croissance a été déterminée par le suivi des variations mensuelles de l'allongement marginal calculé par la formule suivante:

$$AM = \frac{r - r_n}{r_n - r_n - 1}$$

Avec rn et rn-1: rayons du dernier et avant dernier annulus. Les moyennes des longueurs standard pour chaque groupe d'âge ont été rétro calculées et les couples de valeurs âge - longueur sont ainsi ajustés au modèle de Von Bertalanffy. Les paramètres de l'équation  $(L\infty, K, t_0)$  sont déterminés par le programme Fishparm. La croissance pondérale est également décrite par l'équation de Von Bertalanffy. La nature de l'allométrie a été évaluée par le test t de Student. L'indice de performance de croissance F'= log k + 2 log  $L\infty$  [1] a été utilisé pour comparer les paramètre de croissance obtenus dans différentes régions.

## Résultats et discussion

Le suivi mensuel de l'allongement marginal chez les différents groupes d'âge montre l'individualisation d'un seul anneau d'arrêt de croissance par an. Ce dernier se forme en août indiquant un ralentissement de la croissance qui semble être influencée par la reproduction. Les tailles des sparaillons à différents âges ont été rétro calculées grâce à l'existence d'une corrélation significative entre la longueur totale du poisson et le rayon de son écaille (r = 0,835, p <0,01). L'âge maximum des poissons péchés était de 6 ans. Les croissances linéaire et pondérale absolues sont respectivement exprimées par les formules suivantes:

$$L_t = 19.54 \left[ 1 - e^{-0.46(t+0.565)} \right]$$

$$P_t = 201.791 \left[ 1 - e^{-0.46(t+0.565)} \right]^{-0.137}$$

Les valeurs observées et théoriques de la longueur et du poids des poissons sont très proches et montrent que les croissances linéaire et pondérale sont parfaitement décrites par le model mathématique choisi avec un coefficient de détermination égal à 98.8 % (fig.1).



Fig. 1. Croissances linéaires absolues de D. annularis du golfe d'Annaba.

Le taux de croissance linéaire est plus important durant la première année de vie au bout de laquelle une taille de 100 mm est atteinte. Ce taux tend à diminuer progressivement jusqu'à 9 mm / an à cinq ans. Avec un indice de performance de croissance égal à 5,17; la croissance linéaire estimée de D. annularis du golfe d'Annaba est plus rapide que celle observée dans le golfe du Lion (F'= 5,08) [2], dans le golfe de Gabès (F'= 4,40) [3] et dans les Iles Canaries où cet indice est égal à 5,11 [4]. Cependant, la vitesse de croissance linéaire de ce poisson est lente par rapport aux autres espèces de sparidés de la même région. Le poids des sparaillons évolue plus rapidement que la taille avec un coefficient d'allométrie de 3,137 (p <0,001). Cette valeur est supérieure à celle obtenue en Tunisie (b = 3,094)[3], aux îles Canaries [4] et à celle obtenue au Portugal (b = 3.096)[5] ce qui indique une bonne croissance pondérale de D. annularis dans le golfe d'Annaba. Toutefois deux cas d'allométrie minorante ont été enregistrés en mars (b = 2,54; p <0,001) et en août (b = 2,29; p <0,001). La croissance relative est meilleure chez les individus matures (b = 3,191 ; p < 0,001) que chez les immatures (b = 3,08 ; p > 0,05). Le taux d'accroissement pondéral annuel est de 24,11 g. / an durant la première année. Ce taux augmente progressivement entre la deuxième et la troisième année, puis commence à diminuer pour atteindre une valeur de 22,8 g / an durant la cinquième année. Le poids maximal théorique est de 156,78 g, il est inférieur au poids maximum échantillonné soit 118,42 g.

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## EXPLOITATION DE DEUX ESPÈCES DE CREVETTES PROFONDES *ARISTEUS ANTENNATUS* (RISSO, 1816) ET *PARAPENAEUS LONGIROSTRIS* (LUCAS, 1846) DE LA RÉGION ALGÉROISE

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## Résumé

Les chalutiers du port d'Alger exploitent *Aristeus antennatus* et *Parapenaeus longirostris* durant toute l'année sur des fonds allant de 200 à 400 mètres de profondeur. Un chalutier capture, en moyenne par journée de pêche, 62,5 Kg de *A. antennatus* 18 Kg de *P. longirostris*. Le rendement horaire est de 7 Kg/h pour la crevette rouge et de 2 Kg/h pour la crevette blanche. Les paramètres de croissance et d'exploitation déterminés pour ces deux espèces sont en accord avec ceux des différents travaux méditerranéens. *Mots clès : Algerian Basin, Crustacea, Growth, Fisheries.* 

## Introduction

En Algérie Aristeus antennatus (Risso, 1816) et Parapenaeus longirostris (Lucas, 1846), par leur qualité et leur abondance, constituent la presque totalité des captures en crevettes. Entre 1980 et 2000, les apports en crevettes sont en moyenne de 3000 tonnes par an, représentant environ 4% de la production totale annuelle et 10% de la valeur économique globale [1]. Durant toute l'année, les chalutiers de la région d'Alger exploitent des zones de pêche, de profondeur allant de 200 à 400 mètres, connues pour leur bon rendement en crevettes [2].

## Matériel et méthode

Pour l'année 2004, les indices d'exploitation sont définis par analyse des apports de la pêche commerciale des chalutiers du port d'Alger. Des mensurations effectuées en mai 2005 sur 2330 individus de A. antennatus et 1105 individus de P. longirostris ont permis la détermination de certains paramètres biologiques. Les relevés journaliers (exprimés en kilogramme) sont regroupés en apports mensuels répartis en trois groupes (CR : A. antennatus, CB : P. longirostris et un groupe A représentant l'ensemble des autres espèces de poissons, de Crustacés Décapodes et de Mollusques Céphalopodes). Pour chaque mois, la prise moyenne journalière de l'ensemble des chalutiers actifs est calculée à partir du rapport du total des prises sur le nombre de jours de pêche. Pour un chalutier, considéré comme unité d'effort, la prise par unité d'effort journalière correspond au rapport de la prise moyenne journalière sur le nombre de chalutiers actifs. Les paramètres de croissance de von Bertalanffy sont déterminés par analyse des structures de taille avec les méthodes de Powell-Wetherall [in 3] pour L $\infty$ , de [4] pour K et de [5] pour to. Le coefficient de mortalité totale (Z) est estimé par la méthode de Powell-Wetherall, celui de la naturelle (M) par l'équation de [6]. Connaissant Z et M, le coefficient de mortalité par pêche F est estimé.

#### Résultats

Dans l'ensemble, les apports de *A. antennatus* sont trois fois plus importants que ceux *P. longirostris* (Tableau 1).

Tab. 1. Apports mensuels et prises journalières de *A. antennatus* (CR), *P. longirostris* (CB) et des autres espèces (A) au port d'Alger en 2004.

|       | Ap    | port me | nsuel  | Nombre   | e Prise moyenne    |        | Moyenne    | Prise jo               | urnalière | par unité |        |
|-------|-------|---------|--------|----------|--------------------|--------|------------|------------------------|-----------|-----------|--------|
|       |       | (en Kg  | 9      | de jours | journalière (Kg/j) |        | de navires | d'effort (Kg/j/navire) |           |           |        |
| Mois  | CR    | CB      | A      | actifs   | CR                 | CB     | A          | actifs                 | CR        | СВ        | A      |
| Janv. | 5415  | 1680    | 18555  | 11       | 492,27             | 152,73 | 1686,82    | 5                      | 98,45     | 30,55     | 337,36 |
| Févr. | 5175  | 2010    | 30766  | 13       | 398,08             | 154,61 | 2366,62    | 5,3                    | 75,11     | 29,17     | 446,53 |
| Mars  | 5685  | 1060    | 42215  | 18       | 315,83             | 58,89  | 2345,28    | 6,3                    | 50,13     | 9,35      | 372,27 |
| Avril | 4925  | 1185    | 27835  | 12       | 410,42             | 98,75  | 2319,58    | 6,5                    | 63,14     | 15,19     | 356,86 |
| Mai   | 5355  | 1275    | 1412   | 12       | 446,25             | 106,25 | 117,67     | 6,5                    | 68,65     | 16,35     | 18,1   |
| Juin  | 12320 | 2150    | 2110   | 24       | 513,33             | 89,58  | 87,92      | 7                      | 73,33     | 12,8      | 12,56  |
| Juil. | 9665  | 2352    | 2320   | 25       | 386,6              | 94,08  | 92,8       | 6,3                    | 61,37     | 14,93     | 14,73  |
| Août  | 6725  | 1615    | 1400   | 14       | 480,36             | 115,36 | 100        | 7                      | 68,62     | 16,48     | 14,29  |
| Sept. | 2325  | 2460    | 24902  | 12       | 193,75             | 205    | 2075,17    | 6                      | 32,29     | 34,17     | 345,86 |
| Octo. | 4830  | 2155    | 34700  | 21       | 230                | 102,62 | 1652,38    | 6,7                    | 34,33     | 15,32     | 246,62 |
| Nove. | 5145  | 1885    | 10842  | 17       | 302,65             | 110,88 | 637,76     | 5                      | 60,53     | 22,18     | 127,55 |
| Déce. | 4485  | 1070    | 10702  | 14       | 320,36             | 76,43  | 764,43     | 4                      | 80,09     | 19,11     | 191,11 |
| Total | 72050 | 20897   | 207759 | 193      | 373,32             | 108,27 | 1076,5     | 71,6                   | 62,57     | 18,15     | 180,41 |
| 96    | 24    | 7       | 69     |          |                    |        |            |                        |           |           |        |

Ces deux crevettes, représentant 31% de la capture totale (avec 24% pour la crevette rouge et 7 % pour la crevette blanche), sont exploitées durant toute l'année. Le suivi mensuel des apports indique un maximum en été pour *A. antennatus*, période où la capture des autres espèces est relativement faible. Ces variations sont dues à la fermeture des zones de pêche côtière. Durant l'année 2004, le nombre de jours de pêche des

chalutiers du port d'Alger est de 193 jours, avec en moyenne un nombre de 6 chalutiers actifs (ou opérationnels) par jour. Un chalutier capture, en moyenne, 62.5 Kg de *A. antennatus* et 18 Kg de P. longirostris par journée de pêche. Sachant que la durée de pêche effective est de 9 heures par jour, le rendement horaire est de 7 Kg/h pour *A. antennatus* et de 2 Kg/h pour *P. longirstris*. Les paramètres de croissance et d'exploitation obtenus pour ces deux espèces sont reportés dans le Tableau 2. Ces résultats sont en accord avec ceux des différents travaux méditerranéens ([7, 8] pour *A. antennatus* et [9] pour *P. longirstris*).

Tab. 2. Paramètres de croissance et d'exploitation de *A. antennatus* (CR) et *P. longirostris* (CB). N: effectif; L $\infty$ : longueur céphalothoracique asymptotique (mm); K: coefficient de croissance (an); t<sub>o</sub>: temps où la longueur est nulle; Z, M, F: coefficient instantané de mortalité totale, naturelle et par pêche; E: taux d'exploitation (=F/Z), Ø': taux de croissance.

| Espèce | Sexe | N    | L∞    | K    | t <sub>o</sub> | Z    | M     | F     | E     | ø,    |
|--------|------|------|-------|------|----------------|------|-------|-------|-------|-------|
| CR     | F    | 2095 | 62,43 | 0,47 | -0,53          | 1,24 | 0,515 | 0,725 | 0,584 | 1,278 |
|        | M    | 235  | 33,09 | 0,65 | -0,24          | 1,63 | 0,656 | 0,974 | 0,597 | 0,855 |
| CB     | F    | 670  | 34,09 | 0,92 | -0,41          | 1,85 | 0,76  | 1,09  | 0,59  | 1,03  |
|        | M    | 435  | 31,11 | 0,72 | -0,42          | 1,86 | 0,78  | 1,08  | 0,58  | 0,844 |

#### Discussion

Les zones de pêche situées entre 200 et 400 mètres de profondeur correspondent à la répartition optimale de *P. longirostris*. La diminution nette du rendement pour cette espèce, en comparaison avec nos résultats antérieurs [1], traduit une situation de surexploitation. *A. antennatus*, en raison de sa haute valeur commerciale, se trouve très recherchée et donc plus ciblée par l'exploitation. Bien que le rendement de *A. antennatus* a sensiblement diminué, sa valeur commerciale qui, en nette augmentation, compense les faibles apports pour les professionnels.

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# USE OF THREE-DIMENSIONAL CONSTRUCTION TECHNIQUE IN PHOTO-IDENTIFICATION OF THE MEDITERRANEAN MONK SEAL (*MONACHUS MONACHUS*) IN THE NORTHEASTERN MEDITERRANEAN

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## Abstract

In order to photo-identify the critically endangered Mediterranean monk seal (*Monachus monachus*) inhabiting the northeastern Mediterranean, the monk seal photographs were processed using three-dimensional construction technique. This results show that in order to reach an accuracy level sufficient to identify a monk seal, which has a specific body shape, at least 4 phonographs taken simultaneously from 4 opposing angles are needed. On each these photos, at least 100 matching reference points are needed to be determined. *Keywords : Conservation, Eastern Mediterranean, Sampling Methods.* 

The Mediterranean monk seal (Monachus monachus, Hermann 1779) has been listed as one of the most endangered mammals [1]. Amongst the Mediterranean coastal areas, the northeastern Turkish coast provide one of the last refuge areas where the monk seal still exists and can successfully reproduce. Status of the monk seal colony in the area has been monitored since 1994 by METU, Institute of Marine Sciences. In general, various direct and indirect methods are used to observe and monitor the monk seal populations. The standard sampling methods that are commonly applied to other animals are not practical for the Mediterranean monk seals due to its critical status. One of the most effective methods for identification. cataloging and monitoring individuals without creating any disturbance in their habitat is to use camera traps to obtain high resolution photographs [2]. This technique was effectively used on monk seals by Scoullos et al. [2] Hiby and Jeffery [3], and Gucu et al. [4]. In this study, 3D model construction from photographs was tested as an alternative photoidentification method for monk seals. This technique is based on matching the points on a set of photographs of the same object taken from different angles.

The photogrammetry software Photomodeler Ver.3.1a was used for 3D model construction of monk seals from photographs. In order to obtain appropriate photographs for the software, some of the caves that are suitable for seal use were equipped with Vigil P-Box infrared monitors that may detect a seal up to 18 meter distance with a passive infrared motion detector and sense heat-in-motion with its conical beam. This system was deployed in the caves from January 2004 to December 2005. Besides, to choose sufficient and appropriate reference points that precisely describe the shape of the monk seal, the object having true proportions of a monk seal was used to estimate the minimum number of reference points. For this estimation, after the 3D model construction, real volume of the object was calculated and compared to those estimated by the model. Total number of reference points used in the estimation was plotted against the error term (the error term: the real volume / the estimated volume by the model. The software has several steps including setting the approximate project size and data unit, defining the parameters of the camera used, importing the photographs, marking and referencing points on each photograph and finally processing the project. In the first trial, the best scenes in a video footage of a seal displaying all aspects of the body were captured in still images. These images were transferred to computer and processed following the steps mentioned above. In the next step, still photographs of a seal taken at the same time from varying angles were required due to the limitation emerged in the use of photo captures from a video footage. Therefore, four digital cameras automatically triggered by infrared sensors were installed to the corners of a hauling platform in 2 different caves in order to capture four main aspect of a seal.

The 90 % accuracy was obtained above 100 reference points to construct 3D model of the monk seal including 25 reference points in the head, 66 reference points in the abdomen and 9 reference points in the tail and the maximum accuracy was reached at 150 reference points (Fig.1). The seal modeling trials using the photographs captured from video footage did not reach the necessary levels to give accurate results because of the plasticity of the body of the seal while swimming or crawling on the land. Increasing the number of the reference points, even higher than 150 did not improve the accuracy. After that, 4 seals were photographed from different direction at their haul out platforms in the resting caves. A total of 98 pictures were taken. The ceiling of one the cave was too low to mount the cameras in the proper position. Therefore, none of the photographs were good enough to display entire body of the seal. In the other cave,

the photographs were able to frame the whole body of the seal. Due to dimmed light in the cave, only 25 reference points could be choosen on the photographs which was not enough for 3D model construction.





In this study, as an alternative photo-identification method for monk seals, 3D construction from photographs by using the Photomodeler Version 3.1a were not yielded successful, however it was proven that the technique is able to provide valuable data on seals without giving any disturbance to the animals. At least 4 cameras should be placed horizontally in a way to capture lateral, anterior and posterior aspects of the animal and at least 100 reference points should be defined. Moreover, wider angle lens may be preferred, source of the light may be improved and infrared film may be used to improve the method.

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## DEMOGRAPHIC STRUCTURE OF EARLY STAGES OF *ENGRAULIS ENCRASICOLUS* AND *SARDINELLA* AURITA AND WATER MASS CIRCULATION IN THE SOUTHERN CATALAN SEA

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## Abstract

The demographic structure of the early stages of anchovy (*E. encrasicolus*) and round sardinella (*S. aurita*) in the southern Catalan sea in late June 2005 were analysed and results discussed based on the hydrographic situation. Contrasting to previous studies, distribution patterns showed an important overlap, with most of the larvae of both species located between the coast and the 200 m isobath (horizontal pattern) and between the surface and 30 m (vertical pattern).

Keywords : Ichthyoplankton, Larvae, Spawning, Circulation, Western Mediterranean.

The stratified summer period is the main spawning season for anchovy (*E. encrasicolus*) and round sardinella (*S. aurita*) in the NW Mediterranean [1]. Previous studies have documented that their eggs and larvae have different distribution patterns [2]. The present work investigates the conspicuous overlapping distributions observed in June 2005 throughout the analysis of the demographic structure of their early stages and the hydrographic situation. Horizontal egg and larval distributions of the anchovy and round sardinella, as well as microzooplankton biomass presented the highest concentrations over the continental shelf (<200 m) (Fig. 1).



Fig. 1. Egg distributions and ADCP currents at 17 m depth.

A sharp decrease in egg abundance was observed in both species from stations located at <100 m isobath to those located beyond the shelf break (>200 m) (77% of anchovy eggs and 97% of round sardinella eggs were found inshore of 100 m isobath). Although larvae exhibit a wider inshore-offshore distribution, the pattern of abundance also exhibits the highest concentrations in the coastal band (56% of anchovy and 77% of round sardinella).

An increase in the modal size class was evident from the first to the second group of stations, while mode and size range was maintained in the shelf break stations.

The weak SW surface current velocities on the continental shelf could explain this slight cross-shelf larval displacement, but the strong current at the shelf break region (sometimes reaching the maximum values characteristic of this current [3]) could prevent further dispersal.

This coastal pattern for anchovy eggs and larvae is in opposition to the general trends for the species in the region, in which spawning occurs mainly in the shelf break zone and secondary modal size classes of larger larvae appear offshore-wards [1]. The conspicuous overlapping distributions of the two species, together with the similar size structure of their larvae in the different sectors, imply that, under the environmental situation found in June 2005, larvae had to share the available food resources. The fact that the main microzooplankton biomass was also coincident with the main larval distributions would work in favour of survival likelihood of larvae of these species.

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## APERÇU ÉCOLOGIQUE SUR LE ZOOPLANCTON DES EAUX DE LA MER NOIRE SITUÉS AU-DESSUS LE CHAMP A *PHYLLOPHORA* (29.07-01.08.2006)

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## Résumé

Some data, based on 11 quantitative zooplankton samples performed in summer 2006 during the cruise of "Akademik" (Bulgaria) in the water column above the *Phyllophora* belt from the Black Sea, are given in the paper. Great density values (2058-2708 ex  $m^{-3}$ ) are common in the deeper zone, where also the biological diversity is higher (14-15 species). There were identified 20 taxa, *Noctiluca scintilans* followed by *Acartia clausi, Paracalanus parvus*, Bivalvia larvae and *Oikopleura dioica* being characteristic for the studied area. *Mots clès : Biodiversity, Black Sea, Zooplankton*.

Une importante caractéristique qui concerne à la mer Noire son statut d'unicité hydrobiologique est l'ainsi nommé champ à *Phyllophora* du Zernov, en effet la biocénose du circalitoral *Mytilus-Phyllophora-Lithothamnion*, dont la surface se réduit de nos jours dramatiquement, dû à l'eutrophisation [1].

On a fait l'étude du zooplancton des eaux au-dessus le champ à *Phyllophora* analysant 11 échantillons qualitatifs prélevés avec un filet à traction verticale avec la maile du tissu filtrant de 90  $\mu$ , durant la croisière du bateau de recherche bulgare "Akademik". On a conservé les organismes par une solution de formaldéhyde (4%). Le triage s'est accompli avec un stéréomicroscope Nikon SMZ-2T et un microscope Nikon E200. On exprime les données de densité (D) en nombre d'exemplaires rapportés à un mètre cube d'eau (ex<sup>-m-3</sup>).

On a identifié 20 organismes zooplanctoniques, dont 15 sont holoplanctoniques, les autres méroplanctoniques (25%) [tableau 1].

Tab. 1. Structure qualitative et quantitative du zooplancton des eaux de la mer Noire au dessus le champ à Phyllophora (29.07-01.08.2006) (F% = fréquence; A = abondance;  $D_{moy}/D_{eco}$ = densité moyenne/ écologique; D%= dominance; W = indice de signifiance écologique;  $R_{kD}$  = rang selon les valeurs de densités).

|                                                | F%     | AD    | DAVG    | DECO    | D%    | W     | RkD |
|------------------------------------------------|--------|-------|---------|---------|-------|-------|-----|
| Flagellata                                     |        |       |         |         |       |       |     |
| Noctiluca scintilans (Macartney) Kofoid -Swezy | 100,00 | 23612 | 2146,51 | 2146,51 | 82,38 | 90,77 | 1   |
| Ciliophora                                     |        |       |         |         |       |       |     |
| Favella ehrenbergi(Clapared & Lachmann)        | 63,64  | 21    | 1,92    | 3,02    | 0,07  | 2,17  | 13  |
| Ctenophora                                     |        |       |         |         |       |       |     |
| Pleurobrachia rhodopis Chun                    | 36,36  | 14    | 1,27    | 3,50    | 0,05  | 1,33  | 16  |
| Rotatoría                                      |        |       |         |         |       |       |     |
| Synchaeta littoralis Rousselet                 | 63,64  | 285   | 25,88   | 40,66   | 0,99  | 7,95  | 7   |
| Chaetognatha                                   |        |       |         |         |       |       |     |
| Sagitta setosa (O.F.Müller)                    | 81,82  | 147   | 13,40   | 16,38   | 0,51  | 6,49  | 9   |
| Larvae Polychaeta (nectochaeta)                | 81,82  | 174   | 15,82   | 19,33   | 0,61  | 7,05  | 8   |
| L. Mollusca (Bivalvia) (veligera)              | 100,00 | 344   | 31,27   | 31,27   | 1,20  | 10,96 | 4   |
| L. Mollusca (Gasteropoda) (veligera)           | 90,91  | 80    | 7,27    | 7,99    | 0,28  | 5,04  | 11  |
| Arthropoda                                     |        |       |         |         |       |       |     |
| Larvae Balanus improvisus Darwin (nauplia)     | 45,45  | 24    | 2,18    | 4,80    | 0,08  | 1,95  | 14  |
| Penilia avirostris Dana                        | 90,91  | 250   | 22,73   | 25,00   | 0,87  | 8,91  | 6   |
| Pleopis polyphemoides (Leuckart)               | 27,27  | 16    | 1,44    | 5,30    | 0,06  | 1,23  | 18  |
| Pseudoevadne tergestina Claus                  | 36,36  | 24    | 2,18    | 5,98    | 0,08  | 1,74  | 15  |
| Evadne spinifera P.E. Müller                   | 45,45  | 140   | 12,74   | 28,03   | 0,49  | 4,71  | 12  |
| Acartia clausi Giesbrecht                      | 100,00 | 2101  | 190,96  | 190,96  | 7,33  | 27,07 | 2   |
| Paracalanus parvus Claus                       | 81,82  | 898   | 81,68   | 99,83   | 3,13  | 16,02 | 3   |
| Pseudocalanus elongatus (Boeck)                | 9,09   | 4     | 0,40    | 4,39    | 0,02  | 0,37  | 19  |
| Centropages kroeryi var. pontica Karawajev     | 36,36  | 234   | 21,26   | 58,46   | 0,82  | 5,45  | 10  |
| Oithona similis Claus                          | 27,27  | 17    | 1,52    | 5,59    | 0,06  | 1,26  | 17  |
| Larvae Decapoda                                | 9,09   | 2     | 0,18    | 2,00    | 0,01  | 0,25  | 20  |
| Chordata                                       |        |       |         |         |       |       |     |
| Oikopleura dioica                              | 90,91  | 274   | 24,86   | 27,35   | 0,95  | 9,31  | 5   |

Dans la région centrale de la surface investiguée, plus profonde (38-51 m) que celle de la périphérie, la diversité taxonomique est plus grande (14-15 espèces), lui correspondant aussi des hautes valeurs de la densité (2058-2708 ex m<sup>-3</sup>), comparables à celles déterminées pour le pelagial des côtes roumaines [2]. Les valeurs extrêmes (732 ex m<sup>-3</sup> en B1 et 6379 ex m<sup>-3</sup> en D7) on été calculées pour les station marginales, situation bien illustrée par les valeurs de la similarité entre les stations [figure 1].



Fig. 1. Similarité entre les stations d'échantillonnage du zooplancton audessus le champ à *Phyllophora* (29.07-01.08.2006).

Selon les valeurs de l'indice de signifiance écologique, *Noctiluca scintilans* est l'espèce caractéristique de la communauté zooplanctonique étudiée, suivie par les copépodes *Acartia clausi* et *Paracalanus parvus*, les larves veligeres de bivalves et *Oikopleura dioica*.

On peut conclure que la communauté zooplanctonique des couches d'eau au-dessus du champ à *Phyllophora* présente une diversité taxonomique remarquable (20 espèces), dont *Noctiluca* est le taxon caractéristique, indiquant la présence d'une grande quantité de matière organique en suspension.

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## MACRO-EPIBENTHIC ASSEMBLAGES ON THE TRAWLING GROUNDS ALONG THE SHALLOW CONTINENTAL SHELF OFF THE BALEARIC ISLANDS (WESTERN MEDITERRANEAN)

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## Abstract

The contents of 183 experimental bottom trawl hauls off the Balearic Islands at depths of 38 to 255 m were analyzed. The macro-epibenthic species assemblages of the shallow and deep shelf appear well separated. On the shallow shelf, soft red algae bottoms had a much higher biomass of non commercial species, mostly echinoderms, than maërl beds and sandy-muddy bottoms. *Keywords : Algae, Biomass, Trawl Surveys, Continental Shelf, Balear Islands.* 

## Introduction

Red algae dominate soft bottoms fishing grounds on the shallow shelf off the Balearic Islands [1, 2]. It is assumed that this habitat may be the source of much of the discards reported by the trawl fisheries [3]. The present study characterizes the macro-epibenthic assemblages and their commercial and non-commercial species.

## Materials and methods

The present work analyzed data collected during the BALAR surveys (2001 - 2005) on the continental shelf off the Balearic Islands (38 to 255 m). Sampling scheme and gear were identical to the MEDITS surveys. Biomass and abundance were based on the swept area method. Cluster, MDS and similarity percentage (SIMPER) were used to analyze the data. ANOVA was applied to test for differences between mean biomass of macro-epibenthic assemblages.

#### Results

A total of 183 hauls were analyzed. Cluster and MDS analyses of demersal resources (individuals/km<sup>2</sup>) and macro-epibenthic species biomass (kg/km<sup>2</sup>) separated hauls carried out on the shallow shelf (between 38-96 m and 38-91 in both analyses, respectively) from those on the deep shelf (between 79-255 m and 90-255 m, respectively) at very low levels of similarity (15 and 25%, respectively). Cluster and MDS analysis of macro-epibenthic species yielded three groups on the shallow shelf at 30-35% of similarity. A SIMPER analysis identified three macro-epibenthic assemblages:

- Soft Red Algae bottoms (SRA), with the highest biomass indices, dominated by the echinoderms *Spatangus purpureus* and *Astropecten aranciacus*, the algae *Codium bursa*, *Phyllophora nervosa* and Corallinacea, the ascidian *Ascidia mentula* and the sponge *Suberites domuncula*. Other important species within this group were the alga *Peysonellia squamaria*, the echinoderms *Echinaster sepositus*, *Stichopus regalis* and *Sphaerechinus granularis*, the ascidians *Phallusia mammillata*, *Microcosmus vulgaris* and *Diazona violacea*, and the crustacean *Dardanus arrosor*.

- Maërl Beds (MB), dominated by Corallinacea. Other important species were *S. domuncula*, *A. mentula*, *D. arrosor* and *D. violacea*, the echinoderms *Luidia ciliaris*, *S. purpureus*, *A. aranciacus* and *E. sepositus*, and the alga *Laminaria rodriguezii*.

- Sandy-Mud bottoms (SM) with the lowest biomass indices and very low biomass of red algae.

The biomass of non-commercial species were higher ( $F_{2,75}$ = 48.78 p<0.001) in SRA bottoms (10535±2534 kg/km<sup>2</sup>) than in MB (1377±452 kg/km<sup>2</sup>), or SM bottoms (519±96 kg/km<sup>2</sup>). No significant differences were found for commercial species yields, 935±88, 801±181, 689±124 kg/km<sup>2</sup> respectively. The average composition of the hauls is detailed on Table 1.

#### Discussion

The trawl fishery off the Balearic Islands often operates on SRA bottoms, consisting of *Peysonellia* spp. in the basal layer (and lower biomass of Corallinacea) and *Phyllophora nervosa* in the erect stratum [1, 2]. Invertebrates, mainly echinoderms (up to 52%), and rodophyte algae constitute much of the high percentage of discards reported for the trawling fleet operating on the shallow shelf [3]. These bottoms presented the highest biomass of non-commercial species. Although the commercial fraction showed different compositions for the three types of bottoms examined, no significant differences were found for the mean biomass of commercial species, which highly increases the percentage of the non-commercial fraction on SRA bottoms. The analysis confirms that the exploitation of

SRA bottoms, which have been considered of special importance in other areas [4, 5], results in the removal of large amounts of non-commercial biomass, without increasing commercial yields. A responsible ecosystembased management of the shallow shelf trawl fishery off the Balearic Islands should take those results into account.

Tab. 1. Average composition (% of the biomass  $\pm$ S.E) of commercial and non-commercial fractions from hauls corresponding to each macro-epibenthic assemblage. SRA: Soft red algae bottoms; MB: Maërl beds; SM: Sandy-mud bottoms.

| Commercial          | SRA           | MB                | $\mathbf{SM}$    |
|---------------------|---------------|-------------------|------------------|
| Cephalopod molluscs | 25.1±3.1      | 43.3±6.6          | 26.1±4.1         |
| Decapod crustaceans | $0.2 \pm 0.2$ | $0.3 \pm 0.4$     | $0.6 \pm 0.4$    |
| Chondrichthyes      | 30.4±2.9      | 26.7±2.2          | 25±5.5           |
| Teleosts            | 44.3±2.7      | 29.7±5.2          | 48.3±6.7         |
| Non-comercial       | SRA           | MB                | $_{\rm SM}$      |
| Algae               | 34.9±4.7      | 63.3±10.1         | 22.2±5.6         |
| Posidonia oceanica  | $2.8 \pm 2.5$ | 10 <del>0</del> 1 | 20 <del>10</del> |
| Sponges             | $1.6 \pm 0.4$ | $5.4 \pm 0.9$     | $8.8 \pm 2$      |
| Cnidarians          | $0.2 \pm 0.1$ | $0.1{\pm}0.1$     | $0.3 \pm 0.1$    |
| Molluscs            | 777           | $0.4 \pm 0.3$     | $0.2 \pm 0.1$    |
| Crustaceans         | $1.1 \pm 1.1$ | $0.4 \pm 0.2$     | $1.6 \pm 0.7$    |
| Echinoderms         | 52.2±5.4      | 13.1±7.7          | 32.3±5.7         |
| Ascidians           | $5.2 \pm 1.1$ | $10.3\pm5.8$      | 15.3±4.4         |
| Chondrichthyes      | $0.9 \pm 0.4$ | $6.4 \pm 4.8$     | 4.2±5.8          |
| Teleosts            | $1.0 \pm 0.5$ | $0.5 \pm 0.4$     | $14.6 \pm 4.8$   |
| Other invertebrates | -             | $0.1 {\pm} 0.1$   | 0.5±0.3          |

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## SPAWNING PERIOD AND SEXUAL MATURITY OF SYMPHODUS CINEREUS (TELEOSTEI, LABRIDAE) IN THE GABES GULF (TUNISIA)

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## Abstract

In this paper, we studied for the first time in Tunisia the spawning period and the sexual maturity of the Gray wrasse *Symphodus cinereus* in the Gabes gulf. The monthly evolution of the gonado-somatic index GSI, liver-somatic index LSI, and conditional factor K, showed that the spawning period of the Grey wrasse in the Gabes gulf occurs from April to June. The length at 50% of sexual maturity,  $L_{50}$ , was 8.3 cm for males and 7.0 cm for females.

Keywords : Gulf Of Gabes, Spawning, Teleostei.

## Introduction

The Grey wrasse *Symphodus cinereus* was one among the twelve species of wrasses in Tunisia waters [1]. In the Gabes gulf this species is mainly caught by the artisanal fishing gears in spring. In this area, the biology of the wrasses was carried out for the first time [2]. In this work we present data on its spawning period and estimate the size at first sexual maturity.

#### Material and methods

The present study is based on 679 individuals, 534 males and 145 females, having a total length between 6.6 and 13.8 cm. Each individual was weighed for total weight, gonad and liver weight, and its total length was measured. The degree of sexual maturity was estimated. The spawning period was determined by analyzing the monthly evolution of the gonado-somatic index GSI. The liver-somatic index LSI and the condition factor K were also calculated. The degree of maturity was determined after macroscopic observation of the gonads. The percentage of mature specimens by sex was calculated for each size class and the size at first maturity,  $L_{50}$ , was determined using the logistic function [3] which was fitted to the observed data using the software 'FSAS' and the Maquardt non-linear adaptation [4].

#### Results and discussion

The evolution of the GSI, LSI and K showed that *Symphodus cinereus* reproduction takes place from Junuary to June. Gonad maturation took place from Junuary to April; spawning occurred in April, May and June, while sexual resting extended from July to October (Figure 1). At the beginning of the gonad maturation, LSI is decreasing. This can be explained probably by the use of the liver reserves for developing its gonads.



Fig. 1. Monthly evolution of GSI, LSI and K for the female *Symphodus* cinereus.

 $L_{50}$  was estimated equal to 8.4 cm for males and 7 cm for females. The coefficients of the logistic function were: males, a = 0.958; b = 8.013; females, a = 0.592; b = 7.926.

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## NOTES ON THE ERYTHREAN ALIEN FISHES OF DATÇA-BOZBURUN PENINSULA - A SPECIALLY PROTECTED AREA IN THE SOUTH EASTERN AEGEAN SEA (TURKEY)

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## Abstract

Fourteen alien fish of Red Sea origin are reported from Datça-Bozburun Peninsula (SE Aegean Sea, Turkey). Their biology and ecology were explored by underwater visual surveys and interviews with local fishermen. We report the first records of *Etrumeus teres* and *Apogon pharaonis*, and the second occurrence of *Pteragogus pelycus* off the Turkish coast of the Aegean Sea. *Keywords : Aegean Sea, Species Introduction.* 

This study is based on the project "Coastal and Marine Biological Diversity Assessment of Datça-Bozburun Specially Protected Area" [1]. The survey of Erythrean alien fish species was carried in 5 sub-regions specified along the Specially Protected Area (SPA) [Fig.1].



Fig. 1. Datça-Bozburun SPA is situated in the southwestern Anatolia.

The presence of 14 alien fish of Red Sea origin was determined by means of underwater visual assessment and interviews with local fishermen.

1) Etrumeus teres (DeKay, 1848): not observed during dives.

2) Saurida undosquamis (Richardson, 1848): not observed during dives.

3) Atherinomorus lacunosus (Forster in Bloch & Schneider, 1801): one of the most common species, preyed upon by another Red Sea alien, *Fistularia commersonii*. Large schools were observed while snorkeling at the depths of 1 to 2 m. 4) *Sargocentron rubrum* (Forsskål, 1775): one of the most common species, encountered in small groups of 5-10 individuals among rocks and in caverns at depths of 15-40 m. It shares that habitat with *Apogon imberbis*, an indigenous species.

5) *Fistularia commersonii* Rüppell, 1835: first recorded from the Datça-Bozburun Peninsula on 17.5.2002, from Selimiye Bay (III). Solitary or small groups of up to 10 individuals were observed to a maximum depth of 20 m. *F. commersonii* was observed changing its colour patterns and staying motionless while waiting to prey on *A. lacunosus* schools.

6) *Apogon pharaonis* Bellotti, 1874: first recorded from the Datça-Bozburun Peninsula on 11.9.2002, from east of Kocaada Island (III). *A. pharaonis* was mostly observed in turbid waters near fish farms or dockyards.

7) *Alepes djedaba* (Forsskål, 1775) was not observed during dives but its eggs were found in the ichthyoplankton survey [1].

8) *Upeneus moluccensis* (Bleeker, 1855): its eggs were recorded in June and September ichthyoplankton surveys [1]. *U. moluccensis* and the indigenous *Mullus surmuletus* were observed feeding in the same area.

9) *Pempheris vanicolensis* Cuvier, 1821: groups of 10-15 individuals were observed in caverns.

10) *Pteragogus pelycus* Randall, 1981: first recorded from the Datça-Bozburun Peninsula on 16.9.2002, in waters off Bozburun village (II). Solitary individuals were generally seen swimming in and around *Posidonia oceanica* meadows.

11& 12) Siganus luridus Rüppell, 1828, and Siganus rivulatus Forsskål, 1775: The most common species, generally recorded in mixed groups of 10-20 individuals at depths between 2-30 m. Juveniles were seen together with adults at 2-8 m. Both species were observed feeding on algae in rocky areas and on epiphytic algae off *Posidonia oceanica* leaves and *Cystoseira* spp., together with the indigenous *Diplodus vulgaris*, *Diplodus sargus*, *Symphodus tinca* and *Sparisoma cretense*. Interviews with fishermen revealed that siganids are target species for the local artisanal fishery and constitute its main catch between May and October.

13) Scomberomorus commerson (Lacepède, 1800) (no sample obtained):

a rare species seen only in Yeşilova Bay(II). Local fishermen indicated that, *S. commerson* populations have declined sharply in 2005 due to over-exploitation between 2000-2004.

14) Stephanolepis diaspros Fraser-Brunner, 1940: mostly solitary individuals were seen at a depth range of 10-20 m.

Tab. 1. Observation notes on the alien fish species of Red Sea origin(a: purse seine, b: gill net, c: hand net).

|                                    |            | Mat<br>Exar | erial<br>nined |             | Underwater<br>Observations |                       |               |  |
|------------------------------------|------------|-------------|----------------|-------------|----------------------------|-----------------------|---------------|--|
| ERYTHREAN<br>ALIEN FISH<br>SPECIES | No of spm. | TL<br>(mm)  | Fish.<br>Gear  | Location    | Freq.<br>(%)               | Depth<br>Range<br>(m) | Location      |  |
| E. teres                           | 40         | 107-145     | а              | III, IV     | -                          | -                     | -             |  |
| S. undosquamis                     | 4          | 209-250     | a,b            | III, IV     |                            | <u> </u>              | -             |  |
| A. lacunosus                       | 5          | 93-100      | а              | III, IV     | 30,8                       | 1-2                   | 1,11,111,1V,V |  |
| S. rubrum                          | 4          | 106-140     | a,b            | III, IV, V  | 27,8                       | 15-40                 | 1,11,111,1V,V |  |
| F. commersonii                     | 4          | 591-748     | a,b            | III, IV, V  | 12,7                       | 3-20                  | 1,11,111,1V,V |  |
| A. pharaonis                       | 1 jvl.     | 27          | С              |             | 0,58                       | 5-6                   | 11, 111, IV   |  |
| A. djedaba                         | 2          | 105-118     | а              | III, IV     | -                          |                       | -             |  |
| U. moluccensis                     | 8          | 95-129      | a,b            | III, IV     | 0,58                       | 10-20                 | ,             |  |
| P. vanicolensis                    | 2          | 103-157     | b              | III, IV, V  | 0,58                       | 1-2                   | 1,111,1V,V    |  |
| P. pelycus                         | -          | -           |                | -           | 0.87                       | 6-15                  | ,             |  |
| S. luridus                         | 202        | 135-221     | b              | 11,111,1V,V | 67,2                       | 2-30                  | 1,11,111,1V,V |  |
| S. rivulatus                       | 84         | 86-222      | a,b            | II,III,IV,V | 67,9                       | 2-30                  | 1,11,111,1V,V |  |
| S. commerson                       | -          | -           |                | -           | 0,29                       | 15-25                 |               |  |
| S. diaspros                        | 3          | 98-212      | a,b            |             | 0,96                       | 10-20                 | I, II, IV     |  |

*E. teres*, *A. pharaonis* and *P. pelycus* are rarely encountered in the studies carried out along the Aegean Sea coasts. The first records of these species in Aegean waters were from Rhodes Island (SE Aegean Sea-Greece) [2,3,4]. The presence of *P. pelycus* along the Turkish coasts of the Aegean Sea is mentioned in [5] as personal observation, without giving a specific reference. In 2005 it was recorded for the first time from Gökova Bay (SW Aegean Sea-Turkey) [6].

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## ON THE RANGE EXTENSION TWO EXOTIC DECAPOD CRUSTACEAN ALONG THE LEVANT SEA COAST OF TURKEY

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## Abstract

The decapods of Fethiye bay, on the southwestern coast of Turkey were collected by gill net between 2004 and 2006. For two exotic decapod crustaceans, *Melicertus hathor* and *Charybdis hellerii*, the records constitute significant extension of their range. *Keywords : Decapoda, Crustacea, Red Sea, Levantine Basin.* 

31 species of exotic decapods are known to occur along the Turkish coast [1,2], most are found along the southeastern coast. In recent years many species extended their range westwards along the Turkish coast [3]. of Fethiye bay, on the southwestern coast of Turkey were collected by gill net at depths between 3-20 m, between 2004 and 2006. Two species of Red Sea origin were found, both new record for Fethiye Bay, and a significant range extensions within Turkey.

*Melicertus hathor* (Burkenroad, 1959) was recorded for the first time in the Mediterranean Sea from the coast of Israel [4]. The first Turkish record was collected in Yumurtalik Bight [5], and subsequently off Kaş Peninsula [6], and Antalya Bay [7]. The two male specimens (TL 15.2, 15.8 mm) were collected on sandy bottom from the Fethiye Bay.

The records of *Charybdis hellerii* (A. Milne Edwards, 1867) in Turkey were collected off Iskenderun and Mersin [8,9], and Kaş Peninsula [6]. In September 2004, *C. helleri* was collected off Göcek. The Göcek specimens (1 male CL 56 mm, 5 females CL55-61 mm) were fully developed adults, 4 of 5 females were ovigerous. The eggs were bright yellow in color, their diameter 0.224 - 0.266 mm. The minimum, maximum and average number of the eggs from 4 ovigerous females of *C. hellerii* were examined as 42016, 93913, 106994, 152583 and 98876 respectively. In 2006 the species was widespread in the region. This is the westernmost record of *C. hellerii* along the Turkish coast, and nearly 450 km west of the previous record. *C. hellerii*, like *C. longicollis*, occupies the entire Levantine coast of Turkey. It seems that the habitat preferences, spawning period, egg number and egg diameter do not differ significantly from known records for *C. hellerii*, though the maximum carapace length of both species is very close to the highest values of the early reports.



Fig. 1. Distribution of *Charybdis helleri* and *Melicertus hathor* in Turkish coast. (Star: *Charybdis helleri*; Point: *Melicertus hathor*).

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## ABUNDANCE OF ZOOBENTHIC EXOTIC SPECIES ON ROCKY REEFS IN THE SOUTHERN AEGEAN SEA

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## Abstract

In order to provide information on the abundance of the zoobenthic exotic species on the rocky reefs in the southern Aegean Sea, samplings were carried out between August 2003 and May 2004. The examination of the 2294 macrozoobenthic specimens collected revealed the presence of ten exotic species among 211 species. The abundance and distributional details of these species are discussed. *Keywords : Aegean Sea, Eastern Mediterranean, Zoobenthos.* 

## Introduction

The Aegean Sea, as part of the Mediterranean Sea, is characterized by numerous islands and islets. Its complicated geomorphology, including caves, reefs etc., creates a high habitat diversity, which leads to high species diversity [1]. The present research aimed to determine the abundance and distribution of the established exotic species on rocky reefs which are partially the most untouched and remote habitats in the southern Aegean Sea.

#### Materials and Methods

This research was carried out between August 2003 and May 2004, in the southern Aegean Sea by SCUBA diving. A total of 80 samples were taken, seasonally, from four depth levels and six stations (Figure1). 400 cm<sup>2</sup> quadrates were sampled, including both sessile and motile species. All samples were sieved through 0.5 mm screens, labeled and preserved in 4% formalin. After the sorting process, the macrofauna was counted and identified at species level.



Fig. 1. Study area indicating sampling sites.

## Results

The examination of the 2294 macrozoobenthic specimens collected revealed the presence of ten exotic species among 211 species (127 molluscs, 9 sponges, 59 crustaceans, 16 echinoderms) [2]. The most abundant (44.2%) and dominant taxon in terms of species richness (46.9%) was Gastropoda on the reefs. Among the total of 99 Gastropod species with an average abundance of 317 individuals/m<sup>2</sup>, there were 5 exotic species with the average abundance of 34,25 ind/m<sup>2</sup>, that comprised mainly by *Strombus persicus* (Table1). The highest amphipod abundance (843,75 ind/m<sup>2</sup>) was found at the depth of 10 m, where there were dense *Cystoseira* canopies, and the abundance decreased with depth. Among 30 amphipod species, the exotic species, *Stenothoe gallensis* constituted 7,1% of the amphipod abundance at 10m.

## Discussion

The present study reports ten exotic species. These species are recognizing as established Lessepsien invaders that entered the Mediterranean Sea through the Suez Canal [3,4,5,6,7]. Among them, *Strombus persicus* was a keystone species that was common and dominant in all stations, seasons and depths. This species occurs in very dense numbers in the Eastern Mediterranean, where it is a major competitor for herbivorous species [8].

| Tab.  | 1.   | The  | abundance | of the | exotic | species | at four | depth | levels | on t | he |
|-------|------|------|-----------|--------|--------|---------|---------|-------|--------|------|----|
| rocky | / re | efs. |           |        |        |         |         |       |        |      |    |

| TAXA                                  | 10 m                      | 20 m                      | 30 m                     | 40 m                      |
|---------------------------------------|---------------------------|---------------------------|--------------------------|---------------------------|
| AMPHIPODA                             | 843,75 ind/m <sup>2</sup> | 65 ind/m <sup>2</sup>     | 18,75 ind/m <sup>2</sup> | 23,75 ind/m <sup>2</sup>  |
| Stenothoe gallensis Walker, 1904      | $60 \text{ in d/m}^2$     | $1 \text{ in d/m}^2$      | 1 <del>1</del>           | (10)                      |
| DECAPODA                              | 63,75 ind/m <sup>2</sup>  | 38,75 ind/m <sup>2</sup>  | 32,5 ind/m <sup>2</sup>  | 22,5 ind/m <sup>2</sup>   |
| Thalamita poissonii (Audouin, 1826)   | 121                       |                           | 12                       | $1 \text{ ind/m}^2$       |
| GASTROPODA                            | 267,5 in d/m <sup>2</sup> | 286,25 ind/m <sup>2</sup> | 517,5 ind/m <sup>2</sup> | 196,25 ind/m <sup>2</sup> |
| Cerithiopsis pulvis (Issel, 1869)     | 1.7                       | $3 \text{ in d/m}^2$      | $4 \text{ in d/m}^2$     | $4 \text{ ind/m}^2$       |
| Cerithium scabridum Philippi, 1848    | $4 \text{ ind/m}^2$       | <del></del>               | -                        | ((=))                     |
| Ergalatax obscura (Houart, 1996)      | $1 \text{ in d/m}^2$      |                           | $1 \text{ in d/m}^2$     | (2)                       |
| Pyrunculus fourierii (Audouin, 1826)  | 31 <u>4</u> 1             | <u>14</u>                 | $1 \text{ in d/m}^2$     | -                         |
| Strombus persicus Swainson, 1821      | $71 \text{ ind/m}^2$      | $31 \text{ ind/m}^2$      | $13 \text{ in d/m}^2$    | $4 \text{ ind/m}^2$       |
| BIVALVIA                              | $35 \text{ in d/m}^2$     | 61,25 ind/m <sup>2</sup>  | 47,5 ind/m <sup>2</sup>  | 32,5 ind/m <sup>2</sup>   |
| Malvufundus regula (Forsskal, 1775)   | ( <del>1</del> )          | $3 \text{ ind/m}^2$       | $1 \text{ in d/m}^2$     | (H)                       |
| Pinctata radiata (Leach, 1814)        | $6 \text{ ind/m}^2$       | 6 ind/m <sup>2</sup>      | $3 \text{ in d/m}^2$     | $4 \text{ ind/m}^2$       |
| ECHINODERMATA                         | 87,5 ind/m <sup>2</sup>   | 23,75 ind/m <sup>2</sup>  | 8,75 in d/m <sup>2</sup> | $65 \text{ ind/m}^2$      |
| Synaptula reciprocans (Forskal, 1775) | $4 \text{ in d/m}^2$      | $4 \text{ in d/m}^2$      | $1 \text{ in d/m}^2$     | 553                       |

Rocky reefs play an important role for migrant species by extending their distribution in the high sea by facilitating the larval dispersal and settlement. This is also relevant for exotic species. Thus, long-term approaches are required to monitor of the exotic species in proportion to local and endemic species and to document the displacement and replacement events. Acknowledgements - The present work was supported by the Research Fund of Istanbul University, Project No. T-321/03112003. The authors thank to Prof.Dr. Tuncer Katağan, Prof.Dr. Henk K. Mienis, Assoc.Prof.Dr. Bilal Öztürk, Assist.Prof.Dr. Bülent Topaloğlu, Assist.Prof.Dr. Fevzi Kirkim, Assist.Prof.Dr. Murat Sezgin, Dr. Ayaka Amaha Öztürk and Mr. Doğan Çeviker.

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## ADDITION TO THE KNOWLEDGE OF TURKISH MOLLUSC FAUNA

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## Abstract

The present study reports 15 new mollusc records for the Turkish mollusc fauna. Samples were collected along the Turkish Aegean and Levantine coasts, at depths 0-200 m, between 2000 and 2005. Among the established species, *Tiberia minuscula* Monterosato, 1880, is also reported for the first time from the Aegean Sea. In this study, ecological remarks on the established species are presented. *Keywords : Mollusca, Aegean Sea, Levantine Basin.* 

### Introduction

Nearly 2000 mollusc species are known from the Mediterranean Sea, 745 of which were reported from Turkish seas (1). In recent years additional records were added (2, 3, 4, 5 and 6), and the number of species is estimated at over 800. In the present study, 15 mollusc species are reported for the first time from Aegean and Levantine coasts of Turkey.

#### Materials and methods

The samples were collected along the Turkish Levantine and Aegean coastline in the framework of various studies conducted between years 2000 and 2005 with different purposes. The sampled material was taken at depths ranging from 0 to 200 m. The specimens are deposited at the museum of the Faculty of Fisheries, Ege University, Turkey (ESFM).

## Results and discussion

As a result of our studies, 15 new records to Turkish Seas (14 gastropods and a bivalve) (Table 1) were identified of which 7 species are from northern Aegean Sea, 2 species are from southern Aegean Sea, 3 species are both from northern and southern Aegean Sea and 3 species are from Levantine Sea.

Tab. 1. The list of mollusc species determined as new records and some of their ecological characteristics and the regions where they are established: \* Levantine Sea, \*\*Northen Aegean Sea, \*\*\* Southern Aegean Sea, \*\*\*\* Aegean Sea (total)

| Species                                              | Depth<br>(m)      | Habitat                   | Ind.        |
|------------------------------------------------------|-------------------|---------------------------|-------------|
| GASTROPODA                                           |                   |                           |             |
| **Bittium lacteum (Philippi, 1836)                   | 46                | Sand+corralligen          | 2           |
| *Alvania fractospira Oberling, 1970                  | 5                 | P. oceanica               | 1           |
| **Nodulus contortus (Jeffreys, 1856)                 | 0.5               | Padina pavonica           | 10          |
| ***Monophorus erytrosoma (Bouchet & Guillemot, 1978) | 13                | P.oceanica + sand         | 2           |
| **Aclis attenuans Jeffreys, 1883                     | 94                | sandy mud                 | 2           |
| **Graphis albida (Kanmacher, 1798)                   | 105               | muddy sand                | 1           |
| ****Parvioris ibizenca (Nordsieck, 1968)             | 6-15              | P.oceanica+sand           | 8           |
| **Microdrillia loprestiana (Calcara, 1841)           | 115<br>195<br>169 | muddy sand<br>clay<br>mud | 2<br>2<br>3 |
| **Raphitoma atropurpurea (Locard & Caziot, 1900)     | 41                | sand                      | 1           |
| ***Mathilda gemmulata Semper, 1865                   | 9                 | P. oceanica+sand          | 1           |
| **Tiberia minuscula Monterosato, 1880                | 160               | sandy mud                 | 1           |
| *Crenilabium exile (Jeffreys, 1870)                  | 7                 | muddy sand                | 1           |
| ****Japonacteon pusillus (McGillivray, 1843)         | 160<br>194<br>169 | sandy mud<br>mud<br>mud   | 1<br>2<br>1 |
| **Ascobulla fragilis (Jeffreys, 1856)                | 44                | sandy mud                 | 1           |
| BIVALVIA                                             |                   |                           |             |
| *Mytilaster solidus Monterosato, 1883                | 0-1               | On rocky substrata        | ~ 5000/m    |

Among the new records, *T. minuscula* is being reported for the first time from the Aegean Sea, which seems to be a new report also for the eastern Mediterranean according to literature. In addition, *Dizoniopsis coppolae* (Aradas, 1870) has also been found in this study. A total of 9 individuals of this species were sampled from Salih Island coast, near Bodrum (Southern Aegean Sea), obtained from *P. oceanica* and sand mixture dredged from a depth of 13 m. *D. coppolae* was reported from the Turkish coasts only once, from the Sea of Marmara (7).

In the last two decades, parallel to the increasing number of researches carried out, the mollusc species known from Turkish coasts was also increased. On the other hand, a rapid increasing of the rate of alien species known from Turkish seas is another remarkable point as a result of these studies. For example, according to the addendum given by (8), 90 alien

mollusc species are recently known from Turkish coasts, of which the majority (84 species) were reported from Levantine coast of Turkey. It should not be neglected that the monitoring of these species (both settled and potential settlers) incoming the region by various pathways is of great importance, in order to determine their probable negative effects on time in the ecosystem where they have been settled, even they make contribution to the biological richness of the region and no evident negative effect to the native fauna has been reported to date.

#### Acknowledgement

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## LITTER AS A SOURCE OF HABITAT ISLANDS ON DEEP WATER MUDDY BOTTOMS

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## Abstract

Certain types of marine litter, usually considered as pollutants, may also be a resource, serving as artificial reefs on sedimentary bottoms. In order to study this aspect, marine debris was collected by bottom trawl from muddy bottoms (depths of 45-700m) in the waters around the Maltese islands, during July 2005. The associated fauna was identified and quantified. Litter was found to support a higher abundance of organisms than the surrounding sediment, but a lower species richness. However, the suite of epifaunal species on the debris was different from the infauna of the surrounding substratum. Thus litter was found to increase the overall biodiversity of particular areas. *Keywords : Metals, Plastics, Pollution, Secondary Production, Biodiversity*.

#### Introduction

Litter is usually viewed as a pollutant due to its detrimental effects, especially while still floating or suspended [1,2,3]. However, relatively inert, sunken marine litter may potentially serve as a resource for benthic fauna. Anthropogenic material may act as an artificial reef especially where hard substrata for settlement are at a premium. To explore this aspect, marine litter from sedimentary bottoms in deep water (45-700 m) around the Maltese Islands was sampled. The sessile biota associated with the different kinds of debris was identified and counted. The results obtained were compared with data on the infauna of the sediment on which the litter was settled, in order to evaluate the contribution of such deep-water debris to benthic biodiversity on these grounds.

#### Methods

Samples were collected by trawling during a research cruise on the RV *Sant' Anna* made in July 2005 as part of the ongoing MEDITS trawl survey programme [4]. Litter was gathered from 44 hauls made in deep water (45 - 700m) around the Maltese islands (Fig. 1). The debris was separated into different categories (cloth, glass, metal, plastic, pottery and sacks). For each item, the surface area was measured and any associated live macrofauna were identified and counted; abundance was then standardised per m<sup>2</sup> of litter substratum. The data were analysed using univariate and multivariate (non-metric multidimensional scaling and agglomerative, hierarchical clustering) methods.



Fig. 1. Map of the 44 sampling stations (dots) distributed around Malta.

#### Results and Discussion

The marine debris recovered consisted of 47% plastic, 13% metal, 13% glass, 4% cloth, 3% sack and 2% pottery. The biotic growth density on all litter collectively was 141 (412 s.d.) individuals per m<sup>2</sup> of litter substratum. Biota was more abundant on litter than in the surrounding sediment, where the mean density of infauna was 64 individuals per m<sup>2</sup> as estimated from 0.0625m<sup>2</sup> box core samples (DM unpublished data, 2005). However, the sediment supported a higher species richness (38 species from a collective sediment surface area of 1.88m<sup>2</sup>, DM unpublished data, 2005) than the marine debris (47 species from a collective litter surface area of 635.62m<sup>2</sup>). Nevertheless litter supported a totally different suite of fauna from that of the sediment, which would otherwise have been absent without the debris.

The mean Shannon-Wiener diversity per  $m^2$  of litter substratum was 0.14 (0.30 s.d.). This low value and high standard deviation are a result of many

litter items either without epibiota or with only one species, consequently resulting in a diversity index of zero. The associated mean Pielou's evenness measure per  $m^2$  of litter substratum was 0.7 (0.25 s.d.), calculated excluding those litter items with no growth, or with a Shannon-Wiener index of zero. Calculated thus, evenness was quite high, confirming that an overall low diversity was primarily due to several litter items being colonised by only one species. Metals and pottery items had a relatively high species richness, but both parameters were low for sacks, plastic and cloth. The exception was glass, which had a relatively high species richness but a low abundance of epifauna.

Multivariate classification of the different litter types based on species abundance data resulted in three groups: plastics and glass, pottery and metals, and sacks. This seemed related to the surface texture of each litter type. Plastic (especially bottles) and glass usually had very smooth surfaces, while metal and pottery had much rougher faces. The woven fabric of sacks had a totally different texture from all other litter types. Classification based on presence/absence of different faunal species resulted in three groups: metals, plastics and sacks, and pottery and glass. This classification may be related to the different resting position of the litter types on the seabed, and to the stability of this orientation. Sacks and plastic bags can be easily turned over by slight water movements, while metal cans and plastic bottles are highly prone to being rolled over, smothering the attached fauna. Glass bottles are heavier than both plastic containers and metal cans, therefore are less susceptible to rolling. In contrast, pottery is the litter type on which the orientation of fauna with respect to the substratum and the water column is least liable to change.

## Conclusions

Anthropogenic debris was found to support a higher abundance of organisms than the surrounding sediment, but a lower species richness. However, the suite of epifaunal species on litter was different from the epi- and infauna of the surrounding sediment. Thus the presence of litter on deep water sedimentary bottoms increases the overall biodiversity of particular areas. A more diverse benthic biota may result in a more diverse demersal fish fauna due to the greater scope for trophic specialisation and possibly an increase in secondary production.

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## DISTRIBUTION AND DENSITY OF DISCARDED LIMESTONE SLABS USED IN THE TRADITIONAL MALTESE LAMPUKI FISHERY

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## Abstract

The Maltese *Coryphaena hippurus* fishery employs fish aggregating devices anchored to the seabed by limestone slabs that are discarded after each season. It is estimated that more than 15,000 such slabs are deposited on the seabed each year, thus the number of limestone blocks left on the seabed by the decades-old fishery must be quite high. This study attempted to estimate the distribution and abundance of limestone slabs in the sea around Malta. The abundance of slabs was much less than expected, implying that a mechanism that gradually removes slabs from the surface of the seabed is operating in the area studied.

Keywords : Pollution, Fisheries, Trawl Surveys.

#### Introduction

*Coryphaena hippurus* (Maltese: *Lampuki*) is a key species targeted by the Maltese fishing industry, accounting for ca 40% by weight of the total annual catch [1]. Lampuki are captured by means of FADs which are anchored using limestone slabs (the same that are generally employed in the Maltese building industry). When the *lampuki* season (September-December) is over, fishermen retrieve the FADs but leave the slabs behind and each year fresh slabs are used. Considering that this traditional fishery is decades-old, and that more than 15,000 FADs are laid each year [2], the number of slabs that have been deposited on the seabed over the years must be substantial. The aim of this study was to estimate the density and distribution of limestone slabs on the seabed around Malta, as a preliminary tstudy of their ecological effects.

#### Methods

Limestone slabs were collected by trawling during a research cruise of the RV *Sant' Anna* made in July 2005 as part of the ongoing MEDITS trawl survey programme [3]. Slabs were recovered from 45 hauls (45-700 m) distributed around the Maltese islands (Fig. 1); 59% of the swept area was located on FADs trajectories (these trajectories have remained constant for decades), while the remaining 41% of the trawled area was non-FAD area where the laying of such devices is illegal. The slabs collected were classified into age categories: pre-1976, 1976-1980 and post-1980; age could be determined from the dimensions of the slabs, since these building blocks have a standard size which was changed at known times [4]. The mean abundance of limestone slabs was calculated. A map showing the abundance of slabs at each station was superimposed on a map of FAD distribution around the Maltese islands to see if the blocks are being dispersed from the points of deposition.

#### Results and discussion

The total number of limestone slabs (l.s.) was 28 in  $3.5 \text{ km}^2$  of swept area (8 l.s. km<sup>-2</sup>), 15 of which were found in  $1.4 \text{ km}^2$  of non-FAD area (10.5 l.s. km<sup>-2</sup>) and the remaining 13 were found in 2.1 km<sup>2</sup> of FAD area (6.1 l.s. km<sup>-2</sup>). This implies that slabs were more common in areas where the laying of FADs is not allowed than in areas where FAD trajectories are allocated (Fig. 1).

The reasons for this can be threefold: (1) the illegal deployment of FADs in non-FAD areas; (2) the use of slabs for other purposes, such as ballast to stabilise fishing boats when empty, the slabs then being disposed of randomly; (3) the movement of the limestone slabs from their point of deposition to other areas. Even though at the depths sampled water currents of sufficient strength to move the heavy slabs are not likely, the blocks may still be moving as a result of trawling activities, which generally involve an initial clearing of the area to be trawled from litter, and disposing of this in other non-trawled areas.

61% of the slabs collected were of recent origin, deposited after 1980; 25% were from the 1976-1980 period, while pre-1976 slabs constituted a mere 14%. Assuming that the number of FADs laid has remained constant over the years, it would appear that in the area surveyed, blocks are being removed from the seabed with time. Two plausible explanations can be either that the slabs were cleaned by trawlers from the area studied (all sampling stations in this study were located in areas where trawling is permitted), or that the limestone blocks are gradually sinking into the sediment until completely buried. However, whilst still on the seabed, the blocks can serve as islands of hard substratum on the otherwise soft sed-

imentary bottoms surrounding the Maltese islands at the depths sampled, thus increasing biodiversity by providing attachment space for epibiota [5]. Nonetheless, the slabs can also have detrimental effects as a result of smothering sessile biota. They can also inhibit exchange between the water column and the interstitial waters of the sediments, although this might be negligible since the overall surface area covered by the blocks is very small (ca  $23 \times 26 \times 60$ cm).



Fig. 1. Standardised abundance of limestone slabs at each station (dots), superimposed on a map of FAD distribution around the Maltese islands.

#### Conclusions

Even though the traditional *lampuki* fishery has been in existence for decades and more than 15,000 slabs are deployed each year, the estimated abundance of limestone slabs was much lower than expected. This implies that in the area studied mechanisms are operating to remove the slabs from the surface of the seabed, counterbalancing the yearly input of blocks.

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## MODELLING THE ECOLOGICAL ROLE OF SMALL PELAGIC FISH IN THE CATALAN SEA (NW MEDITERRANEAN)

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## Abstract

This contribution aims at investigating the ecological role of small pelagic fish in the South Catalan Sea (NW Mediterranean) by applying mass-balance and trophodynamic modelling. Results describe the high importance of these organisms within Mediterranean food webs and evidence the need of progressing towards a sustainable management of their fisheries. *Keywords : Pelagic, Fishes, Food Webs, Models, Western Mediterranean.* 

Small pelagic fish (SPF) are important elements of marine ecosystems due to their relevant biomasses at intermediate levels in the food web, notably contributing to canalize the energy connecting the lower and upper trophic levels. Fluctuations in SPF populations due to fishing or to environmental factors can contribute to modify the structure and functioning of marine ecosystems [1]. Environmental factors are essential to explain their dynamics, which are subjected to fluctuations due to their relatively short life cycle (3-4 years). Moreover, an intense fishing activity can contribute to impair their populations.

Main SPF inhabiting the NW Mediterranean Sea are anchovy (*Engraulis encrasicolus*), sardine (*Sardina pilchardus*), round sardinella (*Sardinella aurita*) and sprat (*Sprattus sprattus*). Anchovy and sardine represent almost 50% of the total landings in the Catalan Sea and support important biomasses [2]. Both landings statistics and biomass estimates have shown a steadily decline in the area during the last decades. The production of sardine and anchovy in the region is clearly influenced by changes in the environment [3].

An ecological model of the South Catalan Sea [4] using Ecopath with Ecosim (EwE) approach [5] was used to put available ecological data from SPF into an ecosystem context. Global results showed how they are essential mid trophic levels of the food web, in line with results from other Mediterranean and upwelling areas [1,6]. They are involved in main trophic flows and constitute important elements controlling prey and predator populations (Figure 1), most probably related with bottom-up and wasp-waist flow control situations.



Fig. 1. Schematic flow diagram of the South Catalan Sea, where SPF trophic links are highlighted. B = Biomass (t km<sup>-2</sup>); P = Production and Q = Consumption (t km<sup>-2</sup> yr<sup>-1</sup>). Drawings from www.gencat.net.

Results of the ecological model also highlighted how fishing activity had a high impact on these groups during the 1990s (Table 1). SPF were related with high exploitation rates and high primary production required to sustain their catches, and consumption of SPF production by the fishery was also high. These results are in line with an increasing concern of high fishing intensity on these species and a recruitment overfishing situation related with anchovy stocks [7]. Moreover, cross-system comparisons of standardized trophic models of South Catalan Sea with upwelling systems from Humboldt and Benguella regions had evidenced the higher fishing impact on small pelagic fish in the Mediterranean area due to the smaller production and biomass rations and higher fishing rates [8].

Tab. 1. Indicators for small pelagics' fisheries in the Catalan Sea.

| Group       | TL1               | PPR SPF (%) <sup>3</sup> | F/Z <sup>5</sup> | Consumption (%) <sup>6</sup> |
|-------------|-------------------|--------------------------|------------------|------------------------------|
| Anchovy     | 3.09              | 9.78                     | 0.30             | 27.80                        |
| Sardine     | 3.01              | 15.80                    | 0.53             | 54.28                        |
| Other SPF   | 3.05              | 0.19                     | 0.10             | 10.39                        |
| Total Catch | 3.12 <sup>2</sup> | 10.6 <sup>4</sup>        | -                | 20.20 <sup>7</sup>           |

 $^1$  TL = trophic level of species;  $^2$  mean trophic level of the catch;  $^3$  PPR SPF (%) = primary production required to sustain the catch of SPF in relation with total %PPR,  $^4$  Total PPR%;  $^5$  F/Z = exploitation rate;  $^6$  Consumption (%) = consumption of SPF production by fishing;  $^7$  Total consumption of fishable production (%).

The impact of fishing was also analysed by developing dynamic simulations with trophodynamic modelling [5]. The steady decline of pelagic landings between 1994 and 2003, coupled with a decrease of the pelagic biomass within the ecosystem, could be reproduced by the model combining different scenarios of moderate increase of fishing effort and an environmental forcing under wasp-waist flow control [4]. This decline underlined the low resistance of the system in front of perturbations and the relevance of fishing, in conjunction to environmental forcing, to understand the dynamics of small pelagic fish in the area. These results are of relevance in terms of management of exploited marine resources in the area since the high exploitation of small pelagic fish can produce important impacts of the structure and functioning of the exploited ecosystem.

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## CYSTOSEIRA CRINITA COMMUNITY IN THE AEGEAN SEA

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## Abstract

The algal community dominated by *Cystoseira crinita* was studied at 26 sites of the Hellenic "NATURA 2000" network in the Aegean Sea. The aim of the study was to give an overall aspect of the community structure, corresponding to its "typical" composition in unpolluted areas of the North-Eastern Mediterranean. A SIMPER analysis was carried out on 62 samples of phytobenthos from the Hellenic "NATURA 2000" data-base. From 113 species identified in total, 9 species contributed cumulatively by 90% in the community, while a group of 34 species contributed cumulatively by 99% in the community.

Keywords : Algae, Phytobenthos, Coastal Management, Aegean Sea, Eastern Mediterranean.

#### Introduction

In the pristine areas of the Mediterranean coastline, the species of the genus *Cystoseira* are usually the dominant benthic vegetation elements at the upper infralittoral zone (0-1 m depth). According to Pérès & Picard the *Cystoseira* algal community is considered as the final stage (climax) of the photophilic algal communities' succession, thus it can be considered as indicative of the environmental conditions ([1]).

In the Aegean Sea the *Cystoseira crinita* Duby community is one of the most common elements of the vegetation in undisturbed areas, with an extensive distribution from exposed to sheltered sites ([2]).

The present paper studies the *C. crinita* algal community at different putatively pristine Aegean Sea sites in order to develop an objective and statistically valid "virtual" list of the most common algal species in the Aegean under undisturbed conditions, and also to test the conceptual model and the biotic index EEI recently developed by Orfanidis *et al.* ([3]) for the implementation of Water Framework Directive (2000/60/EC) in Greek coasts.

## Methodology

The data used in the present paper are part of the Hellenic "NATURA 2000" data-base build up by a scientific consortium (scientists in charge in Panayotidis *et al.*, [4]) in years 2000 to 2001. A selection of 62 *Cystoseira crinita* quantitative (20 x 20 cm or 25 x 25 cm) and destructive samples from 26 putatively pristine Aegean sites was undertaken (Fig. [1]). They were representatives of the photophilic algal community of the rocky upper infralitoral zone. In the laboratory formalin fixed samples were carefully analyzed by identifying species presence and by estimating their vertically projected coverage. The total coverage usually exceeded 100% due to the presence of different vegetation layers (canopy, bushy, crusts and epiphytes). Untransformed data were analyzed by SIMPER-analysis (PRIMER v. 5) to estimate algal species abundance and contribution (%). The species were classified in two Ecological State Groups (ESG), in accordance to Orfanidis *et al.* ([3]) approach.

#### Results and Discussion

In total 113 taxa (73 Rhodophyceae, 25 Phaeophyceae, 15 Chlorophyceae) were identified. Nine (9) major taxa contributed cumulatively by 90%in the community: Haliptilon virgatum, Cystoseira compressa, Jania rubens, Padina pavonica, Herposiphonia secunda, Corallina elongata, Cladophora spp., Sphacelaria cirrosa and Titanoderma cystoseirae (see also [5]). Moreover, 34 taxa contributed cumulatively by 99%. Bushy layer considerably dominated to the community with most common representatives the red coralligenous algae Haliptilon virgatum, Corallina elongata and Jania rubens, and the brown alga Padina pavonica. It was followed by C. crinita epiphytes distinguished in: 1) filamentous green ( Cladophora spp.), brown (Sphacelaria cirrosa) and red (Herposiphonia secunda) algae, and 2) in encrusting red algae (Titanoderma cystoseirae and Hydrolithon spp.). Cystoseira compressa contributed significantly (23.08%) to C. crinita community indicating that these species share common habitat resources in the Aegean Sea, a phenomenon also known, at least at the past ([1]), in the Albéres coasts of France.

Within the most common *Cystoseira crinita* taxa, 21 (62%) belong to opportunistic ESG II, whereas 13 (38%) taxa belong to late-successional ESG I (Table 1). By contrast, the ESG I taxa (87%) dominated quantitatively the ESG II (13%) taxa in the *C. crinita* community. This result is in accordance both: a) to the conceptual model of Orfanidis *et al.* ([3]) that "in less anthropogenic stressed coastal areas (pristine) the late-

successional species dominate" and b) to the basic assumption of the Ecological Evaluation Index (EEI) that ESG II average contribution in undisturbed areas is less than 30%.



Fig. 1. Map of the sampling sites.

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## THE IMPACT OF SCAVENGERS ON THE CREEL FISHERY FOR *NEPHROPS NORVEGICUS* IN THE CENTRAL ADRIATIC SEA

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## Abstract

Scavenging activity in the western Pomo pit fishing grounds (Adriatic sea) was studied by means of baited funnel traps with the aim of evaluating its impact on a hypothetic creeling activity for *Nephrops*. The isopod *Natatolana borealis* was the main responsible for bait consumption, which took place completely within 24 hours of trap deployment. Amphipods arrived later, not before 12 h. *Keywords : Adriatic Sea, Crustacea, Fisheries, Food Webs*.

## Introduction

In Mediterranean waters, Norway lobster (*Nephrops norvegicus*) is mainly targeted by bottom trawlers. The selectivity of bottom trawls with respect to this species is very poor and large quantities of discards are produced [1, 2]. The reduction of discards and incidental by-catch is a priority in the Common Fishery Policy of the European Union. For these reasons, an alternative fishing method targeting *Nephrops* was sought through the use of baited creels.

The western Pomo pit (200 - 250 m depth, central Adriatic Sea) is an area intensively exploited for *Nephrops* by the Adriatic trawling fleet and thus all experimental work was carried out there. This area has been reported to be characterised by conspicuous numbers of benthic scavengers that could considerably affect creel catches [1]. This paper summarises the results of an investigation into the species composition and activity of scavenging invertebrates living in the area, with the aim of evaluating their impact on a hypothetic creeling activity for *Nephrops*.

#### Materials and methods

In order to identify benthic scavengers, baited funnel traps made from PET bottles (volume = 1 litre; entrance  $\emptyset$ = 18mm) were deployed in the same area as *Nephrops* creels within the western Pomo pit. The traps were baited with salted sardine (3 fish per trap), exactly in the same manner as were the creels. On two occasions (20/08/2004 and 23/08/2004), four separate fleets of traps (n = 10 traps per fleet) were laid at the same time (sunrise) and lifted after 3 h, 6 h, 12 h and 24 h. The contents of each trap were kept and the remaining bait weighed. The species caught were identified, measured and weighed in the laboratory. Differences between soak times in terms of bait consumed, scavenger species, number, weight and length were investigated by means of analysis of variance, following appropriate transformations where necessary. Any significant differences resulting from ANOVA tests were investigated using Student-Newman-Keuls (SNK) a-posteriori pairwise comparisons.

## Results and discussion

A very high scavenger activity was found in the area, with over 30% of bait consumed within 12 h and up to 100% within 24 h (Fig. 1). The organisms responsible for this were the cirolanid isopod, *Natatolana borealis*, which arrived at the bait shortly after the traps were deployed, and the Lysianassid amphipods, *Scopelocheirus hopei*, *Tmentonyx similis* and *Hippomedon bidentatus* (Fig. 1). A few Decapods (*Munida intermedia*, *Processa canaliculata*) were found in the 24 h deployments.



Fig. 1. (a) Bait consumed (+ SD) and (b) individual rates (% number) of occurrence by scavengers over 24 hours.

*Natatolana borealis* always numerically dominated trap catches (Fig. 1) and marked effects of soak time were revealed, with traps of the 12 h deployments catching significantly higher numbers of individuals (mean

= 75.95  $\pm$  13.94 animals per trap) (Fig. 2). In general, arrival time of *N. borealis* tended to be longer for larger individuals: mean size and mean individual biomass were significantly higher at 24 h of soak time (Fig. 2). In the 24 h deployments, the number of isopods significantly decreased implying that the smaller individuals were able to exit the traps. Amphipods arrived later than isopods and were absent in the 3 h and 6 h deployments, whilst they comprised 4% of catch in the 12 h deployments and 38% in the 24 h deployments (Fig. 2).

The results revealed a very intense scavenging activity in the western Pomo pit with very high consumption of bait. This factor, together with the prevalence of small *Nephrops* individuals in the catches, would severely decrease the fishing potential of a hypothetic creeling activity for *Nephrops* in the area, rendering it not feasible economically.



Fig. 2. (a) Mean total number (+SE), (b) mean total length (TL) (+SE) and (c) mean individual biomass (+SE) of Natatolana borealis individuals caught in traps over 24 hours, with an indication of analysis of variance and SNK pairwise comparison results (a) F= 5.06; \* = p<0.05); (b) F= 8.02; c) F = 7.20; \*\* = p<0.01).

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## BIOLOGICAL PARAMETERS OF *TRACHYRHYNCHUS TRACHYRHYNCHUS* (RISSO, 1810) (OSTEICHTHYES, MACROURIDAE) IN THE NORTH AEGEAN SEA: PRELIMINARY RESULTS

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## Abstract

Aspects of the biology of *Trachyrhynchus trachyrhynchus* (Risso, 1810) were studied in the North Aegean Sea. The male:female (M:F) ratio was 1:1.44. Age determination based on otolith reading showed that the population has a maximum age of 14 years. The species exhibits a positive allometric growth (b=3,37). The von Bertalanffy growth parameters for all individuals are  $L_{inf} = 460.4$  mm, k = 0.2406 year<sup>-1</sup>, and to = -1,07 year. Gonad examination revealed that during the sampling period, the species was mainly immature. *Keywords : Aegean Sea, Deep Waters, Fishes.* 

The Roughsnout grenadier *Trachyrhynchus trachyrhynchus* (Risso, 1810) [1], is a benthopelagic species for which very few studies exist. Its presence has been recorded annually since 1996 at depths between 400-700 m especially in the North Aegean Trench in Lemnos basin. The purpose of this study is to present data on various aspects of its biology.

The samples were collected during the MEDITS expedition (which is conducted during the June and July every year) in the North Aegean Sea from 1996 to 2006. Total length (TL) in mm, and total weight (TW) in gr were measured on board, otoliths were extracted and sex was determined by macroscopic examination of the gonads. A number of otoliths and gonads were processed and examined in the laboratory under stereoscopic and microscopic examination respectively. Counts of opaque zones in otoliths were converted in number of years as an absolute age.

A total of 847 individuals were caught of which 750 were measured. Total length of the individuals ranged from 125 to 507 mm. The length class with most individuals was the 365-374 mm (9.2%).

Otoliths (left sagittae) from 54 individuals were used for age determination (Fig. 1).



Fig. 1. Photomicrograph of otolith from a 437 mm fish.

Due to their thickness, otoliths were polished with sandpaper until the nucleus was reached, immersed in ethanol and read under transmitted light. The otolith reading revealed up to 14 annual increaments indicating a maximum age of 14 years. The von Bertalanffy growth parameters were computed by mean of non linear regression analysis applied to the age-at-length data. The results are (all individuals):  $L_{inf}$  = 460.4mm, k= 0.2406 year<sup>-1</sup>, and to= -1.07 years.

Overall, 360 fish (42,5%) were sexed: 135 were males, 195 females and 30 unsexed with the sex ratio M:F being 1:1.44. Deviations from 1:1 null hypothesis were statistically tested using  $X^2$  - test and revealed no significant difference (P=>0,05) between male and female percentages.

The parameters of the length - weight relationship for males (TL 202-433 mm, TW 20.42-301.30 gr) and females (TL306-456 mm, TW 114.5-324.66 gr) were for males: Ina=-15.85, b=3.57, SEb=0.16,  $R^2$ =0.95; for females: Ina= -10.05, b=2.59, SEb=0.25,  $R^2$ =0.76; and for sexes combined: Ina=-14.71, b=3.37, SEb=0.13,  $R^2$ =0.91.

Gonads from 60 individuals were histologically processed and examined microscopically (Fig 2).



Fig. 2. Histological section of ovary.

The majority of gonads of both male and female were immature. However, ovaries of some females contained few oocytes in vitellogenesis, coupled with atretic vitellogenic oocytes.

The sex ratio indicates that sexes were equally distributed. Males and females had positive and a negative allometric growth respectively, but the species had a positive allometric growth overall. Gonad examination revealed that the species, during the sampling period, was mainly immature. However, the presence of some isolated oocyte in vitellogenesis associated with the presence of vitellogenic oocytes in atretic phase might indicate that spawning occurred recently.

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## **BIODIVADR: A REFERENCE DATASET ON DIVERSITY OF SOFT BOTTOM MACROBENTHOS**

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## Abstract

An extensive field study was done in July 2003 to provide a quantitative description of spatial patterns of benthic assemblages in the North Western Adriatic Sea; 288 samples were collected over an area of 240 km<sup>2</sup>. Overall, 115.670 specimens belonging to 209 taxa were identified. The most abbundat taxa were Crustacea (43%), Polychaeta (31%) and Mollusca (21%), while other taxa accounted for about 4% of the total abundance. Four new records of polychaete species, 2 for the Adriatic and 2 for the Mediterranean Sea, were reported. A new species of spionidae was described

Keywords : Adriatic Sea, Biodiversity.

Vatova's [1] classic paper on Adriatic soft bottom macro-zoobenthos has so far provided the baseline for studies investigating patterns of distribution of benthic assemblages in the Adriatic Sea. This work, was aimed at providing a comprehensive regional-scale description of the Adriatic benthic fauna. Following the approach developed by Petersen [2], Vatova [1] classified Northern and Central Adriatic benthic assemblages in "zoocoenoses". Several Authors have re-analysed Vatova data, reinterpreting them in terms of "biocoenoses" [3-6] or using multivariate statistical tools [7]. Results of cluster analises reported by Di Dato et al [7] did not support the "zoocoenosis" identified by Vatova, suggetsing that they derive from a subjective interpretation.

In June 2003 an extensive field study was done to provide a quantitative description of spatial patterns of benthic assemblages in the North Western Adriatic Sea. The aim of the study was to estimate variability of assemblages at different spatial scales. A hierarchical nested design, including spatial scales from hundreds of metres to tens of kilometres. was developed. The sampling area was of about 240 km<sup>2</sup>, delimited by 44.5617 and 44.1254 latitude North, and by the 10 and 30 meters depth contours. To implement the hierarchical sampling design the study area was devided in strata, locations, areas and sites (Fig1). At each sampling site 4 replicated grab samples were collected with a 0.1 m<sup>2</sup> Van Veen grab. Overall 288 samples were collected and processed, obtaining an everage sapling density of 1.2 per km<sup>2</sup>. This large sampling effort allowed the construction of an updated list of macrozoobenthos in the North Western Adriatic.



Fig. 1. Sampling area with the desciption of the structure of the sampling design.

Overall 115.670 specimens belonging to 209 taxa have been identified. The most abbundat taxa were Crustacea (43%), Polychaeta (31%) and Mollusca (21%), wile other taxa were relatively rare. The Amphipod Ampelisca spp, accounted for 41.8% of the total abbundance. The most abbundant polychaete specie were Lumbrineris spp (4.6%), Levinsenia (Levinsenia) gracilis (3.6%), Sternaspis scutata (2.9%), Polydora flava (2.9%) and Paraonis fulgens (2.1%). Two new records of polychaete species for the Adriatic Sea ( Paraonis fulgens (Levinsen, 1883), Harmothoë andreapolis (McIntosh, 1874)); together with 2 new records for the Mediterranean Sea (Ampharete finmarchica (Sars, 1866) and Atheros-

pio disthica (Mackie & Duff, 1986)) were reported. A new species beloning to the Family Spionidae so far named Laonice cf. cirrata was found. Most abbundan molluscs were Corbula gibba (2.3%), Abra nitida (2.1%) and Mysella bidentata (1.7%). Moreover, high densities of the arcid bivalve Andara demiri, an invasive species firstly recorded in the Adriatic Sea in the year 2000, were observed.

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## SUIVI DE LA CINÉTIQUE DE COLONISATION SECONDAIRE POST NÉCROSE DES AXES DE QUATRE ESPÈCES DE GORGONES (RÉGION DE CALVI, CORSE, MÉDITERRANÉE OCCIDENTALE) ENTRE 1998 ET 2006

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## Résumé

Suite aux importants phénomènes de nécrose qui ont affecté les quatre espèces de gorgones présentes en baie de Calvi (*Eunicella verrucosa, E.singularis, E. cavolinii* et *Paramuricea clavata*) entre 1998 et 2006, on a assisté à la colonisation secondaire des axes cornés dénudés. Cinq étapes consécutives de constitution des communautés épibiontes sont décrites. *Mots clès : Cnidaria, Coastal Waters, Zoobenthos.* 

Suite aux importants phénomènes de nécrose qui ont affecté les quatre espèces de gorgones présentes en baie de Calvi (*Eunicella verrucosa, E.singularis, E. cavolinii* et *Paramuricea clavata*) entre 1998 et 2006, on a assisté à la colonisation secondaire des axes cornés dénudés. Cinq étapes consécutives de constitution des communautés épibiontes sont décrites.

Depuis une vingtaine d'années, on a enregistré un nombre croissant de perturbations d'origine climatique ou édaphique, affectant les communautés benthiques à l'échelle de tous les océans [1] ; les épisodes de nécrose qui ont affecté les groupes les plus divers d'invertébrés, et notamment les gorgones en mer Méditerranée ont permis le développement de communautés d'épibiontes au sein desquels la recherche d'organismes traceurs de l'altération environnementale pourrait se révéler prometteuse. Le programme RACE de l'Université de Liège associé à la Station océanographique STARESO (ARC, Convention n°05/10-333) s'inscrit dans ce cadre général de définition des modalités d'analyse et de suivi des impacts en milieu côtier.

Cette étude fait état de la dynamique de colonisation des axes cornés des gorgones lors des phénomènes de nécrose du coenenchyme le long de quatre transects plus ou moins affectés par l'impact touristique, dans la région de Calvi (Corse, Méditerranée occidentale) entre1998 et 2006. Des prélèvements (fragments de colonie à l'interface entre zone "saine" et zone nécrosée et recolonisée) ont été effectués en plongée autonome tous les ans à la mi-juillet et immédiatement et individuellement fixés. Le suivi de l'état de surface des gorgones par microscopie électronique à balayage nous a permis de décrire la cinétique de cette nécrose et de la colonisation secondaire.

Reconnues pour leur qualité de "sentinelles" [2], les gorgones, organismes fixés, filtrants à longue durée de vie, sont particulièrement aptes à offrir un "substrat" aux colonisateurs secondaires dont les variations locales (en diversité et/ou en abondance) peuvent intégrer les variations environnementales, qu'elles soient d'origine locale ou climatique. Les gorgones "saines" ne portent pas d'épibiontes et sont quasiment stériles (phase 0), résultat de la sécrétion de métabolites secondaires induisant une répulsion non seulement chez les organismes prédateurs [3,4], mais aussi assurant un rôle antifungique et antimicrobien et inhibant le dépôt des colonisateurs secondaires [5].

Les premières atteintes morphologiquement visibles se manifestent par le dépôt de bactéries en populations éparses et de diatomées à la surface des tissus ectodermiques (phase 1). Par la suite, la dissociation de ce tissu révèle les spicules sous-jacents (phase 2) et permet une colonisation, puis une prolifération bactérienne en profondeur du coenenchyme. Dans certains cas, les bactéries sont accompagnées de fungi.

L'érosion progressive des spicules (phase3) révèle progressivement l'axe qui, une fois dénudé, se fait rapidement recouvrir d'une épibiose importante, essentiellement composée de diatomées pennées au départ. Ce tapis de diatomées sert de point de départ à une colonisation par des organismes dressés, colonisation essentiellement algale au départ (phase 4), puis à prédominance animale par la suite (foraminifères, annélides polychètes, bryozoaires, ...phase 5).

L'évolution apparaît réversible (recolonisation de l'axe après cicatrisation et croissance du coenenchyme) jusqu'à la phase 3.

Tant l'état intrinsèque des populations des différentes espèces (taux de nécroses) que les informations données par le recouvrement des axes

post nécrose des colonies [2] confirment l'intérêt des populations de gorgones comme outil potentiel d'évaluation et de suivi de la qualité de l'environnement côtier en Méditerranée.

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## SUIVI DE L'ÉTAT DES POPULATIONS DE QUATRE ESPÈCES DE GORGONES (RÉGION DE CALVI, MÉDITERRANÉE OCCIDENTALE) ENTRE 1998 ET 2006

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## Résumé

Les quatre espèces de gorgones présentes en baie de Calvi (*Eunicellaverrucosa, E. singularis, E. cavolinii* et *Paramuricea clavata*) ontsubi une nette régression de leurs populations entre 1998 et 2001. Ensuite,entre 2001 et 2006, on a assisté à un recrutement important mais ce recrutement s'est accompagné d'une dégradation significative de l'état de santé des quatreespèces (nécroses et colonisation secondaire). *E. verrucosa* semble avoirdisparu des transects investigués.

Mots clès : Bio-indicators, Coastal Waters, Cnidaria, Population Dynamics, Zoobenthos.

Ces dernières années, on a enregistré un nombre croissant de perturbations des communautés benthiques à l'échelle de tous les océans [1] : de nombreux épisodes de nécrose ou de mortalité ont affecté les groupes les plus divers d'invertébrés (gorgones, éponges, bivalves, échinodermes, ...[2-3]), notamment en mer Méditerranée. Ceci implique la mise en place de réseaux de surveillance des populations d'organismes clé dans des sites de référence [4,5]. Le programme RACE (ARC, Convention n° 05/10-333) dont cette étude est partie prenante s'inscrit dans ce cadre général de la définition des modalités d'analyse et de suivi des impacts en milieu côtier. Cette étude fait état de la dynamique des populations de gorgones dans la région de Calvi (Corse, Méditerranée occidentale) le long de quatre transects définis dans des zones aux caractéristiques bien tranchées (avec impact touristique évident ou non, entre 5 et 47 m de profondeur). Ces transects ont été relevés en plongée autonome (comptages des colonies et évaluation de l'état sanitaire des populations) tous les ans à la mi-juillet. Reconnus pour leur qualité de "sentinelle"[5], ces organismes fixés, filtrants à longue durée de vie, sont particulièrement aptes à intégrer les variations environnementales, qu'elles soient d'origine locale ou climatique. Les quatre espèces présentes dans cette tranche bathymétrique ( Eunicella verrucosa, E. singularis, E. cavolinii et Paramuricea clavata) ont fait l'obiet d'une étude démographique (nombre d'individus sur le transect et spectres de tailles) et d'un suivi temporel de leur état de santé (nécrose, épibiose, ...) entre 1998 et2006.Faisant référence aux épisodes de mortalité enregistrés à la fin de la décennie précédente dans le sud de la France [2], et dont on a souvent attribué l'origine aux anomalies thermiques positives enregistrées dans les eaux de surface [3.6] on a considéré la faune benthique corse comme relativement épargnée. Une vision plus pessimiste ressort de nos mesures : les populations de gorgones, toutes espèces confondues ont subi une dégradation générale au cours de la période 1998-2001. Certains site sont connu des diminutions d'effectif de l'ordre de 50 % : E. cavoliniiet E. singularis de 32 à 58 % de pertes selon les sites et P. clavata, 27 à 41%. E. verrucosa, sténotherme plus froide, tend à disparaître dès 2000 : une seule colonie a subsisté le long d'un transect jusqu'en 2005, de plus en plus nécrosée. Elle a fini par disparaître en 2006. Pour les trois autres espèces, les colonies implantées aux profondeurs plus faibles (au-dessus de la thermocline durant une partie importante de l'année) ont reflété l'impact le plus important. Les différences entre le site "hors baie" et les trois sites dans la baie de Calvi (plus anthropisée) sont peu significatifs. P. clavata, occupant la tranche bathymétrique la plus profonde, entre 25 et >47 m, apparaît la moins touchée par les phénomènes de nécrose. Hormis dans le cas d' E. singularis (populations les plus exposées puis qu'occupant la tranche bathymétrique supéreieure, entre 5 et 18 m dans la zone concernée par cette étude), les différences entre le site "hors baie" et les trois sites dans la baie de Calvi (régulièrement utilisés comme sites de plongée touristique), sont peu significatifs ; ceci aurait tendance à nous faire privilégier l'impact d'un facteur climatique plutôt qu'anthropique. Après 2000-2001, la période est apparue plus favorable au renouvellement des populations avec un recrutement important des trois espèces principales ( E. cavolinii, E. singularis et P.clavata). En revanche, l'état de santé général des colonies tend à se dégrader nettement depuis 2001. En 2005-2006 les populations d' E. singularis étaient atteintes de nécrose dans 60  $\pm$  17 % des cas sur les transects expérimentaux, celles d' *E. cavolinii* dans  $52 \pm 8$  % et celles de P. clavata dans 52  $\pm$  10 % des cas. De telles indications confirment l'intérêt des populations de gorgones comme outil potentiel d'évaluation

et de suivi de la qualité de l'environnement côtier en Méditerranée.

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## SPATIO-TEMPORAL DISTRIBUTION OF RECRUITS OF HAKE (*MERLUCCIUS MERLUCCIUS* L.) IN THE CALABRIAN TYRRHENIAN SEA (CENTRAL MEDITERRANEAN)

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## Abstract

The distribution of hake (*M. merluccius*) recruits has been investigated along the Calabrian Tyrrhenian coasts. Data coming from national and international trawl survey projects have been integrated with seasonal catches carried out between 2004 and 2005 in the framework of a regional research SFOP-POR project. Two well defined areas, although characterized by spatio-temporal variability, were identified between 100 and 300 m in the Gulf of S. Eufemia and near C.po Suvero. *Keywords : Fishes, Recruitment, Tyrrhenian Sea, Western Mediterranean.* 

The identification of nursery areas of the hake *Merluccius merluccius* and their variability in space and time is very important for its management. The recruitment patterns of hake have been studied in many Mediterranean sites [1, 2, 3] but the information about seasonal variations in recruitment is still scarce. Along the Tyrrhenian coast of Calabria research trawl surveys (GRUND and MEDITS) which were carried out during the last ten years provided useful information about the distribution of hake recruits [2]. Data coming from these projects have been integrated with seasonal catches carried out between 2004 and 2005 in the framework of a regional research SFOP-POR project.

Data come from eleven seasonal trawl surveys carried out along the Calabrian coast from C.po Suvero to P. ta Pezzo. In particular eight GRUND (spring-summer 1994-2002), eight MEDITS (autumn1994-2002) and three POR surveys (autumn and summer 2004-2005) were analysed. Overall, 140 hauls were carried out between 10 and 800 m of depth, during daylight from dawn to sunset. To separate the recruits from the older specimens a cut-off, elaborated for each survey, is used [2]. On the basis of swept area, the number of recruits "R "of each haul were transformed into R per km<sup>2</sup> (Recruits Density Index-RDI). The nursery areas were identified using a GIS approach.

Despite the variability recorded between the different seasons and years (MEDITS and GRUND data), the density of recruits showed two stable areas (between 100 and 300 m) characterized by high concentrations of juveniles which were identified near C.po Vaticano (the larger one) and inside the S. Eufemia Gulf. The presence of these two areas was confirmed by the RDI found during POR surveys (Figure 1). During November 2004 both areas were found at a depth between 50 and 350 m; the RDI index showed a total mean value of 483 R/km<sup>2</sup> (min 40-max 2588 R/km<sup>2</sup>). On the contrary, during summer survey only the nursery area inside the Gulf was found; the mean RDI recorded was 712 R/km<sup>2</sup> (range 40 - 4170 R/km<sup>2</sup>). Finally in September no nursery area was found (mean RDI=124 R/km<sup>2</sup>).



Fig. 1. Nursery area zones (dark grey) identified along Calabrian coasts during POR survey in November 2004 (A) and July 2005 (B).

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# CHANGING CONCENTRATIONS OF BACTERIA IN SHIPS' BALLAST WATER DURING TRANSIT: ARE BALLAST TANKS INCUBATORS?

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# Abstract

Ships' ballast water is a major source of biological invasions in coastal systems and contains a diversity of microorganisms, yet their population dynamics remain largely unexplored. We measured temporal changes in total bacteria concentration in 75 ballast tanks (34 with mid-ocean exchange and 41 unexchanged controls) across 21 ocean voyages, from multiple departure ports (5% of Mediterranean source, including Fos-sur-Mer and Tel Aviv) and representing all seasons. Bacteria concentration differences were tested as a function of depth, time, ballast management and season. Total bacteria decreased significantly over time, and the decrease was significantly greater in exchanged tanks. Increases over time occurred occasionally but infrequently in a few tanks (4% for both control and exchanged), suggesting growth (incubation). Across tanks, there was not a significant difference due to depth, as most tanks (85% controls and 89% exchanged) showed no vertical stratification. Overall, there were no significant seasonal effects in total bacteria dynamics across ballast tanks.

Keywords : Bacteria, Species Introduction, Migrant Species.

#### Introduction

The movement of ballast water by commercial ships is a major transfer mechanism for organisms throughout the world, resulting in established non-native populations (biological invasions) that are dramatically changing the structure and function of coastal ecosystems. Several recent studies underscore the large concentrations of protists, bacteria, and viruses in ballast water [1 - 4]. The dynamics of microorganisms, however, during transit remains largely unexplored [1, 2]. There has been some suggestion that conditions in ballast tanks may operate to increase microorganism concentrations, serving as incubators. Here, we test whether bacteria increase over time in ballast tanks, comparing the response in tanks that underwent ballast water exchange (BWE or ocean flushing to reduce the risk of invasion) to untreated control tanks.

#### Methods

From 1999-2005, we sampled 75 different ballast tanks to measure changes in total bacteria concentration. One to several ballast tanks were sampled across 21 different ocean voyages, from multiple routes and source ports (including the Mediterranean ports of Fos-sur-Mer (France) and Tel Aviv (Israel)), seasons, and ship types. A subset of the tanks (n=34) underwent BWE and parallel measures were taken for unexchanged control tanks (n=41) on the same voyage. For each tank, replicate samples were collected from at least two discreet depths, preserved for analysis, and quantified using direct counts and flow cytometry. We compared the effect of depth, season, time, and BWE on changes in total bacteria concentration.

#### Results

For both control and exchange tanks, bacteria concentrations differed significantly between the initial samples (T0) and samples after the first exchange was conducted (T1). On average, a lower concentration was found at T1, although some individual tanks (3 out of 23 control tanks and 3 out of 28 exchange tanks) had significantly higher concentrations at T1. In the latter exchange tanks, all observed increases occurred during the summer season. Across all voyages, there was a clear and significant difference between exchanged and control tanks, with exchange exhibiting lower average concentrations independent of depth The sharpest decrease occurred after the first exchange and stabilized afterwards. Even though time had an effect in reducing bacteria concentration, mid-ocean exchange had a greater effect than time alone. An incubation effect was found in 4%of the each control and exchange tanks. Overall, there was not a significant effect of depth on total bacteria concentrations for either exchanged or control tanks. Stratification was observed, however, in some individual tanks. For initial (T0) samples, stratification was found in 11 of 75 tanks, being significantly higher at the surface for all but 1 of these. For a later sampling time (T1), a stratified distribution was found in 6 control and in 2 exchange tanks; of these eight cases, higher numbers of bacteria occurred in deeper water for 2 control and 1 exchange tank. Therefore, a homogeneous distribution was typically found. Stratification only occurred in around 15% and 11% of the cases, for initial and later samples, respectively. Season had an effect on initial (T0) bacteria concentrations, being significantly greater in spring. For control tanks, the bacteria decreased with time for spring, summer and fall voyages, while increasing in the only winter tank. For exchanged tanks, concentration decreased after ballast exchange, except in summer when bacteria appeared to increase but

not significantly, indicating a possible input of bacteria from mid-ocean. Thus, there was not a concrete difference in dynamics among seasons. Discussion

Our results showed that concentration of bacteria decreased over time in both control tanks and exchanged tanks, although the decline in exchanged tanks was significantly greater. Ballast water exchange significantly decreased the bacteria abundance after the first exchange, becoming constant thereafter. This difference between exchange and control tanks was not observed for the single voyage by Drake et al. [2], and also included as 4 tanks in our dataset, where no differences were observed between these treatments. One possible explanation for this disparity may lie in the source water, originating from the eastern Mediterranean (Tel Aviv) in the latter study. In a second voyage from the Mediterranean (Fos-su-Mer), bacteria concentrations followed a similar pattern with no differences between control tanks (n=2) and exchanged tanks (n=2) after exchange (T2). This further suggests a different dynamic for Mediterranean sourced ballast. Overall, we observed an increase in total bacteria in a few control tanks. For the exchanged tanks, the incubation effect appeared in 3 tanks, whose voyages were all in summer; furthermore, 2 of those tanks were from the same ship, indicating more likely an effect of the ballasting spot instead of a growth effect. Murphy et al. [5] found that some crustacean taxa were more abundant in shallow than in deeper ballast waters. Here, the overall result across voyages was a uniform distribution, even though stratification was observed for a few individual tanks, usually with higher numbers in surface waters. Seasonal effects have previously been documented [2], where bacterial abundances were higher in warm seasons than in cold ones. Here, spring concentrations of bacteria were found to be significantly higher than for the other seasons. No taxonomical identification was conducted in this study, such that our data cannot address the dynamics of individual taxa. Specific components (genotypes) of the bacteria may behave differently from the total, and there is likely to have been considerable compensatory changes in genotypes both through time and as a function of exchange.

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# DESCRIPTION DE LA FAUNE EPIBIONTE DE *PINNA NOBILIS* SUR LES CÔTES NORD ET EST DE LA TUNISIE

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# Résumé

La faune épibionte de *Pinna nobilis* est décrite au niveau de cinq échantillons provenant des cotes nord et est de la Tunisie. Soixante quatre espèces de macro invertébrés appartenant à sept phylums ont été identifiées. Parmi celles-ci, les Mollusques constituent le taxon le plus dominant dans tous les échantillons examinés. La structure de cette faune varie selon le milieu où vit la grande nacre. Les investigations que nous avons menées révèlent que les peuplements épibiontes marins sont plus diversifiés et plus équilibrés que les peuplements lagunaires. *Mots clès : Mediterranean Ridge, Mollusca, Biodiversity*.

La grande nacre représente un important substrat biologique pour plusieurs espèces épibiontes et les communautés qui y sont associées ont été décrites au cours de nombreuses études, effectuées dans certains pays méditerranéens de la rive nord. L'objectif du présent travail est de connaître la faune épibionte de ce mollusque dans un pays de la rive sud, la Tunisie.

Les communautés épibiontes de P. nobilis ont été étudiées, durant la période allant d'août 2004 à août 2005, au niveau de cinq stations, trois marines, une lagunaire et une située entre la lagune et la mer, au niveau du canal de communication. Les stations marines sont du nord au sud, Sidi Rais (située dans le golfe de Tunis), Stah Jaber et Téboulba (localisées sur la façade est du pays). La station lagunaire se situe dans la lagune de Bizerte ; il s'agit de la station de Njila. La cinquième station est celle d'Echaâra, localisée au niveau du canal qui fait communiquer la lagune de Bizerte avec la Mer. Dans chaque station, la faune épibionte de 30 spécimens de P. nobilis a été prélevée en plongée sous marine et à une profondeur qui varie de 3 à 6 mètres. Au laboratoire, l'observation de ces échantillons a permis leur identification au moyen de guides et de clés de détermination appropriés. Une étude, utilisant les indices écologiques (Richesse spécifique, indices de Shannon-Weaver et d'équitabilité de Pielou), a été entreprise, suite au dénombrement des différentes espèces de chaque échantillon. La similitude entre les communautés épibiontes des différents sites prospectés a été analysée au moyen de la classification ascendante hiérarchique de Ward.

Au total, 64 espèces épibiontes appartenant à sept différents phylums ont été identifiées au niveau des cinq échantillons examinés de *P. nobilis*. Le taxon le plus dominant est celui des Mollusques (21,88%), suivi par les Annélides (20,31%), puis viennent, par ordre décroissant, les Ascidies (17,19%), les Spongiaires (15,63%), les Cnidaires (14,06%), les Bryozoaires (7,81%) et les Crustacés (3,13%). Les pourcentages de ces taxons varient selon les stations et donc selon le type d'écosystème et les conditions qui y règnent. La richesse spécifique varie également d'une station à l'autre. Elle est comprise entre un minimum de 15 espèces à Sidi Rais et un maximum de 29 espèces à Stah Jaber (Fig.1).



Fig. 1. Variations de la richesse spécifique (RS) et des indices de Shannon-Weaver (H') et d'équitabilité de Pielou (E) dans les cinq communautés épibiontes de *P.nobilis*.

L'étude de la diversité des communautés épibiontes de *P. nobilis* révèle que l'indice de Shannon-Weaver oscille entre un minimum de 2,19 bits

à Njila et un maximum de 3,11 bits au niveau de la station de Téboulba. Quant à l'indice d'équitabilité, il est compris entre 0,55 à Njila et 0,77 à Sidi Rais (Fig.1). Les valeurs minimales de ces deux indices ont été enregistrées dans la station lagunaire et celle située entre la lagune et la mer. Quant aux valeurs maximales, elles ont été notées au sein des stations marines.

Le dendrogramme de la classification hiérarchique des cinq stations d'étude (Fig.2) a permis de séparer trois assemblages : le premier est formé par les stations marines (Sidi Rais, Stah Jaber et Téboulba), le second est représenté par la station d'Echaâra, située sur le canal reliant la lagune de Bizerte à la mer. Quand au troisième regroupement, il est représenté par la station lagunaire de Njila.



Fig. 2. Dendrogramme de la classification hiérarchique des cinq stations étudiées (EC : Echaâra ; NJ : Njila ; SR : Sidi Rais ; SJ : Stah Jaber ; TB : Téboulba).

Ainsi, malgré la variabilité de la composition spécifique de la faune épibionte du Jambonneau, notée au niveau des communautés étudiées, les Mollusques constituent le taxon le plus dominant quelque soit la station. Ces résultats sont conformes à ceux observés par Zavodnik [1] en Adriatique. En outre, les variations des valeurs des indices de Shannon-Weaver et d'équitabilité de Pielou observées indiquent que les peuplements épibiontes de *P. nobilis* sont plus diversifiés et plus équilibrés en milieu marin qu'en milieu lagunaire. Cette riche faune épibionte met en évidence l'intérêt écologique de ce bivalve. Il s'agit en effet d'"un vrai "micro-écosystème et un abri pour plusieurs espèces de macro-invertébrés. La grande nacre contribue ainsi à la richesse spécifique des écosystèmes où elle se rencontre.

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# INTERANNUAL AND BATHYMETRIC VARIATIONS IN BODY SIZE OF *CALANUS HELGOLANDICUS* (COPEPODA: CALANOIDA) DIAPAUSING POPULATIONS IN THE NORTH AEGEAN SEA

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### Abstract

Significant interannual differences in abundance and size distributions of diapausing *Calanus helgolandicus* populations were observed between four years in the North Aegean Sea (NA) implying a strong variability in the physical regime during the reproduction period. Moreover, a clear increase of mean size with depth was evident in all diapausing populations, possibly related to the overwintering depth selection of the individuals.

Keywords : Aegean Sea, Copepoda, Deep Waters.

#### Introduction

*Calanus helgolandicus* comprises an important part of the zooplankton biomass in the offshore as well as coastal European waters and presents an interesting vertical distribution pattern during its life cycle [1]. The North Aegean Sea, in Eastern Mediterranean, forms a suitable area for the study of this species due to its topography (a deep basin close to the continental shelf) and hydrology (Black Sea Water influence).

#### Materials and Methods

Stratified mesozooplankton sampling was carried out in September 1989, 1997, 2003 and in July 2004 over the Lemnos deep basin (max. depth 1640m) in the North Aegean Sea with a vertically towed WP2 net (200  $\mu$ m). More details for the sampling layers are shown in Fig.2. Total and relative abundance of *C.helgolandicus* copepodite stage V (CV) were estimated. Prosome length (PL) of up to 400 individuals (CV only) was determined in each sample under a stereomicroscope (accuracy ±40  $\mu$ m).

#### Results and Discussion

*C. helgolandicus* was the dominant species in mesozooplankton below 500 m during all cruises, whereas it was absent in the upper 200 m. Mean abundance values of the population below 500 m (18 ind.m<sup>-3</sup>, 19 ind.m<sup>-3</sup>, 104 ind.m<sup>-3</sup> and 20 ind.m<sup>-3</sup> in 1989, 1997, 2003 and 2004 respectively) were the highest reported in the Mediterranean for diapausing populations of the species [1], thus indicating the existence of favorable conditions during the reproduction period (December-May) at the surface layer [1].

Mean values and range of *C.helgolandicus* PL varied significantly among years (Fig.1). Highest values were observed in 2003 (PL= $2.10\pm0.12$ ) whereas lowest in 1989 (PL= $1.91\pm0.14$ ). Temperature and food are considered as the two main factors controlling body size in copepods [2], hence we may assume that their interannual variability in the surface layer during winter/spring, influenced the body size, as well as the abundance of the species. Temperature variability is expected in the study area due to the seasonal and annual variability of the BSW (colder and less saline than Aegean Sea water) outflow intensity and circulation [3]. Variability in food concentration is also expected as the presence of BSW creates a permanent thermohaline front, strongly affecting phytoplankton and zoo-plankton biomass [4].

A significant increase (ANOVA & SNK tests) in mean prosome length with depth was evident in the overwintering populations (Fig.2). This gradual increase might be indirectly related (mainly through stored lipids) with the maintenance of neutral buoyancy during diapause. The maximum amount of stored lipids has been correlated with PL in *C.finmarchicus* [5] and the depth of neutral buoyancy is strongly affected by the amount of lipids in diapausing organisms [6]. Thus, in our case, a possible scenario is that bigger animals, assuming they have stored more lipids, attain neutral buoyancy at greater depth. Supporting evidence comes from *C. finmarchicus* in the Gulf of Maine [5] where a strong separation in oil-sac fullness between depths was evident in the 0-100 m layer and the authors conclude that "*Strong sorting* (i.e. in oil-sac fullness or size with depth) *apparently requires availability of depths greater than 100 m.*". However, further investigation is needed for any safe conclusions on this topic.

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Fig. 1. Prosome length distributions of C. helgolandicus CV.



Fig. 2. Box plot graphs of *C. helgolandicus* PL in different years and layers.

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# UNE APPROCHE ÉCOLOGIQUE DE LA STRUCTURE DES PEUPLEMENTS: UNE APPLICATION SUR LE MACROBENTHOS DES MILIEUX PORTUAIRES.

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# Résumé

L'analyse de la structure des peuplements est décrite à partir les indices de diversité spécifique et des Diagrammes Rangs Fréquences (DRF). L'étude des variabilités saisonnières, spatiales et les changements de structure des peuplements, ont permis d'établir des seuils d'équilibre pour les peuplements du port d'Alger indiquant un peuplement inexistant, en déséquilibre fort, en déséquilibre, en léger déséquilibre et en équilibre. L'application portant sur l'ensemble des analyses révèle des états de peuplement non structuré, peu structuré et structuré.

Mots clès : Bio-indicators, Biodiversity, Zoobenthos, Pollution.

L'étude analytique des peuplements des différentes stations du port d'Alger a permis de décrire et de comprendre la constitution des peuplements, et ce, en réponse aux contraintes du milieu. La structure des peuplements macrobenthiques du port d'Alger a été décrite à partir de la richesse spécifique, de la densité, des indices de diversité spécifique comme l'indice de Shannon (H') et d'équitabilité (E) et pour compléter l'information de la diversité qui est une valeur numérique, une représentation des Diagrammes Rangs Fréquences (DRF) a été utilisé décrivant les variabilités saisonnières et spatiales. De plus, les changements de structure des peuplements, mis en évidence, ont permis de comprendre le fonctionnement des peuplements des milieux soumis à des activités anthropiques [1-2].

Les valeurs obtenues ont montré que la constitution du peuplement est liée au gradient de pollution [1, 3] et des seuils d'équilibre ont été déterminés pour les peuplements de chaque bassin du port d'Alger. Les résultats ont montré que :

- Les plus faibles valeurs de diversité sont observées dans les secteurs les plus confinés ; par contre, les plus élevées dans les secteurs sous l'influence des eaux du large.

- Le peuplement est en équilibre dans les secteurs sous l'influence des eaux du large

- Le peuplement est en léger déséquilibre, au niveau de la passe nord

- Le peuplement est en déséquilibre dans le bassin d'évolution des navires du Vieux Port et la partie adjacente de l'Agha,

- Le peuplement en fort déséquilibre dans le bassin de Mustapha et dans la partie adjacente du bassin de l'Agha.

L'analyse de l'évolution des peuplements du port d'Alger [3-5] a permis de déterminer des états de peuplement non structuré, peu structuré et structuré. Chaque état introduit la dynamique des peuplements qui le composent et de la stratégie adaptative des différentes espèces pour passer d'un état de succession écologique à un autre.

 Pour l'Etat 1 d'évolution, le peuplement peu diversifié, est constitué d'espèces de stratégie r. Cet état permet de passer d'un peuplement non structuré vers un peuplement structuré si les conditions s'améliorent et inversement si les conditions deviennent défavorables

- Pour l'Etat 2, pour la transition d'un peuplement peu structuré vers un peuplement structuré et inversement, le processus est plus complexe. Le peuplement est diversifié et les espèces à stratégie K de différents groupes écologiques se mettent en place.

L'Etat 1 d'évolution de la structure des peuplements est retrouvé dans le bassin de Mustapha du port d'Alger.

L'Etat 2 d'évolution de la structure des peuplements est observé dans le bassin du Vieux Port d'Alger.

Les facteurs biotiques et abiotiques conditionnent l'installation d'un peuplement qui évoluera en fonction du gradient de anthropique permettant la mise en place, la présence, la pérennité et par conséquent la bio-écoéthologie des espèces.

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# RELATIONSHIP BETWEEN TEMPERATURE AND FISHERIES: THE CASE OF *PAGELLUS ACARNE* IN THE NW MEDITERRANEAN

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# Abstract

Sea Surface Temperature (SST) and landings series of axillary seabream, *Pagellus acarne*, were analysed in order to establish the possible effect of temperature on the abundance of this species. Both series, with a two year lag, showed a similar pattern suggesting a relationship between Mediterranean sea warming and increasing *P. acarne* landings. *Keywords : Temperature, Western Mediterranean, Teleostei, Fisheries.* 

#### Introduction

A warming trend in Mediterranean waters has been reported during the last decades, both at surface, as well as in deep waters [1, 2]. It could be assumed that these changes would mainly affect those species of warmwater origin that spawn in summer. In addition, temperature increase would affect gonad maturation, as well as survival and growth of planktonic eggs and larvae. In this regard, there is evidence in the study area that these changes affect the abundance and distribution of some pelagic fish species [3]. Axillary seabream, *Pagellus acarne*, is a subtropical species distributed in the Eastern Atlantic (Bay of Biscay to Senegal) and the Mediterranean Sea. The spawning period in the Mediterranean extends from July to October and eggs and larvae are planktonic. This species is fished mainly by bottom trawl and artisanal fleets in coastal waters down to 200 m depth, as by-catch species [4]. Landings are mainly made up of individuals belonging to age classes 1+ (mainly 2 years old); individuals smaller than 15 cm are discarded.

In the present study, temperature and landings series were analysed in order to establish the possible effect of temperature on the abundance of axillary seabream in the Catalan coast (NW Mediterranean).

#### Material and Methods

Data on *Pagellus acarne* annual landings (1988 to 2004) were recorded along the Catalan Coast (NW Mediterranean;  $40.5^{\circ}N - 42.4^{\circ}N$ ). Considering the latitudinal pattern of temperature in the area, with higher temperatures south of Barcelona, landings were analysed separately: North area (from Barcelona to the French border;  $42.4^{\circ}N - 41.4^{\circ}N$ ) and South area (southwards Barcelona to the Ebre Delta;  $41.3^{\circ}N - 40.5^{\circ}N$ ). Linear regression was used for the analysis.

Sea Surface Temperature (SST) data (1982 - 2004) were obtained from COADS data base [5] (1° square centre 40.5°N 1.5°E). For comparison with landings data, summer temperatures (July to September), which correspond to the spawning and planktonic life of *P. acarne*, were used. Taking into account the age composition of the landings, a two years lag was considered between both series.



Fig. 1. *Pagellus acarne* annual landings (1988-2004) in the southern (- -) and northern (-o-) Catalan coast (significant increasing trend in the South area, p<0.05).

Results and Discussion

Landings showed an increasing trend (Fig. 1). Both series were highly correlated (r = 0.77), but the increasing trend was only significant in the South area (p<0.05). Therefore, the relationship between SST and land-

ings was analyzed in the southern area. Both series exhibited a similar pattern (Fig. 2). Thus, years with high landings corresponded to high temperature values two years before, and conversely, low landings were related with low temperatures. These results highlight a clear relationship between sea warming and increasing *P. acarne* landings. Considering that *P. acarne* is not a target species, the influence of environmental factors on their reproductive biology could be stronger than in other species more subjected to fishing pressure.



Fig. 2. *P. acarne* annual landings in year (t) (solid line) from the southern area and summer SST in year (t-2) (dashed line).

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# PRELIMINARY ESTIMATION OF THE POPULATION SIZE OF CUVIER'S BEAKED WHALE (ZIPHIUS CAVIROSTRIS) IN THE NORTHERN LIGURIAN SEA

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# Abstract

This work aimed to estimate the size of the cuvier's beaked whale population using data collected during 7 years of cetacean survey, carried out in the Ligurian sea. The data collected from 2004 to 2005 lead to an estimation of  $94\pm23$  (using right sides) and  $85\pm18$  (using left sides) different animals.

Keywords : Cetacea, Ligurian Sea, Population Dynamics.

#### Introduction

Cuvier's beaked whale is a poorly-known cetacean species and stranding data indicates that the beaked whale is present all along the Ligurian coast. *Ziphius cavirostris* has been considered common in the Ligurian sea since the sixties but no estimation of population size was carried out until now. This species has hardly been studied, chiefly due to his elusive behaviour. This population, as other population of marine mammals, is subject to different and intensive human activities so conservation and management strategies are needed. An integral part of any management strategy is the assessment of the individual number of the population and any trends in abundance [1]. In order to fill this gap this paper presents the results of a preliminary mark-recapture study, to estimate the absolute size of the population of cuvier's beaked whale in these area.

#### Materials and methods

Photographs were taken from 1998 to 2005 in the Ligurian Sea (Figure 1), during scientific surveys operated by the Department of Biology of the University of Genova and by Woods Hole Oceanographic Institution (WHOI) scientists; during daily whalewatching cruises operated by bluWest. The sampling protocol was to shot as many animals as possible, from both right and left sides, in each herd. The individuals were identified from features such as nicks, scrapes, scars, deformities, and epidermal disease on both their dorsal fin and flanks. Were considered marked only individuals showing one long-lasting mark at least, as described by Ballardini et al. 2005 [2].





All pictures, obtained using 35mm cameras equipped with 100-400 zoom lenses, were examined and ranked according to their quality, from 1 to 6, with 6 representing the highest quality [3], and placed on file. Only photos ranked as  $\geq$ 3 have been used in the analysis.

The data collected during 2004 and 2005 were used to calculate the population size and the analysis were estimated with CAPTURE program, using the model M(h) Chao which supposes an individual heterogeneity in capture probabilities. To obtain the variance and the standard deviation it was applied the method proposed by Wilson and Hammond [4].

#### Results and discussion

During surveys 90 sightings of cuvier's beaked whales heard occured. 52 different hight marked individuals were identified using the left side and 53 by the right side. The estimates of the proportion of hight marked whales for these data set are 0,72 (right) and 0,77 (left) of the whales, these values are greater than the ones found in other species of the ziphidae family, like *Hyperoodon ampullatus* [3]. The estimates of the total number of the cuvier's beaked whales in studied area, during 2004 and 2005, are  $94\pm23$  (mean  $\pm$  st.deviation; cv=0,24) for the right side and  $85\pm18$  (cv=0,21) for the left side, confirming *Ziphius cavirostris* as common species in the northern Ligurian sea.

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# CAPTURES ACCESSOIRES DE REQUINS DANS LE GOLFE DE GABÈS

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#### Résumé

Les pêcheries opérant dans le golfe de Gabès capturent accidentellement les requins. Ces engins pêchent les espèces rares et les juvéniles des espèces communes ce qui pourrait porter préjudice aux populations de requins dans la région. *Mots clès : Gulf Of Gabes, Fishes, Fisheries.* 

#### Introduction

Les requins constituent des prises accessoires des pêcheries ciblées sur les poissons osseux et les crustacés. La connaissance de ces pêcheries et de leurs effets sur les espèces sont requis pour des mesures de gestion. Dans ce travail, nous étudions les captures accidentelles des requins dans le golfe de Gabès.

#### Matériel et méthodes

Notre étude a été basée sur l'examen des apports de la pêche dans les principaux ports du golfe de Gabès entre janvier 2001 et juin 2005. Pour chaque spécimen, le sexe et la longueur totale (LT) au mm près sont notés. Pour statuer sur les prises des requins, les structures des débarquements des captures au chalut de deux espèces communes sont analysées.



Fig. 1. Distribution des fréquences des tailles de *Mustelus mustelus* (A) (n = 600) et de *Carcharhinus plumbeus* (B) (n = 350). Tm : Taille de la maturité sexuelle.

#### Résultats et discussions

Dans la région du golfe de Gabès, la production moyenne annuelle en requin est de 750 tonnes. Plus de 20% de cette production provient des captures accidentelles au chalut. Les espèces communes (émissoles *Mustelus* sp et le requin gris *Carcharhinus plumbeus*), ciblées par la pêche artisanale, sont prises accidentellement par le chalut le long de l'année [1]. L'essentiel des débarquements de *M. mustelus* et de *C. plumbeus* par

le chalut est composée d'individus n'ayant pas atteint la taille de première maturité sexuelle (Fig. 1). L'abondance des juvéniles dans les captures suggère que cette région semble être une nursery et une frayère pour ces espèces.

Plus de 80% des captures de *Hexanchus griseus* et environ 30% des captures de *Carchrodon carcharias* sont rapportés au chalut. Par ailleurs, 70 % des captures du requin blanc sont ramenés par la senne tournante.

Les palangres de surface, ciblant l'espadon, ramènent accessoirement *Isurus oxyrinchus* et les Carchahinidés. Les palangres de fond, utilisées surtout pour la capture des mérous, pêchent également les Triakidés et les Squatinidés.

Les caractéristiques biologiques des requins, telles que la maturité sexuelle tardive et la faible productivité, les rend très vulnérables à la pêche [2]. Une gestion judicieuse des requins consiste à réduire l'impact des pêcheries, plus particulièrement dans les zones côtières qui sont utiliseés comme nurseries par plusieurs espèces.

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# DIET AND FEEDING HABITS OF *SIGANUS RIVULATUS* AND *S. LURIDUS* TWO RED SEA MIGRANTS IN THE SYRIAN COASTAL WATERS (EASTERN MEDITERRANEAN)

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# Abstract

Deux espèces de Siganidae : *Siganus luridus* et *S. rivulatus*, originaires de la mer Rouge, ont établit des populations importantes dans les eaux côtières de Syrie ; formant 55% du rendement de la pêche côtière. L'analyse du contenu stomacal de ces deux espèces montre des restes d'espèces d'algues vertes, rouges, brunes, confirmant leur régime alimentaire herbivore sélectif. L'adaptation éco-physiologique et alimentaire au milieu marin des côtes levantines, différent de celui de la mer Rouge, leur a permis d'installer des populations permanentes. *Keywords : Coastal Waters, Fish Behaviour, Algae, Levantine Basin, Fishes.* 

#### Introduction

Being herbivorous, the Siganus species need a big quantity of algal food to assure their biological activities. The stomach of these fishes is an acid medium able to digest marine plants before entering in the digestive tract for complete digestion and thus excreting feces. In addition to algal food, they can feed accidentally on some non digestible substances such as mollusk shells and other invertebrates attached to algae [1, 2]. The diet and nature of food and feeding habits of siganids were the subject of many investigations in several geographical areas. The two considered species in our study Siganus rivulatus and S. luridus, which are of Indo-Pacific and Eritrean origin, have migrated and adapted to the Levantine sea environment, where they found different algal food from that of the Red Sea. They were obliged to change their diet and feeding habits in order to establish populations in the coastal waters. During the last decades, several investigations were conducted with regard to the feeding regime of some siganids in the Red Sea and in the Eastern Mediterranean [3-6]. In this paper we present data on the diet composition and the feeding regime of S. rivulatus and S. luridus in the Syrian coastal waters.

#### Material and Methods

Samples were taken bimonthly during 2002 at three different areas along the Syrian coast: Lattakia, Tartous and Banias ( $34^{\circ} 40'$ - $35^{\circ} 50'$  N;  $35^{\circ} 50$ - $36^{\circ} 05'$  E). Soon after catching, the stomach and intestine were separated and preserved in 10% formaline for further content analysis. The percent of filled intestine was divided into six categories according to their filled volume; 1: completely empty intestine (0% filled), 2: almost empty intestine (1-25% filled), 3: half empty (26-50%), 4: almost filled (51-75%), 5: completely filled (76-100%), 6: over-filled (>100% filled). After measuring the length, the intestine was dissected longitudinally to extract the content, weighted and transferred into Petri dish for microscopic analysis. After the extraction of all the content, the empty intestine was weighted. The nature of the food content and composition were determined under dissecting and research microscopes. Four coefficients were used to describe the digestion efficiency in *Siganus* species [1, 4].

1-Coefficient of Vacuity of the intestine (CV). This coefficient is calculated by the formula:  $CV=EV / N \ge 100$ , where EV is the number of examined individuals with empty stomach, N is the total number of intestines analyzed. This index reflects the richness or poverty of the environment in food.

2-General Nutrition Coefficient (EP). It is calculated by the equation EP=Es/Pt x 100, where Es is the weight of filled intestine, and P is the body weight. It estimates the % exploitation of food resources available in the environment.

3-Environmental Coefficient Factor (RES). This coefficient is calculated by the formula RES = $Pv/Pt \ge 100$ , where Pv is the weight of digestive tube+liver+spleen, and Pt is the total body weight. It represents the ratio of internal viscera weight over the body's weight.

4-Frequency of Predation Coefficient (Fp). It is calculated by the formula  $Fp = N/M \times 100$ , where N is the number of intestine containing the food, and M is the number of filled intestines. It represents the percent of food prey (algae) available in the environment and the frequency of the surveyed fish to exploit it.

#### Results and discussion

In *Siganus rivulatus* during April the CV was 0% when algal coverage was 65%; during September-October CV was 100%, coinciding with 10% coverage. In Tartous area, *S. luridus* showed CV=90% in October and in Lattakia 80% in February.The minimum EP of *S. rivulatus* was 5% in February and the maximum was 18% in April. The RES was 23% in *S. rivulatus* male and 10% in female during March, whereas during July RES was 10% in male *S. rvulatus* and 16% for females. The Fp was 40% for *Cladophora* and *Enteromorpha*, and 2% for *Gigartina*, *Padina* and *Sargassum*.

*S. rivulatus* and *S. luridus* feed all the time without discontinuity, even during the reproduction and spawning periods that take place in spring. Several varieties of algae were identified in the intestine contents, with prevalence of green algae such as *Ulva*, *Cladophora* and *Enteromorpha*. *S. luridus* seems to be less tolerant to food selection, although the frequency of grazing (Fp) was slightly higher than that in *S. rivulatus*. Some non digested substances were observed in the digestive tubes, such as mud, sand grains, and other debris of phanerogams, which are present in the area, namely *Zostera*, *Halophila* and *Cymodocea*.

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# POT FISHERY OF RAPANA VENOSA VALENCIENNES 1846 IN THE SOUTHEASTERN BLACK SEA

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# Abstract

A survey was carried out to test the effectiveness of three pot designs and location in catching whelk in the southeastern Black Sea of Turkey in July and August 2006. A total 225 pots and 5 fishing trips were conducted. The type III (plastic container) pot appears to be most suitable for future based on the whelk catch rate.

Keywords : Gastropods, Black Sea.

#### Introduction

*Rapana venosa* are large predatory marine gastropods that, to date, are the progenitors of known successful invasions into estuarine habitats around the world. Although native to Asian waters around Japan and Korea, rapa whelks were discovered in Novorosisk Bay in the Black Sea in the mid 1940s and have spread throughout the Aegean, Adriatic and Mediterranean Seas [1, 2] and entered the Chesapeake Bay, Virginia [3], and Uruguay and Argentina [4].

Whelks are commonly caught using dredging or diving in Turkey. The prohibition for whelk fishing is from 1 May- 31 August. Harvesting whelks using pots is applied commonly Canada, Northern Europe and Japan. Pots are often considered a more beneficial type than dredges because there is less impact on the bottom habitat and by-catch can be minimal, depending on the design of the pot [5].

The objective of this research was to determine whether fishing for whelks using pots is an effective method to catch them, and whether this pot type would capture enough whelks to support a fishery. Both objectives were assessed by measuring catch per fishing effort (CPUE) between different pot types with various types of bait including whiting, mussel and ray. The main objective of the survey was to test three different pot types with respect to the effectiveness for catching whelk, the side effects of by-catching other species and identifying an ideal pot type to be used in future surveys of whelk populations.

#### Material and Method

The survey was carried out in summer 2006 in southeastern Black sea of Turkey (Trabzon and Ordu). Fishing was conducted along the coasts at 10 m depths. The pots were fished on strings of 45 pots, setting pot types I, II and III respectively (Fig. 1). The backline was weighted at either end of the pots with an anchor and terminated on the surface, marked by a buoy. A total 225 pots were used. Fishing was conducted using three different pot types. The gear was rigged with pots on 2 m tails attached to a backline at 15 m interval. Frozen offal mainly of mussel, whiting, and ray was used as bait. The catch in each pot of whelk was weighted and, in most cases, 100 randomly chosen individuals were measured to the end of the siphonal canal. By-catch species were identified. CPUE was expressed as kg per pot.



Fig. 1. Whelk pot types I, II and III respectively.

#### Results

In total, 225 pots in 5 fishing trips were executed in summer. The total catch was 188.87 kg. Total average CPUE of whelk was 0.536, 0.594 and 1.136 kg per pot/day in Trabzon and 0.837, 0.758 and 1.996 kg per pot/day in Ordu for type I, II, III, respectively. CPUE varied significantly between areas and whelk pot types (P<0.05) (Fig. 2). The major by-catch species was harbour crab (*Liarcinus depurator*) and goby (*Gobius sp.*). Whelks in pots were 56.43 $\pm$ 0.808 (30.74 - 96.76) mm for Trabzon and 66.73 $\pm$ 0.873 (39.46-94.86) mm for Ordu in shell length.



Fig. 2. *R. venosa*: CPUE at different whelk pot types in Trabzon (Grey bar) and Ordu (white bar). Error bars represent 95 % confidence intervals.

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# HARPACTICOIDS (CRUSTACEA, COPEPODA) ASSOCIATED WITH MACROPHYTES FROM THE ROMANIAN BLACK SEA WATERS

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### Abstract

The paper presents the qualitative composition and makes a synecological evaluation (F %, D %, W %) of harpacticoids variation living associated with macrophytes in the north sector of the Romanian Black Sea shallow waters. Some data about their density in different sites from quantitative algae samples will be analyze, in order to highlight characteristic species and their distribution. *Keywords : Algae, Black Sea, Copepoda, Crustacea.* 

Most of the former studies of Romanian marine harpacticoids associated with macrophytes contain taxonomic observations or represent descriptions of new species. There are only few quantitative data which can explain the modification of qualitative and quantitative state of benthic communities of the Black Sea as result of increasing eutrophication and pollution, mainly in its NW corner [1].

Quantitative samples were taken from the hard substratum, in the north sector of the littoral, seasonally (during a period of five years) from a depth of 0, 5 - 5 m, using a metal scarper and plastic bags, on a  $20 \text{ cm}^2$  area. The most frequent species of algae were *Ceramium rubrum, Enteromorpha intestinalis, Cladophora sp.*, and in spring *Bryopsis plumosa* and *Porphyra leucosticta.* The locations were: Cap Midia - Navodari, Mamaia - Cazino, Mamaia - Fishery, Constanta - Cap Singol. The samples were processed under standard techniques and results were reported at 1 m<sup>2</sup> area. Data from the south sector were presented in a previous paper [2].

26 harpacticoids species were identified. Density values are the greatest for Cap Midia with populations of more than 2000 ind.  $\cdot m^{-2}$  in case of Ameira parvula and Mesochra pontica. Canuella perplexa and Ectinosoma normani recorded around 1000 ind. $m^{-2}$  and another three more than 1500 ind. $\cdot m^{-2}$  (from artificial dams with *Cladophora* and *Entero*morpha). In Mamaia Casino infralittoral waters, even we recorded the most numerous species (20), only five of them have densities values from 700 to 1600 ind. $m^{-2}$ . Canuella perplexa has the highest number of individuals in this zone and it can be considered as characteristic species (Table 1). At Mamaia Fishery density values are less than 600 ind. $\cdot m^{-2}$ . Mesochra pygmaea presents the most numerous individuals being a eudominant, characteristic species for this biocoenosis. Recording great densities is Ameira parvula with a frequency of 60% and an ecological relevance (W %) of 9.05, on rank 2. In Cap Singol (Constanta) zone, Harpacticus littoralis attend more than 750 ind.  $m^{-2}$ , comparing to the other species which have very low densities values.

From synecological data (Table 1, 2) results that the most frequent harpacticoid was *Ectinosoma melaniceps* even it is only an accessory species for most studied zones; the greatest dominance value was recorded in Mamaia Casino for *Canuella perplexa* and the lowest is in the same zone for *Thalestris longimana; Mesochra pontica* records a constant dominance in the first three studied sites; the highest ecological relevance value - W% - is registered for *Harpacticus littoralis* in Constanta shallow waters- as eudominant, characteristic for this zone.

Tab. 1. Synecological analysis (frequency, dominance) of most encountered harpacticoids. Legend: (1. Navodari - Cap Midia= N.C.M.; 2. Mamaia Casino = M.C.; 3. Mamaia Fishery = M.F.; 4.Constanta - Cap Singol = C.C.S.).

| Species                      | F (Frequency %) |        |        | D (Dominance) |           |         |         |           |  |
|------------------------------|-----------------|--------|--------|---------------|-----------|---------|---------|-----------|--|
| -                            | 1. N.C.M.       | 2. M.C | 3. M.F | 4. C.C.S.     | 1. N.C.M. | 2. M.C. | 3. M.F. | 4. C.C.S. |  |
| Canuella perplexa            | 100             | 100    | 40     |               | 8,08      | 17,28   | 3,38    |           |  |
| Ectinosoma melaniceps        | 100             | 100    | 60     | 60            | 3,96      | 7,86    | 7,45    | 4,27      |  |
| Harpacticus littoralis       | 100             |        |        | 100           | 12,43     |         |         | 50,32     |  |
| Altheuta typica              |                 | 100    | 80     | 40            | 4,66      | 9,95    | 8,88    |           |  |
| Thalestris longimana         |                 | 60     |        | 80            |           | 0,54    |         | 7,24      |  |
| Paradactylopodia brevicornis |                 | 40     |        | 80            |           | 2,81    |         | 13,81     |  |
| Ameira parvula               | 100             | 60     | 60     |               | 15,6      | 4,93    | 15,08   |           |  |
| Mesochra pygmaea             | 100             | 80     | 80     |               | 16,06     | 5,8     | 19,49   |           |  |
| Mesochra pontica             | 100             | 80     | 20     |               | 13 77     | 11 27   | 10.34   |           |  |

The identified harpacticoids species which are living associated with macrophytes algae are not strictly phytophyle, many of them being encountered on other rocky faces, among mussels or stones fragments; they have eurybiontic particularities, being adapted to great variations of environmental conditions.

The actual algal communities consist only of species belonging to some genera like: *Ulva, Enteromorpha, Cladophora* and *Ceramium* which per-

sist and proliferate in eutrophic waters, covering the hard substratum up to 90%.

Tab. 2. Synecological analysis (ecological relevance, rank) of most encountered harpacticoids. Legend: (1. Navodari - Cap Midia= N.C.M.; 2. Mamaia Casino = M.C.; 3. Mamaia Fishery = M.F.; 4.Constanta - Cap Singol = C.C.S.).

| Species                      | W (Ecological relevance %) |        |        |          | R (Rank) |        |        |           |
|------------------------------|----------------------------|--------|--------|----------|----------|--------|--------|-----------|
|                              | 1. N.C.M.                  | 2. M.C | 3. M.F | 4. C.C.S | 1. N.C.M | 2. M.C | 3. M.F | 4. C.C.S. |
| Canuella perplexa            | 17,29                      | 3,39   | 1,35   |          | 6        | 1      | 11     |           |
| Ectinosoma melaniceps        | 3,96                       | 7,86   | 4,47   | 2,56     | 9        | 3      | 4      | 7         |
| Harpacticus littoralis       | 12,44                      |        |        | 50,32    | 4        |        |        | 1         |
| Altheuta typica              |                            | 4,66   | 7,59   | 3,55     |          | 6      | 3      | 5         |
| Thalestris longimana         |                            | 0,32   |        | 5,79     |          | 20     |        | 3         |
| Paradactylopodia brevicornis |                            | 1,13   |        | 11,05    |          | 14     |        | 2         |
| Ameira parvula               | 15,6                       | 2,96   | 9,0    |          | 2        | 10     | 2      |           |
| Mesochra pygmaea             | 16,06                      | 4,64   | 15,59  |          | 1        | 7      | 1      |           |
| Mesochra pontica             | 13,77                      | 9,02   | 2,06   |          | 3        | 2      | 10     |           |

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# MARINE FAUNA ASSOCIATED WITH LOLIGO VULGARIS IN CATALAN WATERS (NW MEDITERRANEAN)

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# Abstract

Fauna occurring in association with *Loligo vulgaris* was investigated by sampling on board commercial trawlers in two ports of Catalonia (NW Mediterranean) from October 2003 to December 2005. The composition of the hauls was similar in both ports but the biomass (kg/hour) captured by species varied according to the port. *Octopus vulgaris* and *Merluccius merluccius* were found in 100% of the trawls with *L. vulgaris* in both ports.

Keywords : Biomass, Cephalopods, Western Mediterranean.

#### Introduction

*Loligo vulgaris* have a very important economic value in southern European countries. Much is still to be known about this species in northwestern Mediterranean, and one area of particular interest is its interrelationships with the accompanying fauna. In Catalan waters, marine communities have been classified with regard to the most abundant species, both fishes [1] and cephalopods [2] but not the total community. The aim of this study is provide a better insight into the communities where *L. vulgaris* is found.

#### Material and Methods

Sampling was carried out on board commercial trawlers on a monthly basis, from October 2003 to December 2005 in Cambrils and Roses, Catalonia ports (NW Mediterranean). Differences between ports were tested with an "analysis of similarities" randomisation test (ANOSIM) from PRIMER statistical software.

#### Results and Discussion

ANOSIM test revealed that there are significant differences of the species composition in both groups of hauls (P < 0,001; R = 0,759).

Octopus vulgaris and Merluccius merluccius present 100% occurrence with L. vulgaris (Fig.1). Species like Sardinela aurita and Seriola dumerili have only appeared in the hauls carried out in Cambrils, while Eutrigla gurnardus has been captured only in Roses.

However the biomass (kg/hour) captured by species varied according to the port. *Merluccius merluccius* was more abundant in Roses while *Octopus vulgaris* was in Cambrils (Fig 2).

The species associated to the *L.vulgaris* captures showed that although they are mainly the same ones, the proportion of the appearance and mainly the biomass of the species is different in both ports. This can be due to that the characteristics of the habitat are different in the two areas and it rebounds in the species that inhabit each area. Roses area consists mainly of rocky coast, with predominance of sand and sandy muddy bottoms, while in Cambrils area the bottom is generally of muddy-sand and sand next to small formations of rocky barriers close to the coastal line [1].



Fig. 1. Percentage of occurrence of the most important *Loligo vulgaris* associated species in the two study ports.



Fig. 2. Biomass of the most important *Loligo vulgaris* associated species in the two study ports.

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# TRAWLING EFFORT ESTIMATION IN TWO FISHING GROUNDS FROM THE CENTRAL AND NW MEDITERRANEAN: DIRECT VS. INDIRECT METHODOLOGIES

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#### Abstract

The otter trawl fishing effort from two fishing grounds, located in the Catalan and northern Adriatic Sea was estimated using direct and indirect methods. The direct estimation monitored the trawl fleet activity, whereas the indirect estimation was based on monitoring the trawl tracks on the sea floor by side scan sonar. A significant relationship between the two methods suggested the utility of the indirect estimation as indicator of fishing effort.

Keywords : Adriatic Sea, Western Mediterranean, Fisheries.

#### Introduction

A small-scale estimation of the spatio-temporal distribution of fishing effort on trawling grounds is of paramount importance to develop a management based on fishing effort control. The aim of the present work is to estimate fishing effort at the smallest scale possible by means of direct and indirect methods.

#### Methodology

The study, carried out during 2003 and 2004, analyses the fishing activity of two commercial trawling fleets that operate at Sant Carles de la RÃ pita (Catalan Sea, NW Mediterranean) and Fano (Adriatic Sea, Central Mediterranean).

To obtain a small-scale information on spatio-temporal pattern of fishing activity, different sampling methods have been considered. Firstly, fishing effort was directly estimated by: (i) monitoring daily landings per vessel at the auction, (ii) interviews with fishermen, and (iii) sampling on board. Data on fishing hours per month (h) were converted in Direct Effort Index, D.E.I. = (h ·s ·w ) / A, where s is the mean trawling speed (4.6 km/h in the Catalan Sea and 5.5 km/h in the Adriatic Sea), w is the mean distance between the two doors of the gear (0.06 km), and A is the total surface of each study area.

Secondly, an Indirect Effort Index, I.E.I. was applied, following the temporal evolution of the trawl tracks on the bottom of a 1 km<sup>2</sup> area (S). Data were obtained by Side Scan Sonar (SSS) [1]. I.E.I was calculated as: (w  $\cdot L/2$ ) / S, where L is the total length of the trawl tracks. The relationship between D.E.I. and I.E.I. was estimated with linear regression.

#### Results and Discussion

D.E.I.: three main periods of fishing activity have been identified. In the Catalan Sea: high effort season from September to February, low from March to June, fishing closure in July and August. In the Adriatic Sea: high fishing activity from January to June, low from July to December, fishing closure from August to middle September (Table 1).

Tab. 1. Direct and indirect estimates of the trawl effort (A= Adriatic Sea, B= Catalan Sea).

|            |                                                                                                                                                                                                                                 | 4      |                                           | В   |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------|-----|
| Month      | A       I.E.I.     D.E.I       03     1.8     1.7       03     0.8     1.1       03     0.8     1.1       03     0.2     0.0       03     0.5     0.8       03     0.5     0.8       03     0.8     1.0       04     1.9     04 | I.E.I. | D.E.I.                                    |     |
| March '03  | 1.8                                                                                                                                                                                                                             | 1.7    | 1.E.I.<br>1.7<br>1.2<br>1.3<br>1.5<br>1.8 | 3.7 |
| June 103   |                                                                                                                                                                                                                                 |        | 1.7                                       | 4.2 |
| July 103   | 0.8                                                                                                                                                                                                                             | 1.1    | 1.2                                       | 0.0 |
| August '03 |                                                                                                                                                                                                                                 | 0.0    | 1.3                                       | 0.0 |
| Sept. 103  | 0.2                                                                                                                                                                                                                             | 0.0    | 1.5                                       | 5.3 |
| Oct. 103   | 0.5                                                                                                                                                                                                                             | 0.8    |                                           |     |
| Nov. '03   | 0.8                                                                                                                                                                                                                             | 1.0    | 1.8                                       | 5.4 |
| March '04  | 1.9                                                                                                                                                                                                                             |        |                                           |     |
| June '04   | 1997                                                                                                                                                                                                                            |        | 1.1                                       | 2.3 |

I.E.I.: the images from SSS reflect the same pattern of fishing effort intensity obtained by the D.E.I.: high, low and cessation of fishing activity. A significant relationship was highlighted by ANOVA between direct and indirect effort indices (test  $F_{1,3}$ : p < 0.05, r = 0.923 for the Adriatic fishing ground; test  $F_{1,4}$ : p < 0.05, r = 0.818 for the Catalan one). In the Catalan Sea the best fit between these two measures was obtained using the accumulate value of three previous months as D.E.I. values, while in the Adriatic Sea the best correlation was obtained considering the values from the same month. These differences are related with the permanence of the trawl tracks on the bottom, a factor that depends by the characteristics of the sediment and determines the relationship with the (real) effort carried out on the trawl ground [2, 3]. These results suggest that SSS may be used as an independent approach for estimating the commercial fishing effort, at least in small areas.

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# DISTRIBUTION OF ANCHOVY (*ENGRAULIS ENCRASICOLUS PONTICUS*) EGGS AND LARVAE OFF SINOP IN 2003 (SOUTHERN BLACK SEA)

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### Abstract

In this study, distribution of anchovy (*Engraulis encrasicolus ponticus* Aleksandrov, 1927) eggs and larvae was investigated off Sinop (southern Black Sea, Turkey) in 2003. The mean egg quantity of anchovy was determined as  $27\pm9.26$  and  $80.6\pm34.52$  in vertical and horizontal plankton tows, respectively. Larvae numbers of anchovy in vertically and horizontally hauls were  $8\pm2.52$  and  $22.3\pm11.3$ , respectively. The spawning season of anchovy was confirmed to be between May and September. *Keywords : Ichthyoplankton, Black Sea*.

#### Introduction

Anchovy is the most important fish of the Black Sea constituting more than 60% of total catch [1]. This study aims to evaluate distribution of anchovy eggs and larvae off the coast Sinop of the southern Black Sea in 2003.

#### Material and Methods

The ichthyoplankton samples were collected at six stations. These stations were 1-4 miles off-shore off Sinop (southern Black Sea, Turkey) having a depth of 40-300 meters. Samples were collected monthly during the period January-December 2003 except August. The samples of the plankton were carried out from vertically tows from anoxic zone to surface using a plankton net (having a 50 cm diameter mouth opening and 210 mm mesh size). Horizontal hauls were also utilized by towing the net for 15 min at vessel speed of 2.5-3 miles  $h^{-1}$ . The samples were preserved with borax buffered 4% formaldehyde solution.

#### Results and Discussion

In generally, anchovy eggs and larvae were found from May to September. In vertical hauls, the most abundant eggs and larvae were found in July. In horizontal hauls, the most abundant eggs were found in July and most larvae were found in June. In vertical hauls, eggs and larvae ranged from 7.5 to 260 ind.m<sup>-2</sup>, and from 5 to 115 ind.m<sup>-2</sup>, respectively. In horizontal hauls eggs and larvae were found in the range of 0.4-159 ind.100 m<sup>-3</sup> and 2.6-52.1 ind.  $100m^{-3}$ , respectively. Previously, it was found that the anchovy eggs and larvae were 0-30 ind.m<sup>-2</sup> and 0-2 ind.m<sup>-2</sup>, respectively in 1991 and were 0-40 ind.m<sup>-2</sup> and 0-26 ind.m<sup>-2</sup>, respectively in 1992 [2].

Tab. 1. Average number  $(ind.m^{-2})$  of anchovy (*Engraulis encrasicolus ponticus*) eggs and larvae in the northern (Sevastopol Region) and the southern (Sinop Region) Black Sea in the summers of 2000, 2001 and 2003, from vertical tows.

| Period                 |       | Egg<br>Vertical<br>ind.m <sup>-2</sup> ) | Larvae<br>Vertical<br>(ind.m <sup>-2</sup> ) |            |  |
|------------------------|-------|------------------------------------------|----------------------------------------------|------------|--|
|                        | Sinop | Sevastopol                               | Sinop                                        | Sevastopol |  |
| *2000<br>(June-August) | 31.7  | 10.2                                     | 2.5                                          | 0.7        |  |
| *2001<br>(June-August) |       | 31.6                                     | -                                            | 1.2        |  |
| **2003<br>(June-July)  | 182   | -                                        | 49                                           | -          |  |

\*\*In this study

When results of this study are compared with previous studies, more eggs were found off Sinop coasts of Turkey than those in Sevastopol coast of Ukraine in vertical hauls. Moreover, the numbers were much higher in 2003 compared to 2002 (Table 1). The high numbers of eggs and larvae found in 2003 are in parallel with the highest landing values of anchovy in the same year (about 373 thousand tons [4]).

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# DISTRIBUTION OF THE ALIEN GASTROPOD RAPANA VENOSA IN THE NORTHERN ADRIATIC SEA

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## Abstract

A systematic survey on the invasive alien gastropod *Rapana venosa* was conducted in spring-summer 2004 along the Italian coast of the Northern Adriatic sea in collaboration with squid fishermen. Results showed a scattered distribution of the species between the localities of Marano and Fano (approximately 400 km). Maximum estimated population densities (>500 ind. km<sup>2</sup>) were recorded near the shores of Cesenatico; a comparison with a previous survey demonstrated that the local population of the gastropod has been rapidly increasing thus enhancing risk of invasion and of further spreading.

Keywords : Gastropods, Species Introduction, Coastal Waters, Mapping, Adriatic Sea.

#### Background

*Rapana venosa* (Valenciennes, 1846) represents a good example of a successful marine alien invasive species. This predatory gastropod has been increasing its biogeographical range moving from the native East Asian seas towards Europe and America thanks to ship ballast water and aquaculture transfer vectors. The whelk is internationally considered a serious menace to bivalve fisheries [1,2], being preferentially acclimated in estuarine/brackish water of coastal regions, where intensive bivalve harvesting usually takes place. The first findings of *R. venosa* in the Northern Adriatic Sea occurred in the 1970s when few specimens were collected by the shores of the town of Ravenna [3]; since then the introduced population has been growing undisturbed, being able to colonize the Northern Adriatic coasts of Italy [4]. In this communication we present the results of a field campaign, supported by the Italian Ministry of the Environment, aiming to assess the distribution of the alien gastropod in the Northern Adriatic.

#### Methods

In April 2004 an informative campaign was organised in order to obtain fishermen collaboration in five different localities of the Northern Adriatic: Marano (UD), Chioggia (VE), Goro (FE), Cesenatico (FC), Fano (AN). Three squid fishermen, each fishing over an area of about 10 km<sup>2</sup> per site were involved in the survey. Previous investigations in Cesenatico showed how squid-nets act as efficient sampling devices for the mature reproductive subset of the gastropod population [4]. Therefore squid-fishermen were asked to provide data on: nets location, water depth and number of gastropods captured at each control date for a period of four months (April to July). All samples collected were kept frozen (-18°C) for further structural analysis of the population (biometry, sex ratio, genetics).



Fig. 1. Northern Adriatic distribution of *Rapana venosa* catches by local fishermen in spring-summer 2004. M = Marano (UD); Ch = Chioggia (VE); G = Goro (FE); C = Cesenatico (FC); F = Fano (AN).

#### Results and discussion

Data analysis showed a patchy distribution of Rapana venosa with maximum catches (N >500 ind.  $km^{-2}$ ) concentrated nearby the littoral of Cesenatico at 0.5-10 km from the coast and at 2-15 m depth [Fig.1]. No specimens have been caught South of Fano and North of Marano, which so far represent respectively the southern and northern limit of Rapana distribution. Samples caught at the distribution limits appeared larger, thus older, than individuals caught in Cesenatico [Fig. 2]. In 2001 a survey conducted using the same methods, but only in Cesenatico [4], reported much lower total catches (302) and significative larger dimensions than specimens collected in 2004 (2001 shell height frequency distribution mode = 100; 2004 mode = 90; KS-test, D = 0.45 P < 0.001). Both parameters indicate that the local population of the gastropod was experiencing a phase of expansion. In conclusion this survey has claimed for action to manage and control Rapana population in this area, an important hot spot of dissemination of this NIS towards other localities of the Mediterranean sea.



Fig. 2. Modal values of the size frequency distributions (shell height, mm) of *Rapana venosa* specimens collected in: F = Fano, C'01: Cesenatico, year 2001, C: Cesenatico, G: Goro, Ch: Chioggia. Numbers in brackets represent the total sample size.

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# RAPIDO TRAWL FISHERY IN THE NORTH-CENTRAL ADRIATIC SEA

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### Abstract

This study gives a description of the catches produced by the commercial rapido trawl fleet of Ancona harbour (north-central Adriatic), mainly targeting the common sole, *Solea solea*. Observations onboard were carried out for two years. Catch data showed that the discarded part was greater than the retained one. Discard of commercial species was greater than discard of non-commercial ones, and both of them were dominated by few species.

Keywords : Adriatic Sea, Fisheries, Demersal.

#### Introduction

The rapido trawl fishery has been going on for over 40 years in the western side of the north-central Adriatic Sea where it is carried out all year round on the soft bottoms outside 3 nm offshore. Ancona is an important port for this fishery with a fleet of 10-11 rapido vessels (average Loa =  $27.7\pm0.4$  m) targeting flatfish (*Solea* spp., *Psetta maxima*, *Scophthalmus rhombus*). The rapido trawl is a modified beam trawl, with a rigid mouth fitted with iron teeth (7-10 cm long) along the lower part [1]. A nylon net bag having a codend mesh size ranging from 48 to 52 mm (stretched) is tied to the frame. Ancona vessels typically use 4m-wide rapido trawls and tow 4 gears simultaneously at a speed of 11-13 km h<sup>-1</sup>. Due to the lacking information on this activity, a two-year study was carried out to increase the knowledge on the quali-quantitative composition of the catches.

#### Materials and Methods

Data were collected onboard of randomly chosen professional vessels of the Ancona fleet. A total of 235 hauls were sampled from summer 2000 to spring 2002, without any interference with the fishers' modus operandi. The overall catch was subdivided in retained fraction (target species, Solea solea, and kept by-catch), discard of commercial species (discard C; damaged or smaller than the legally sized specimens), discard of non-commercial species (discard NC; species without any commercial value) and debris (dead shells, wood, stones, anthropic matter, waste, etc.) [2]. The retained fraction was analysed onboard: number of specimens. total weight and size of each individual were recorded for each species. The discard was weighed onboard and a sample was taken and later examined in the laboratory. Discard C and discard NC were determined to the species level; number of individuals and total weight of each taxon were recorded and the specimens of the commercial species measured. Debris was subdivided in categories which were weighed separately. In data analysis, catch (retained and discarded fractions) and debris were treated separately, computing seasonal values for each of them as kg km $^{-2}$ .

#### Results

A total of 188 taxa (58 fishes, 26 crustaceans, 67 molluscs, 14 echinoderms, 23 others) were recorded in the study period. Discard NC included the highest number of taxa, followed by discard C and the retained fraction. Seasonal CPUE ranged from 1080.0±96.5 to 456.4±53.8 kg  $km^{-2}$ (Tab. 1). The retained fraction was always lower than the discard and did not show a clear seasonal trend. S. solea made up from 3 to 18% of the catch, while Bolinus brandaris, Chelidonichthys lucernus, Melicertus kerathurus, Sepia officinalis and Squilla mantis dominated the kept by-catch (Tab. 1). Discard C was the most important fraction of the catch, except in fall '01 and spring '02. The most abundant species were the gastropod Aporrhais pespelecani, the bivalve Ostrea edulis and the decapod Liocarcinus depurator which together made up more than 80% in weight of this fraction in each season (Tab. 1). These species were generally discarded for their low commercial value with respect to the work required for their sorting and, in the case of O. edulis, for subsequent sanitary processes. The remaining portion of discard C was mainly constituted by small specimens of B. brandaris, S. mantis and C. lucernus. As concerns this last species, 94% of individuals caught during the overall period were smaller than the size at first maturity (24.0 cm TL; [3]), and most of them 67% were discarded. Discard NC was the second most important fraction with the highest values in fall '01 and spring '02 (Tab. 1). The main species were the bivalves Anadara inaequivalvis, Anadara demiri and Corbula gibba, the echinoderm Astropecten irregularis and the decapod Goneplax rhomboides (Table 1). Huge amounts of debris were caught in all seasons, sometimes exceeding the total catch (Tab. 1). It included 34 taxa (28 molluscs, 5 echinoderms, 1 phanerogam)

and other materials, such as stones, waste, etc. Dead shells of gastropods and bivalves, belonging to the local thanathocoenoses, always made up the largest portion, constituting 55-86% of the seasonal catches of this fraction.

Tab. 1. Composition of the seasonal catches (kg km<sup>-2</sup>). Wi = winter; Sp = spring, Su = summer; Fa = fall.

|           |                           | Su '00 | Fa'00 | WI '01 | Sp '01 | Su '01 | Fa '01 | Wi '02 | Sp '02 |
|-----------|---------------------------|--------|-------|--------|--------|--------|--------|--------|--------|
| Retained  | Solea solea               | 38.0   | 66.7  | 111.6  | 61.8   | 53.3   | 46.3   | 23.8   | 24.0   |
|           | % on total                | 7      | 9     | 18     | 6      | 11     | 5      | 5      | 3      |
|           | Kept by-catch             |        |       |        |        |        |        |        |        |
|           | Bolinus brandaris         | 9.5    | 16.4  | 2.3    | 2.5    | 3.8    | 16.2   | 0.1    | 39.4   |
|           | Chelidoni chthys lucernus | 14.1   | 8.1   | 2.5    | 0.4    | 8.8    | 6.8    | 8.5    | 3.1    |
|           | Melicertus kerathurus     | 1.7    | 8.1   | 2.0    | 2.5    | 3.8    | 13.1   | 8.6    | 0.1    |
|           | Sepia officinalis         |        | 1.8   | 16.9   | 16.9   | 11.8   | 3.2    | 4.7    | 2.8    |
|           | Sgilla mantis             | 38.8   | 59.6  | 13.7   | 14.4   | 49.9   | 44.9   | 27     | 6.1    |
|           | Others                    | 26.4   | 22.9  | 25.7   | 15.7   | 37.0   | 20.8   | 31.9   | 25.0   |
|           | Total Weight              | 90.5   | 116.9 | 63.1   | 52.4   | 115.1  | 105.0  | 56.5   | 76.5   |
|           | % on total                | 18     | 16    | 11     | 5      | 23     | 12     | 12     | 9      |
| Discarded | Discard C                 |        |       |        |        |        |        |        |        |
|           | Aporthais pespelecani     | 82.8   | 151.1 | 192.1  | 684.7  | 54.9   | 122.3  | 101.0  | 165.7  |
|           | Bolinus brandaris         | 8.2    | 4.0   | 2.4    | 2.3    | 3.1    | 14.0   | 0.6    | 28.6   |
|           | Chelidoni chthys lucernus | 1.8    |       | 0.2    | 1.8    | 8.5    | 7.5    | 21     | 0.4    |
|           | Liocarcinus depurator     | 97.5   | 2.1   | 38.8   | 16.9   | 44.8   | 0.3    | 167.0  | 105.4  |
|           | Ostrea edulis             | 55.8   | 174.7 | 43.9   | 54.7   | 96.8   | 68.0   | 13.8   | 33.8   |
|           | Squilla mantis            | 3.4    | 4.4   | 0.7    | 1.1    | 5.7    | 6.5    | 0.2    | 0.7    |
|           | Others                    | 10.5   | 15.6  | 8.2    | 25.2   | 7.7    | 18.5   | 6.9    | 12.0   |
|           | Total Weight              | 260.8  | 347.5 | 286.2  | 768.9  | 221.5  | 237.1  | 291.6  | 346.6  |
|           | % on total                | 51     | 49    | 48     | 72     | 45     | 27     | 62     | 40     |
|           | Discard NC                |        |       |        |        |        |        |        |        |
|           | Anadara demiri            | 1.2    | 3.3   | 1.4    | 7.8    | 20.4   | 56.8   | 10.3   | 65.6   |
|           | Anadara inaequivalvis     | 25.5   | 95.5  | 28.2   | 51.1   | 24.8   | 369.5  | 14.9   | 202.1  |
|           | Astropecten irregularis   | 25.3   | 36.4  | 46.1   | 22.8   | 18.2   | 15.2   | 5.8    | 12.9   |
|           | Corbula gibba             | 20.1   |       | 21.7   | 74.6   | 6.1    | 14.1   | 6.2    | 77.7   |
|           | Goneplax rhomboi des      | 11.0   | 10.3  | 13.7   | 12.9   | 16.9   | 6.9    | 12.3   | 1.5    |
|           | Others                    | 40.4   | 34.3  | 24.8   | 27.6   | 21.5   | 24.3   | 34.9   | 57.0   |
|           | Total Weight              | 123.5  | 179.8 | 136.2  | 197.0  | 107.9  | 486.8  | 84.5   | 416.8  |
|           | % on total                | 24     | 25    | 23     | 18     | 22     | 55     | 18     | 48     |
| Total     | Total Weight              | 512.8  | 710.9 | 597.1  | 1080.1 | 497.8  | 875.2  | 456.4  | 863.9  |
| Debris    | Total Weight              | 554.0  | 808.8 | 584.0  | 543.9  | 364.8  | 396.3  | 274.0  | 435.1  |

#### Conclusions

The rapido trawls were efficient in the exploitation of common sole and most of the other accessory species, being their discard negligible in most of cases. This was due to the fact that all the caught specimens of these species were marketable, independently from the size. Moreover, the rare individuals damaged by the gear were also easily sold. A noticeable discard was detected only for *C. lucernus*, especially when considerable amounts of small and often damaged specimens were caught and discard C mainly included organisms which remained alive when rejected at sea, such as *A. pespelecani* and *O. edulis*. Discard NC consisted of few dominant species of molluscs and decapods, and also in this case most of them were still alive when rejected. Debris showed to be noteworthy in this kind of fishery, affecting sometimes the fihermen' habits as regards the choice of the fishing zone and haul duration.

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# IS THE ENDEMIC MALTESE TOP-SHELL GIBBULA NIVOSA EXTINCT?

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### Abstract

The trochid gastropod *Gibbula nivosa*, endemic to the Maltese Islands, has recently only been found in two Maltese bays, where it occurred on seagrass leaves and under stones at depths of 1-4m. Intensive sampling of *Cymodocea nodosa* and *Posidonia oceanica* meadows, sediment and pebbles at depths of 2-12m, carried out in 2000 and 2002, resulted only in empty shells but no live animals, suggesting that the species is extinct from these localities where previously good populations were found. However, the occurrence of fresh shells from other Maltese sites suggests that small undiscovered populations may exist. *G.nivosa* is considered to be 'critically endangered'. *Keywords : Biogeography, Conservation, Endemism, Gastropods, Mollusca.* 

#### Introduction

The trochid gastropod *Gibbula nivosa*, first described 1851 has been reported many times from Malta [1,2,3] but not from elsewhere in the Mediterranean or any other sea, and is now widely accepted as endemic to the Maltese Islands [4,5], providing a rare example of a marine point endemism. Within the Maltese Islands, *G. nivosa* appears to be uncommon. Systematic searches in 13 localities distributed round the Maltese Islands made by Palazzi in 1978 [2] resulted in records of empty shells from nine of them, but living animals were only found at St. Thomas Bay, on *Posidonia oceanica* leaves at 1-4m. A later survey [3] reported live specimens from Delimara, close to St. Thomas Bay, and from Santa Marija Bay (Comino) at 2-3m under stones. The most recent catalogue of the marine Mollusca of the Maltese Islands [6] gives this species as common only at St Thomas Bay.

Because of its very restricted regional distribution and rarity, *G. nivosa* is internationally protected (Bern Convention; Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean of the Barcelona Convention) and with the accession of Malta to the European Union, also by the EU's 'Habitats Directive'. As such, there is an obligation to safeguard this species and *G. nivosa* is protected by Maltese legislation. However, no information on its present status exists. To address this, surveys of the two sites from where *G. nivosa* has been reported in recent years - St Thomas Bay (island of Malta) and Santa Marija Bay (island of Comino) - were made in order to assess the status of the species at these localities.

#### Methods

Surveys were made in summer 2000 at St Thomas Bay and in summer 2002 at St Thomas Bay and Santa Marija Bay. Three shore-normal transects were laid at St Thomas Bay varying in length from 150-750m and passing through shallow water (<4m) Cymodocea nodosa meadows, continuous Posidonia oceanica meadows, and reticulate P. oceanica meadows interspersed with sparse patches of sand and pebble beds (4-12m). At Santa Marija Bay, two 400m-long shore-normal transects were laid over P. oceanica meadows interspersed with patches of sand and small pebbles and beds of larger pebbles. In both bays, stations (2m, 4m, 6m, 8m, 10m, and 12m) within these transects were sampled in different ways depending on the substratum. The upper 5cm of sediment was collected from within 0.25m<sup>2</sup> random quadrats (three replicates per station). Seagrass foliar molluscs were sampled using a 20cm x 40cm aperture hand-held net fitted with a 0.5mm mesh pushed 60 times through a 1m distance in the leaves moving forward with each stroke, thus sampling an area of 20m<sup>2</sup> per station (two replicates per station). Sediment and rhizomes at the base of P. oceanica shoots were sampled by pushing a 45cm-diameter circular corer with a toothed edge [7] into the rhizomes, and using a suction sampler to collect sediment and plant debris into a 1mm-mesh net bag (two replicates per station). In the laboratory the molluscs from all samples were sorted by hand, identified and counted, including broken shells of G.nivosa.

#### Results and discussion

A total of 24 whole empty shells and 10 broken shells of *G.nivosa* were collected from St Thomas Bay in summer 2000, with the largest number of whole shells (11) being collected from seagrass from the 6m station using suction sampling. In summer 2002, 100 whole empty shells (and no broken shells) were collected from this bay with the largest number of

whole shells (59) coming from the quadrat sediment samples at the 2m station. At Santa Marija Bay, only 4 whole empty shells (and no broken shells) were collected, half of which came from seagrass at 4m using the suction technique.

*G. nivosa* has been reported from two habitats: on seagrass (*P. oceanica*) leaves and under stones in shallow water (1-4m) [2,3]. In spite of intensive sampling of sediment, pebbles, and seagrass leaves and rhizomes at depths of 2-12m at St Thomas Bay and Santa Marija Bay, no live animals were found. Given that these two bays were a stronghold for *G. nivosa* [2,3], this suggests that this species is almost certainly extinct from these localities.

Although *G. nivosa* has recently only been reported live from these two bays and from Delimara [2,3], empty shells of this species are to be found in sediment from embayments along the entire southeast, east and northeast coasts of the Maltese Islands [6, and authors' unpublished data]. While the bulk of these shells are old and partially eroded, we also have some very fresh-looking shells that suggest that small undiscovered populations may exist in some localities. It is obvious that the status of *G. nivosa* in the Maltese Islands can only be ascertained by intensive sampling of the entire coastline where the reported habitats of this species must now be considered 'critically endangered' under the 2001 IUCN Red List criteria [8,9].

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# INTERANNUAL DIFFERENCES IN REPRODUCTIVE PARAMETERS AND SOMATIC CONDITION OF ANCHOVY IN THE THRACIAN SEA

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### Abstract

We applied the Daily Egg Production Method (DEPM) to the NE Aegean anchovy, *Engraulis encrasicolus* (Linnaeus, 1758) stock during its peak spawning period in June 2003 and June 2004. Analysis of adult samples revealed significant differences between the two years for the parameters of mean weight of mature females, batch fecundity and spawning frequency which had higher values in 2004. In addition, fish grew faster in weight in 2004. The estimated spawning biomass was about three times lower in 2004 than in 2003. *Keywords : Aegean Sea, Stock Assessment, Reproduction, Spawning.* 

#### Introduction

European anchovy is one of the most important pelagic fish in the Mediterranean and the estimation of the spawning biomass of its stocks is an important tool in their assessment [1]. The DEPM is an ichthyoplanktonic method for estimating the reproductive biomass of multiple spawning fish. The application of this method can provide valuable information on the reproductive ecology of these species [1, 2]. The aim of the present study was to examine interannual changes in the DEPM adult parameters of anchovy in the NE Aegean Sea.

#### Methods

During the application of the DEPM on the NE Aegean anchovy stock in June 2003 and 2004, samples of adult fish were collected from both experimental and commercial fishing. Each sample consisted of random collection of approximately 50 anchovies. Processing of an adult sample in the laboratory consisted of length and weight measurements (both total and gonad free weight), sexing, fecundity measurements for batch fecundity estimation (mean number of eggs per mature female per spawning, F), and histological analysis for spawning frequency estimation (fraction of mature females spawning per day, S).

Gonads of all processed females were weighted (0.01 mg) and preserved in 10% buffered formalin. The gonads of 20 randomly selected females per sample were subjected to histological analysis. The analysis involved the identification of the maturation stage of the most advanced group of oocytes and the presence and histological characteristics of atretic and postovulatory follicles (POFs) [3].

All macroscopically detected hydrated or running females were measured and their gonads weighted and preserved in formalin for subsequent histological and batch fecundity analysis. In order to assess batch fecundity we applied the hydrated oocyte method and the data were used to fit a linear model regressing the number of eggs per batch to gonad free weight [4, 5]. Spawning frequency was assessed by the postovulatory follicles method [3].

#### Results and Conclusions

The biomass and adult parameter estimates of the DEPM are presented in Table 1. In 2004 females were heavier and spawned almost every other day (S = 0.44), while in 2003 they spawned every three days (S = 0.34). Similarly, the number of eggs released per individual was higher in 2004 (7053 eggs per batch) than in 2003 (3936 eggs per batch). The weight-specific sex ratio was higher than 0.6 during both years.

Since fecundity is calculated indirectly through gonad free weight, the two parameters were correlated. However, the regression lines of fecundity on gonad free weight were forced through zero because the intercept was not significant at the 0.05 level. This indicated that the F/W ratio (relative fecundity, eggs g<sup>-1</sup>) was not size dependent. In addition, spawning frequency was not related to weight in 2003 or 2004 (Spearman rank correlation,  $r_s = -0.135$ , P = 0.581 and  $r_s = 0.468$ , P = 0.060 respectively).

In addition, the comparison of total length-gonad free weight relationships revealed that, in 2004, fish were growing in weight significantly faster (slope: b=3.1) than in 2003 (slope: b=2.7) (ANCOVA, F = 69.25, P <0.001), which indicated better feeding conditions in 2004.

These differences in reproductive performance and somatic condition could not be attributed to ambient food availability since concurrently measured zooplankton biomass was similar between years (P>0.05). However, estimates of spawning biomass (Table 1) indicated that the size of the

stock was almost three times larger in 2003 (17600 t) than in 2004 (6251 t). These observations suggest that the aforementioned differences can be explained in terms of density-dependence [2].

Tab. 1. Biomass and adult parameter estimates of the DEPM applied to the NE Aegean anchovy stock in June 2003 and June 2004.

| Parameter                       | 2003       | 2004       |
|---------------------------------|------------|------------|
| Mean weight of mature female    | 15.36      | 18.92      |
| (W, g)                          | (CV=0.022) | (CV=0.039) |
| Weight specific sev ratio (P)   | 0.65       | 0.63       |
| weight specific sex ratio (R)   | (CV=0.038) | (CV=0.077) |
| Erection of moture formalog (S) | 0.34       | 0.44       |
| Flaction of mature females (5)  | (CV=0.062) | (CV=0.051) |
| Average batch fecundity (F,     | 3936       | 7053       |
| number of eggs)                 | (CV=0.049) | (CV=0.047) |
| Spourping biomore (SSD t)       | 17600      | 6251       |
| spawning biomass (SSB, t)       | (CV=0.220) | (CV=0.247) |

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# OBSERVATIONS ON THE ALIEN CRAB *PERCNON GIBBESI* (DECAPODA, BRACHYURA, GRAPSIDAE) FROM THE MALTESE ISLANDS

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# Abstract

A preliminary account on habitat preferences, bathymetric distribution, population density, and aspects of the reproductive biology of the alien grapsid *Percnon gibbesi* in the Maltese Islands is given. This alien was first recorded from Malta in 2001 and has since established breeding populations in suitable habitats throughout the Maltese islands where of its preferred habitat types, upper infralittoral boulder fields or rock faces with a sparse algal cover, are available. The crab breeds in summer and recruits in winter. Female crabs may produce up to 30,000 eggs per spawning. Interactions with the native grapsid *Pachygrapsus marmoratus* were observed. *Keywords : Decapoda, Reproduction, Behaviour, Rocky Shores, Species Introduction.* 

#### Introduction

The subtropical crab, *Percnon gibbesi*, was first recorded in the Mediterranean Sea in 1999 contemporaneously from Linosa Island (Straits of Sicily) [1], Capo Passero (southern Sicily) [2] and Ibiza [3]. Records of its occurrence to date are from the western and central Mediterranean [4,5,6]. It was recorded from the Maltese Islands in 2001 [7]. We made observations on the habitat preferences, bathymetric distribution, population density, and egg production of this species in the Maltese Islands in order to assess if there were any differences in the biology of this species in Malta relative to other Mediterranean sites.

#### Method

Habitat preferences and bathymetric distribution were assessed by carrying out surveys at 23 sites around the Maltese Islands where preliminary observations indicated the crabs to occur. At 20 of the investigated sites, the population density in the preferred habitat was determined by counting the number of crabs in replicate  $1m^2$  virtual quadrats. To estimate reproductive output, egg-masses from 30 ovigerous females were weighed and the number of eggs in triplicate sub-samples from each egg-mass was counted.

#### Results and discussion

All individuals of *P. gibbesi* encountered were wholly submerged and occurred between depths of 0.05m and 4m. The preferred habitats were similar to those reported from elsewhere in the Mediterranean [4,5,6], and consisted of submerged boulders covered by a thin microalgal felt, encrusting algae or algal turf, or rock ledges, crevices and vertical rock walls sparsely covered by macroalgae. Population density ranged between 1.6  $\pm$  0.5 s.d. and 11.9  $\pm$  7.1 s.d. crabs m<sup>-2</sup> (Fig. 1) and was significantly higher (Kruskal-Wallis p <0.001, Dunn's pairwise test p <0.05) at Marsascala, Dahlet Qorrot and Hondoq ir-Rummien, where extensive areas of boulder habitat occurred at depths less than 4m that were not interrupted by unsuitable habitats such as homogeneous rocky or sandy bottoms or seagrass patches as in the other sites.



Fig. 1. Mean abundance (error bars represent the 95% confidence intervals) of *P. gibbesi* at 20 sites in Malta and Gozo.

Diurnal changes in abundance were investigated at Pembroke, where a two-fold increase between morning (counts made before 13.30h) and late afternoon (counts made after 16.00h) abundances ( $5.2 \pm 3.4$  crabs m<sup>-2</sup> and  $10.1 \pm 5.7$  crabs m<sup>-2</sup>, respectively; Mann-Whitney U-test; p<0.05) was recorded hence supporting observations from Pantelleria [4] and Isola delle Femmine [5] that *P. gibbesi* becomes most active towards dusk.

We recorded berried females from June until the end of September, and juvenile crabs (carapace length  $\leq$  15mm) from October until March, suggesting that *P. gibbesi* breeds during the summer months and recruitment takes place throughout the winter. Egg brood size ranged between 254 (the total number of eggs in the smallest egg mass) and 32 040  $\pm$  281 eggs and was found to be positively correlated with carapace length (r = 0.677, p <0.001, df = 27). High fecundity and the relatively long breeding season are factors that may have facilitated the rapid and successful spread of this alien species in the Mediterranean.

Contrary to reports by some authors [4,6], *P. gibbesi* was observed to coexist with the grapsid *Pachygrapsus marmoratus* and the xanthid *Eriphia verrucosa*, which are the two native species that occur in the same habitats. Again contrary to reports, *P. gibbesi* was observed to occasionally interact with *P. marmoratus* when the two approached to within c. 15cm. These observations suggest that in the Maltese Islands the alien species is a potential competitor for resources, mainly space, with the native syntopic grapsid. Studies are clearly necessary to assess and quantify the impacts of the alien on the Mediterranean marine systems where it has become established, including the risk of competitive exclusion of native species with similar patterns of resource utilization.

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# INTERSPECIFIC INTERACTIONS BETWEEN THE GRAPSID CRABS PERCNON GIBBESI AND PACHYGRAPSUS MARMORATUS: IMPLICATIONS OF AN INVADER

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# Abstract

One-on-one interspecific encounters between the recently introduced alien *Percnon gibbesi* and the native *Pachygrapsus marmoratus*, with which *P. gibbesi* occurs syntopically, were staged in the laboratory to assess the behaviour of these species relative to each other. Unless the encounter involved large *P. gibbesi* with small *P. marmoratus*, the native species was the 'winner'. These results suggest that the native species has competitive superiority over the invader and is unlikely to suffer from spatial resource partitioning or, worse, competitive exclusion from its natural habitat as a result of the invasion by *P. gibbesi*. *Keywords : Decapoda, Behaviour, Competition, Species Introduction.* 

#### Introduction

Human-mediated transport of species from one biogeographical setting to another is now considered to constitute a serious threat to marine ecosystems and biodiversity [1]. Knowledge on the actual impacts of a specific introduced species on native biota is often anecdotal and detailed evidence is rare [2]. This applies also to the subtropical grapsid crab, *Percnon gibbesi*, which was first recorded from the Mediterranean Sea in 1999 and from the Maltese Islands in 2001 [3]. Field observations made in the Maltese Islands suggest that *P. gibbesi* overlaps in habitat with the native grapsid *Pachygrapsus marmoratus* [4], and therefore, the possibility of competition might occur. This study was designed to investigate the outcome of interspecific interactions between the two crabs when space is restricted.

#### Methods

Individuals of both species were collected by hand from Pembroke and Marsascala, Malta. Crabs were divided into three groups according to their carapace length (CL): large = CL>30 mm, medium = CL 20-30mm, and small = CL<20mm. After an acclimation period of 7 days in aerated seawater at 20 deg.C without feeding, one-on-one interspecific interactions between individuals of the two species in different size combinations were staged in rectangular aquaria of dimensions (29.5 x 20 x 19cm) and were recorded using videography. These video records were then analysed by dividing the behavioural sequence into 'acts' (see legend to Fig 1). The behaviour of the crabs was recorded in an alternating sequence, i.e. act by crab 1, act by crab 2, etc. Ten replicate trials for each size combinations were made.





Fig. 1. Percentage distribution of acts following specific initial acts (shown on the y-axis) during the staged encounters between *P. gibbesi* and *P. marmoratus*. The acts considered were: advance of crab 1 towards crab 2; retreat by crab 2, L = low intensity merus display where the crab adopts a neutral posture by holding its body close to the substratum with chelae folded inwards; M& H = medium and high intensity merus display where the crab lifts its body off the substratum on its dactyls and spreads its chelae open; T = physical touch; Fz = complete cessation of movement; Ac = attack with chelae in open position; G& R& Bur refer to grooming, random movement, and burrowing; 0 (does nothing) is an act used to preserve the alternation of acts whenever an intra-individual transition occurred.

#### Results and discussion

*P. marmoratus* was the initiator of an encounter, defined as the crab that made the first move towards or engaged in physical contact with its opponent, in 80.8% of the trials and the winner of an encounter, defined as the crab that elicited repeated retreats from or inflicted harm to or killed its opponent, in 86.9% of the trials. *P. gibbesi* won encounters only when matched with a small *P. marmoratus*, where the ratio of *P. gibbesi* chelae length to that of *P. marmoratus* was >1. This suggests that the native species has a higher resource holding potential than the invader. *P. gibbesi* was never observed to attack its opponent unless the latter advanced towards or engaged in physical contact with the *Percnon*.

In 10 out of 16 encounters between a large or medium *P. marmoratus* and a small *P. gibbesi*, the former deliberately attacked the latter and killed the *Percnon*. In general, all the initial acts performed by *P. marmoratus* significantly affected the distribution of the following acts (p-value associated with chi-square was less than 0.001) indicating that communication between the two species via visual displays is taking place. This may be important in determining the degree to which these two species overlap in their resource utilization. Irrespective of size, *P. gibbesi* exhibited the highest number of retreat or submissive (low intensity merus display, L) actions (which constituted 92.3% of the acts performed by *Percnon*) in response to acts by *P. marmoratus* such as advance, medium and high intensity merus display (M& H), attack with chelae in open position (Ac) and physical contact (T) (Fig. 1).

#### Conclusion

One determinant of invasion success is the nature of competitive interactions with native ecological analogues. Our results suggest that the native species is unlikely to be excluded from its natural habitat by the alien, or even that any significant spatial resource partitioning on the part of *P. marmoratus* will occur. The successful invasion by *Percnon* on Maltese shores (and perhaps other Mediterranean shores) may be due to this species finding habitat space that does not bring it into competition with native crab species with similar resource requirements.

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# INTERSPECIFIC RELATIONSHIP BY SIZE SEGREGATION BETWEEN TWO PANDALID SHRIMPS IN THE NORTH AEGEAN SEA

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# Abstract

Most of the studies on Mediterranean pandalids focused on their spatial distribution, reproduction patterns and diet but few on interspecific relationships. The present work deals with interspecific comparison between two widely distributed pandalids (*P. martia*, *P. heterocarpus*), analyzing size segregation among three different areas in the northern Aegean Sea. *Keywords : Aegean Sea, Decapoda, Crustacea, Population Dynamics, Competition.* 

Logarithmic decline of food energy availability in deep water is the most important factor in shaping of deep water fauna [1]. In the Mediterranean Sea, other factors such as oligotrophic water, scarce energy food availability under 200m and higher water temperatures play a main role in the organization of community structure in order to minimize inter and intra specific competition for exploitation on resources [2].

Intraspecific size segregation by depth is a common pattern in pandalid shrimps. Furthermore, among pandalid species co-occurring at the same depths different size composition and mean carapace length were observed [3]. This observation can be related to the diet composition of the species of similar morphology and trophic habits since interspecific segregation could be an adaptation that allows co-existence [4].

In this context, this study has the objective to investigate size segregation between the two most abundant and widely distributed species of pandalid shrimps in the northern Aegean Sea, *P. heterocarpus* (Costa, 1871) and *P. martia* (A. Milne Edwards, 1883),.

Samplings were carried out during Mediterranean International Trawling Survey (MEDITS) in the years 2003, 2004 and 2005 in the northern Aegean Sea. Specimens were collected from samples where the two species were found co-existing. A total of 15 stations ranging between 350-600m were taken in account. Three main surveyed areas (Hios, Sporades and Halkidiki) were defined within the Medits survey protocol.

The samples were fixed on board in 10% formalin and transferred in laboratory. For each specimen, carapace length (CL) was measured from orbital edge to the median posterior margin of cephalotorax, using a vernier caliper to the nearest 0,01mm.

The variances of CL between species by each area were compared using the parametric analysis of variance (ANOVA) or the non parametric Kruskal-Wallis ANOVA by median test.

Although size overlapping was found in all three areas, significant differences between mean or median CL were observed in Hios and Halkidiki, whereas in Sporades populations didn't show size segregation in their size distribution.

At slope depths, pandalid species, where they co-occur, showed a high dietary overlap [5]. Partitioning among species has been argued to reduce interspecific competition. As feeding strategy, it has been observed that smaller species directed its feeding activities towards smaller prey items within their diets and selection of different prey sizes attenuates the exploitation of the same resource.

In this sense, different mean sizes founded in *P. heterocarpus* and *P. martia* in Hios and Halkidiki regions could be an adaptation to exploit resources in those environments where food scarce availability could determine the presence of competition as factor for resource partitioning.

Pandalids populations examined in Sporades region didn't show a significant segregation. Absence of competition could be postulate.

However, to establish presence of competition it requires determining on dietary overlap and food availability. In future, further studies should be undertaken to evaluate dietary composition of the two species and deep water resource concentration in the studied area.

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# DEPTH DISTRIBUTION OF PANDALIDS GENUS IN THE NORTH AEGEAN SEA

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#### Abstract

Many aspects of pandalids biology and ecology such feeding behaviour and growth were studied in the Mediterranean Sea. However, information from eastern Mediterranean are scarce. The objective of the present study is to describe pandalid species community and the growth of the most widely distributed species in the northern Aegean Sea. *Keywords : Aegean Sea, Decapoda, Population Dynamics, Crustacea.* 

Deep-water pandalid species have an extensive geographical distribution. Since this taxon presents a high diversity and biomass, it has a great potential as a fishery resource in bathyal environments. In western and central Mediterranean, various aspects on trophic habits, depth distribution and reproduction patterns have been investigated.

In eastern Mediterranean, available information on their biology and ecology are limited [1, 2]. The present study has the objective to analyze main characteristics of bathyal distribution and population structure of pandalid shrimps in the northern Aegean Sea.

The material was obtained during 1996-2001 at 64 sampling area in North Aegean Sea within Mediterranean International Trawling Survey (MED-ITS) at depth ranging between 27 to 633 m.

Specimen were preserved in 10% formalin and tranferred in laboratory.

Shrimps were identified at species level. Carapace length (CL) was measured from the post orbital socket to the posterior median edge of the cephalotorax using a digital vernier caliper to the nearest 0,01mm.

General affinities between samples were estabilished using a presenceabsence cluster analysis on a species x hauls matrix. Lenght distribution by depth was studied using mean CL for each haul and plotted versus depth. Correlation and significance level were calculated using Pearson r. In the survey, 9 pandalids species were identified: *Chlorotocus crassicornis* (Costa, 1871), *Pandalina profunda* (Holthuis, 1946), *Plesionika acanthonotus* (Smith, 1882), *P. antigai* (Zariquiey Alvarez, 1955), *P. edwardsi* (Brandt, 1851), *P. gigliolii* (Senna, 1903), *P. heterocarpus* (Costa, 1871), *P. martia* (A.Milne Edwards, 1883) and *P. narval* (Fabricious, 1787).

*C. crassicornis*, *P. antigai*, *P. heterocarpus* and *P. martia* showed the highest occurrence.



Fig. 1. a) Depth range by species. Cc *C. crassicornis*, Pp *P. profunda*, Pn *P. narval*, Pac *P. acanthonotus*, Pan *P antigai*, Pe *P. edwardsii*, Pg *P. gigliolii*, Ph *P. heterocarpus*, Pm *P. martia*.b) Presence-absence cluster: aggregation of pandalids species in the survey samples.

In summary, *P. heterocarpus* and *C. crassicornis* were the shallowest species. *P. profunda, P. antigai, P. edwardsii,* and *P. gigliolii* were species characterizing the upper slope. *P. martia* and *P. acanthonotus* were found at the upper-midle slope depths.

*P. acanthonotus* and *P. martia* occurred in deepest water, reaching the maximum depth of the survey campain (633m).

P. profunda showed a low occurrence since it has been found in 2 hauls

at depth of around 400m. (fig. 1a). However, pandalid species examined in this study showed to inhabit depth strata as described from the western Mediterranean [3]. Neverthless, it was observed for each species a wider depth distributions with their upper limit founded at deeper waters.

Cluster analysis has identified a homogeneous group that includes 5 species (fig. 1b). *C. crassicornis*, *P. antigai*, *P. gigliolii*, *P. heterocarpus* and *P. martia* could represent a community occurring at the upper slope (300-500m) in three sector of the survey area (Hios, Sporades, Halkidiki).

Length distribution by depth was calculated for the most distributed 4 species. Three of them *C. crassicornis*, *P. heterocarpus* and *P. martia* showed a strong linear relationship (p<0.05) of mean size (CL) upon depth (fig. 2). For pandalids, tendency to increase size with depth is a common pattern. This tendency has been correlated to the presence of particulate matter layer that could affect the occurrence of juveniles and adults ontogenetic depth migration [4].



Fig. 2. Plot of mean size (CL) by depth. *C. crassicornis* r = 0,5450; p <0.05; *P. antigai*: r = 0,4294; p >0.05; *P. martia*: r = 0,9394; p <0.05; *P. heterocarpus*: r = 0,7376; p <0.056.

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# VARIABILITÉ SPATIALE ET TEMPORELLE DU ZOOPLANCTON DANS LE BARRAGE NABHÉNA (TUNISIE)

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#### Résumé

Durant une année (Mai 2005-Avril 2006), des prélèvements d'eau collectés mensuellement de la colonne d'eau du barrage Nabhéna, nous ont permis de dresser l'inventaire du zooplancton, ainsi de suivre leur évolution. L'analyse des résultats met en évidence une faible richesse spécifique et une hétérogénéité de la colonne d'eau.

Mots clès : Zooplankton, Copepoda.

### Introduction

Le barrage Nabhéna est situé dans le gouvernerat de Kairouan (50 Km de la ville de Kairouan) a été mis en eau en 1966. La superficie totale de cette étendue d'eau est de 532 ha et de hauteur maximale de 62.5m et un volume de  $87x106 \text{ m}^3$ . Il est alimenté par l'oued Nabhéna. Le bassin versant de la retenue draine une superficie d'environ 855 km<sup>2</sup>. Cet écosystème joue un rôle important dans l'irrigation, la protection contre les crues et l'alimentation en eau potable. L'objectif de cette étude est de suivre la dynamique des communautés zooplactoniques en fonction des paramètres physico-chimiques du barrage.

#### Matériel et méthodes

Des prélèvements d'eau destinés aux analyses physico-chimiques et biologiques ont été réalisés de mai 2005 à avril 2006, selon un pas de temps mensuel au niveau d'une station central (0-5-10 et 15m). Les prélèvements du zooplancton ont été réalisés à l'aide d'un filet à plancton de type Juday (1 m de long et de 85  $\mu$ m de vide des mailles). L'étude du zooplancton est réalisée sous loupe binoculaire à l'aide d'une cuve de Dollfus. La biomasse des espèces zooplanctoniques a été calculée par la méthode indirecte développée par Bottrel et al. (1976) [1].

#### Résultats et discussion

Des études antérieures [2], ont monté que les communautés phytoplanctoniques se composent de principaux groupes suivants: diatomées (42 %), dinoflagéllés (24%), cyanobactéries 13%, autres (21%). L'examen de l'ensemble des prélèvements réalisés nous a permis de recenser 10 espèces zooplanctoniques :2 Copépodes Copidodiaptomus numidicus C.n.(Gurney,1909) (963.75µm) et Acanthocyclops robustus A.r (Kiefer, 1927) (900µm) ; 3 Cladocères Diaphanosoma brachyrum D.b (Lievin,1848) (587.5µm), Bosmina longirostris B.1 (Müller, 1976) (400µm) et Ceriodaphnia quadrangula C.q (O.F Müller, 1785) (475µm) ; 5 rotifères Keratella quadrata K.q (O.F.Mûller, 1786) (275µm), Keratella cohlearis Kc (Gosse, 1851) (222.5µm), Asplanchna sp (406.25µm), Filinia longiesta F.1 (Zacharias, 1893) (150µm) et Hexarthra mira H.m (Hudson, 1871). La communauté zooplanctonique regroupe trois catégories (Fig.1) : les copépodes (70 %), les cladocères (25%) et les rotifères (5%). La faible richesse spécifique touche l'ensemble des groupes et plus particulièrement celui des copépodes qui est, toutefois, le groupe le plus représenté quantitativement. La succession saisonnière des différentes espèces zooplanctoniques (Fig. 2) a présenté un cycle annuel caractérisé par la dominance de l'espèce Copidodiaptomus numidicus (67 % du zooplancton total). Cette dernière présente un pic estimé à 89637 Ind. m<sup>-3</sup> (634.46 mg PS/m<sup>3</sup>). En utilisant l'ensemble des données, nous avons illustré une variabilité saisonnière et une ségrégation verticale des différentes espèces zooplanctoniques, ainsi l'espèce Copidodiaptomus numidicus se maintient dans l'épiliminion où elle trouve une quantité suffisamment abondante [3]. Les facteurs environnementaux modulent la succession saisonnière car les diverses espèces ont leurs propre tolérances physico-chimiques [4], ainsi d'autres facteurs telle que la compétition pour l'exploitation des ressources, la prédation. L'évolution des communautés zooplanctoniques en réponse à tous ces facteurs confirme la forte réactivité de ces types de milieux aquatiques peu profonds et renforce l'intérêt de son suivi écologique en raison de l'importance de ce barrage et d'autres barrages de la Tunisie.

 $10^{3}$  (Ind. m<sup>-3</sup>)



Fig. 1. Variation mensuelle de l'abondance du zooplancton total et les groupes zooplanctoniques au cours du cycle d'étude.



Fig. 2. Evolution spatio-temporelle des espèces zooplanctoniques dans le barrage Nabhéna en fontion des profondeurs (0m-5m-10m et 15m).

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# SOFT-BOTTOM CRUSTACEANS FROM THE SAROS BAY (NE AEGEAN SEA)

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# Abstract

This study was carried out to determine the benthic crustaceans inhabiting on soft bottoms distributed in the sublittoral zone of the Saros Bay (NE Aegean Sea) and their ecological characteristics. Qualitative and quantitative samples of bottom sediments were collected in 12 different stations during single cruise on board R/V K. Piri Reis in January 2002. As a result of the study, a total of 222 individuals belonging to 57 taxa were identified.

Keywords : Crustacea, Aegean Sea, Systematics.

#### Introduction

Marine diversity is often a scope of environmental research especially within the framework of global environmental changes. Benthic macrofauna of soft sediments plays an important role in the degradation of organic matter produced in the pelagic zone and several species serve as food for demersal fish. Saros Bay is an inlet of the Northern Aegean Sea located in the north part of the Gallipoli Peninsula, Turkey (GPS coordinates 40°37'55"N 26°43'25"E). Systematic qualitative and quantitative investigations alongside the Aegean Sea (Turkey shelf) have been conducted since 1970. However, few studies focused on the crustacea fauna of the Saros Bay, and existing ones only analyzed shallow zone ([1], [2], [3], [4], [5]). The aim of the present study is to describe the species composition and diversity of soft-bottom crustacean fauna of Saros Bay.

#### Material and Methods

The material of soft sediments were collected in short periods during January 2002 at 12 stations (sta.1: 25 m, grab; sta.2: 55 m, grab, sta.3: 72 m, grab; sta.4: 32 m, grab; sta.5: 65 m, grab; sta.6: 240 m, dredge; sta.7: 105 m, dredge; sta.8: 590 m, dredge; sta.9: 580 m, dredge; sta.10: 90 m, dredge; sta.11: 520 m, dredge; sta.12: 610 m, dredge) chosen in the Saros Bay: (fig. 1). Samplings were made either by  $0.1 \text{ m}^{-2}$ van Veen grab, or by dredge. At each station, a single replicate was taken for benthic community analyses. Samples were sieved on board through a 0.5 mm sieve and stored in 4% formalin solution. In the laboratory the material was sorted into the taxonomic groups under a stereomicroscope and preserved in 70% ethanol. A presence-absence matrix was constructed for species found in the dredge samples, but was not used for further community analyses. The material was deposited at the laboratory of faculty of Fisheries, Ondokuz Mayis University (SFF).



Fig. 1. Map of the investigated area with the location of sampling sites.

#### Results and Discussion

The soft-bottom samples collected from several stations (five vith van Veen grab and seven with dredge) in the Saros Bay. This collection includes a total of 57 crustacean taxa and 222 specimens: Mysidacea (one species, four individuals), Cumacea (11 species, 27 individuals), Tanaidacea (three species, 57 individuals), Isopoda (six species, 22 individuals), Amphipoda (28 species, 81 individuals) and Decapoda (eight species, 31 individuals). The amphipods Gammaropsis dentata, Pardaliscella boecki are reported for the first time from the Aegean Sea, and the isopod Gnathia maxillaris, the amphipods Urothoe Corsica, Laetmatophilus ledoyeri, Liljeborgia psaltrica, Nicippe tumida are new records for the Turkish fauna. Sediments consist of a sandy-muddy clay mixture and are appareanly well aerated. The tanaid Leptochelia savignyi ranks first in abundance (%12) in the soft-bottoms followed by Apseudes latreillei (10%), the thalassinid Upogebia pusilla (7%), the amphipods Stenothoe marina (5%), Ampelisca planierensis (4%) and Urothoe elegans (3%). Several other species occurred regularly but in small numbers. Regarding the number of individulas, the amphipods made 39% of the fauna, the tanaids 20%, the cumaceans 16%, the decapods 15%, the isopods 8% and the mysids 2%. The most frequent species in all samples were the tanaid A. latreillei (67%), the amphipods S. marina (50%), Harpinia truncata (42%) and the isopod G. maxillaris (33%). The majority of individuals of crustaceans (deposit feeding amphipods were dominant) occurred at 25-240 m depth range. The cumaceans Diastylis cornuta, Ekleptostylis walkeri, Vaunthompsonia cristata, the amphipods Ampelisca calypsonis, A. spinipes, G. dentata, L. ledoveri, Leucothoe incisa, Stenothoe tergestina, P. boecki, M. cornutus, N. tumida, Urothoe intermedia, U. elegans and the decapod Dorchynchus thomsoni were only collected at the 240-610 m depth range. In contrast the mysid Siriella jaltensis, the cumacean Bodotria scarpioides, the tanaid Apseudes acutifrons, the isopod Gnathia vorax, the amphipods Paraphoxus oculatus, H. truncata, Ampelisca pseudosarsi, and the decapods Alpheus glaber, Callinassa subterranea, U. pusilla and Pisidia longimana were only present at the 25-105 depth range. There were include 39 (68%) which are Mediterranean endemic. There are also 18 (32%) species which zoogeographically are Atlanto-Mediterranean originated.

Only a single replicate sampling does not permit the presentation of a complete description of all soft bottom crustaceans. Moreover, since our data is restricted to a small area within the Aegean Sea, future studies on a wider area are needed before we can summarize our findings.

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# STATUS OF *MYTILUS GALLOPROVINCIALIS* LAMARCK, 1819, IN THE SOUTHEASTERN ADRIATIC CONFIRMED BY GENETIC MARKERS

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### Abstract

The species of the *Mytilus* complex are difficult to differentiate morphologically because of their high degree of similarity and the impact of the environment on the shell shape. A nuclear DNA marker Me 15 and 16 (adhesive protein gene), which is diagnostic for *Mytilus galloprovincialis, M. edulis* and *M. trossulus* was examined for 262 individuals (wild and cultured) sampled along the south-eastern Adriatic coast. All individuals proved to be *M. galloprovincialis.* 

Keywords : Adriatic Sea, Biodiversity, Bivalves, Genetics.

*Mytilus* spp. are considered key species of the coastal ecosystem in the Adriatic sea and are commercially valuble. Genetic characterization of their populations may serve to monitor changes in diversity, and possibly for understanding the biodiversity changes in the coastal ecosystems in in the Adriatic sea. Changes in current directions, temperature and salinity, related to possible global climate changes, higher number of comercial vessels may impact the distribution of mussels [3]. Around Mali Ston *Mytilus* cultivation has long and succesful tradition, which has been mass-cultured since the second half of the 20th century. The origins of *Mytilus* spp. in Mali Ston culture facilities, as well as in other parts of eastern Adriatic coast, are unknown. During 2005 and 2006, as part of comprehensive project concerning *Mytilus* species complex in the Mediterranean and parts of the eastern Atlantic, we conducted series of samplings along the eastern Adriatic from Boka Kotorska bay to the Limski channel. The results of these investigations are presented in this paper.

#### Me 15 CCA GTA TAC AAA CCT GTG AAG A Me 16 TGT TGT CTT AAT AGG TTT GTA AGA

#### Fig. 1. Sequences of Me15 and 16 PCR primers.

Species within the *Mytilus* complex are difficult to differentiate morphologically because of their high degree of similarity and due the impact of the enviroment on the shell shape [3]. However some differences in certain "variable region" of a sequence in the nonrepetitive domain of the foot protein 1 are correlated with the taxonomic rank of these species. The length of nonrepetitive region fragments amplified with Me15 and 16 [2] is specific to each species and differs interspecifically, enabling the use of these primers as diagnostic markers for determination and comfirmation of the species.

We sampled 262 individuals from 10 locations: 1. Boka Kotorska bay (cultured); 2. Boka Kotorska bay (wild); 3. Konavle Rocks (wild); 4. Rijeka Dubrovacka (wild); 5. Elafiti islands (wild) 6. Vrnjak (wild); 7. Bistrina bay (cultured); 8. Brijesta (wild); 9. Brijesta (cultured); 10. Ploce harbour (wild). Following DNA extraction (Quiagen, Dneasy Tissue kit), and PCR amplification using genetic markers, electophoresis revealed one single and uniform band for all of investigated individuals on the position characteristic for *M. galloprovincialis*. Expected size is 126 bp because the sequence of *M. galloprovincialis* contains deletion of 18 amino acids. For the final verification we obtained the standard confirmed total DNA of *M. galloprovincialis, M. edulis* and *M. trossulus* and upon comparison of these bands on electriphoreses - all of our individuals equaled the band position as that of standard *M. galloprovincialis* (Fig. 2). We suggest that *M. galloprovincialis* is an invasive species by its nature [1] and that trait may be the reason for preserving its purity.



Fig. 2. Photo of electrophoresis gel. Lane 1 to 7: mussels sampled during this investigation; lane 8: standard DNA of *M. galloprovincialis*; lane 9: standard DNA of *M. edulis*; lane 10: standard DNA of M. trossulus; lane 11: DNA ladder.

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# DONNÉES PRÉLIMINAIRES SUR LE RÉGIME ALIMENTAIRE DE *CARANX RHONCHUS* (OSTEICHTYENS, CARANGIDAE) DANS LE GOLFE DE GABÉS (TUNISIE)

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### Résumé

Le régime alimentaire de *Caranx rhonchus* des côtes sud tunisiennes est étudié d'août 2004 à juillet 2005. Cette espèce est un poisson carnivore dont le bol alimentaire est basé essentiellement sur les Téléostéens notamment les Engraulidae et les Clupeidae. Le coefficient de vacuité digestive est de 56,8%.

Mots clès : Diet, Gulf Of Gabes.

#### Introduction

*Caranx rhonchus* (Saint-Hiliaire, 1817) est le poisson Carangidae le plus commercial du genre *Caranx* sur les côtes tunisiennes et notamment celle de la région sud. Dans ce travail, nous étudions le régime alimentaire de cette espèce selon ses aspects quantitatif et qualitatif par l'analyse du coefficient de vacuité et de certains indices alimentaires.

#### Matériel et méthodes

Les échantillons ont été récoltés aux ports de pêche des côtes sud de la Tunisie (Sfax, Mahdia et Mednine). Durant la période qui s'étend d'août 2004 à septembre 2006, un total de 777 individus, de longueur totale (LT) comprise entre 60 et 306 mm (3,31g<Mt<227,48g), ont été examinés. Après analyse des contenus stomacaux, les différentes proies ingérées sont identifiées, dénombrées puis pesées au centième de gramme près. Les estomacs vides ont été notés. Le coefficient de vacuité stomacale (Cv%) a été déterminé selon les tailles et ses variations ont été analysées en fonction des mois.

Pour étudier l'aspect quantitatif du régime alimentaire et pour classer les proies ingérées, nous avons calculé pour chaque item les indices suivants : pourcentage en nombre (N%), pourcentage en poids (W%), fréquence d'occurrence (F%) et Indice d'Importance Relative (IRI%) [1].

#### Résultats

L'analyse des valeurs moyennes du coefficient de vacuité a montré qu'elles restent toujours élevées, ce qui explique, qu'il y a plus d'estomacs vides que d'estomacs pleins. Ces valeurs varient entre 28% et 69%. Les valeurs moyennes les plus élevées correspondent aux mois de mars (61%), mai (54%), juillet (69%) et août (58%). La valeur du coefficient de vacuité moyen est importante pour *Caranx rhonchus* dépassant 56%. Par ailleurs, la valeur moyenne annuelle est plus grande chez les individus de plus de 20 cm (individus adultes), ceci pourrait s'expliquer par le fait que les gonades occupent la majeure partie de la cavité abdominale chez les adultes matures.

Au total, 822 proies pesant 432g ont été dénombrés, ce qui correspond à un nombre et un poids de 2,69 et 1,4g par estomac.

A partir du calcul des différents indices alimentaires relatifs à l'analyse qualitative notamment le pourcentage de l'indice d'importance relative (IRI%), nous avons établi le classement des différentes proies pour cette espèce.

La première constatation qui ressort de cette analyse est que *Caranx rhonchus* est une espèce carnivore dont le régime alimentaire est basé sur les poissons. L'analyse du tableau 1 montre que *Caranx rhonchus* présente un spectre alimentaire assez varié renfermant les divers groupes zoologiques : Des vertébrés représentés par les poissons appartenant à 6 familles notamment les Engraulidae et les Clupeidae, des crustacés, des annélides et des végétaux.

Les téléostéens constituent le groupe d'aliment majeur pour cette espèce (F%=64,2 ; N% =31,7 ; W%=81,4 et IRI%=59,3), L'anchois *Engraulis engrasicolis* constitue la proie principale avec W%=49,6 et IRI% de l'ordre de 13. Toutefois, la présence de crustacés (notamment les crevettes) dans le régime alimentaire de *Caranx rhonchus* est de moindre importance, avec un IRI de l'ordre de 20%. Nos résultats sont comparables à ceux trouvés par Fischer et al. [2].

| Tab.   | 1.   | Valeurs    | des   | différentes | indices | alimentaires | chez | Caranx |
|--------|------|------------|-------|-------------|---------|--------------|------|--------|
| rhonch | usde | s côtes su | ıd de | la Tunisie  |         |              |      |        |

| Groupe ou espèce       | F%    | N%   | W%   | IRI    | IRI%   |
|------------------------|-------|------|------|--------|--------|
| Engraulis engrasicolis | 25,2  | 13   | 49,6 | 1579,1 | 12,9   |
| Clupeidea              | 12,1  | 5,3  | 16,1 | 260,7  | 2,1    |
| Boobs boobs            | 2,6   | 1,3  | 2,7  | 10,7   | 0,09   |
| Lithognathus mormyrus  | 1,9   | 1,9  | 0,6  | 5      | 0,04   |
| Gobius Niger           | 1,6   | 0,8  | 3,6  | 7,3    | 0,06   |
| Millus surmeletus      | 0,6   | 0,2  | 0,3  | 0,4    | 0,003  |
| Scomber scombrus       | 0,3   | 0,1  | 0,02 | 0,048  | 0,0004 |
| Téléos. non identifiés | 24,6  | 10,8 | 14,9 | 632,9  | 5,2    |
| Total Téléosteéns      | 64,3  | 31,7 | 81,4 | 7270,9 | 59,3   |
| Crevettes              | 9,18  | 5,35 | 5,57 | 100,2  | 0,8    |
| Penaeus kerathurus     | 2,29  | 0,97 | 1,85 | 6,45   | 0,05   |
| Isopodes               | 1,3   | 0,48 | 0,52 | 1,3    | 0,01   |
| Gammaridae             | 1,9   | 1    | 0,05 | 2,01   | 0,02   |
| Mycidace               | 6,55  | 18,5 | 0,3  | 123,27 | 1      |
| Crust. non identifiés  | 12,13 | 6,2  | 3,86 | 122,02 | 1      |
| Total crustacés        | 33,1  | 60,6 | 14,1 | 2474   | 20,2   |
| Total mollusques       | 1,31  | 0,1  | 13,2 | 18,3   | 0,1    |
| Total annelides        | 1     | 1,3  | 0,3  | 1,3    | 0,01   |
| Total végétaux         | 2     | 0,7  | 0,2  | 1,7    | 0,01   |

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# POLE LINE FISHING IN THE EASTERN ADRIATIC

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# Abstract

Within four different category of fishing in Croatia, sport fishing has the highest number of participants. Research of pole line fishing, which is mainly performed in sport competitions, has been performed during 2005. Sparidae was the most dominant family of the catch, while common pandora, *Pagellus erythrinus*, within species. Bray-Curtis index of similarity showed that resemblance between community compositions is dependent on region and depth.

Keywords : Adriatic Sea, Fisheries, Biodiversity.

Within four different categories of fishing, allowed by regulations in Croatia, sport fishing has the highest number of participants. According to the official data [1] 44927 sport fishing licenses have been issued in 2004. However, research in western Mediterranean area, around island of Majorca [2], showed that only 59% of sport fishermen had legal licenses, which means that even in the eastern Adriatic, the number of actual participants in sport fishing is probably higher than reported. Fishing gear category of hooks and lines is the most important gear category in sport fishing. Within that category pole line is used in most of sport fishing competitions. The description of pole line would be a hooked line attached to a pole. Although this gear is also used in commercial fisheries, e.g. for fishing tuna, it is mainly used for sport fishing. Previously, poles were made of wood, but lately most are made of fiberglass. In commercial fisheries, poles are usually mechanized, with the pole movement being entirely automatic, but in sport fishing poles are hand operated. Pole lines can be operated either from the shore or from any type of vessel, on very wide range of depths. With pole line fishing is possible to catch fish on rough ground, even in their hiding places between the rocks. As the line is much longer than the pole, a moulinet has to be used during fishing. Fish are attracted by the different bait, depending on hook size and target fish. Research has been performed during 2005 and included sport fishing competitions, which are held under the sponsorship of Croatian federation of sport fishing at sea. Competitions that have been monitored included seniors and competitors of U21 category (under 21 year of age), both female and male. According to regulations, at every competition each competitor had the same conditions, from weight and kind of bait to allowed area of fishing. Thus, obtained catch was dependent solely on each competitor's ability and skill. Usually, fishing lasted for 5 hours each day, from 8 am until 1 pm. Total catch was analyzed in the way that all species were determined, while length in mm and weight in g were measured for each specimen. Using Primer 5 software, the similarity of community composition between all areas of research was calculated using the Bray-Curtis index. A total of 8 competitions were analyzed: Lovran, Primošten and Podgora were sites where pole line fishing from the shore occured, while at Lovran, Kukljica, Pag, Rovinj and Volosko fishing was performed from the vessel (Fig. 1).

The total number of fish caught and analyzed during those competitions was 17587, while their total weight was 981.74 kg. 70 different species were determined, of which 69 were Osteichthyes and one was a Chondrichthyan fish. Those species were representative of 24 different families. Sparidae was the most representative family with 14 species. Hence, in total catch Sparidae was the family with highest number and weight of caught specimens: 8233 (46,81%) specimens and 589958 g (60,09%) of weight, respectively. Second dominant family in total catch was Centracanthidae with 3863 specimens and 155195 g of weight, followed by Labridae with 3550 specimens and 133205 g of weight.

The most dominant species was the common pandora, *Pagellus erythrinus*, with 4649 caught specimens and total weight of 370231 g. Second most dominant species was picarel, *Spicara flexuosa*, with 3312 specimens and 119695 g of weight, followed by rainbow wrasse, *Coris julis*, with 3004 caught specimens and weight of 102660 g.

Grouping of adjacent sites showed that similarity between community compositions is dependent on region, as there is more resemblance between adjacent than distant areas (Fig. 2). However, dendrogram showed that such similarity is dependent also on depth as in case of Lovran area, where, in the same time, competitions from shore and vessels occurred. Dendrogram revealed that community structure off coast of Lovran, where pole fishing from vessel occured, is more similar to adjacent off coast community of Volosko area, where same fishing technique was applied, than to nearest littoral community of Lovran, where pole fishing occurred from shore, therefore, at smaller depth.



Fig. 1. Sampling sites: 1 - Rovinj; 2 - Lovran; 3 - Volosko; 4 - Pag; 5 - Kukljica; 6 - Primošten; 7 - Podgora.



Fig. 2. Bray - Curtis dendrogram of similarity between the sites shown in figure 1..

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# SPEAR FISHING IN THE EASTERN ADRIATIC

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# Abstract

Recent investigations show that spear fishing can have similar effects as commercial fishing. Research of spear fishing competitions in eastern Adriatic was performed during 2005. Overall, 28 different species were determined (26 teleost and 2 chondrichthyan species). The dominant (by number and weight) species were *Labrus merula*, *Diplodus sargus* and *Conger conger*. *Keywords : Adriatic Sea, Coastal Waters, Fisheries, Rocky Shores.* 

The importance of sport and recreational fishing has been consistently understated and under-reported [1]. However, nowadays it has been considered that all fishing activities have environmental impacts, so it is not appropriate to assume that these are negligible until proved otherwise. Hence, latest investigations pointed that such fishing can also cause ecosystem degradation of similar scales and types compared with commercial fishing [2]. Within sport fishing, spear fishing is one of the most popular and increasing fishing techniques in the Adriatic. Additional benefit for spear fishing in the Adriatic is the fact that mean annual sea temperatures are relatively high, which is suitable for performing of such fishing technique throughout the whole year [3]. Latest research of spear fishing in the Balearic Islands (west central Mediterranean) showed that during sport competitions spear fishing affected over 30 species, among which the most abundant were Diplodus sargus, Symphodus tinca, Labrus merula and Mugilidae. Hence, a decreasing trend over time for the mean CPUE was observed [4]. Conversely, it has to be pointed that it is a selective sport, as spearfishers tend to harvest larger individuals within a species. Thus, each target is individually selected, so bycatch should be zero, which is definitely a positive feature. According to Croatian regulations spear fishing using SCUBA gear is banned, as is night spear fishing. Research of five different competitions, which occurred in different locations throughout eastern Adriatic coast and lasted for several days, was performed from June to December 2005. Each caught specimen was identified, while length was measured to the nearest mm and weight to nearest g. CPUE was calculated for each competitor (g/competitor per hour). Overall, 628 specimens, weighing 554,82 kg, were caught, belonging to 28 species (26 teleost and 2 chondrichthyan species). Of 13 families present in total catch, Labridae and Sparidae were most dominant by number, while Congridae and Sparidae by weight (Fig. 1).



Fig. 1. Number and weight % of dominant families in spear fishing.

By species, the highest number of caught specimens belonged to brown wrasse, *Labrus merula*, white seabream, *Diplodus sargus* and european conger, *Conger conger*, while by weight *C. conger* was, due to its size, most dominant, followed by *L. merula* and *D. sargus*. Obtained results are similar to the data from west-central Mediterraenan [4], which means that, due to the same fishing technique, spear fishing targets mainly the larger stationary fish species, which inhabit coastal, mainly rocky, areas of depths up to 40 m. CPUE varied between different sites (Fig. 2) and this shows that prior access by spearfishers to the site is important, e.g. data from the Senj area, where most competitors spent a long period exploring the area prior the competition, due to its importance as National championship, was also the site with the highest recorded CPUE. Another

factor influencing CPUE is the season. This is indicated by checking the data from the Podgora area, where a difference in CPUE can be observed between two competitions held at the same site, but with a 3-month period in between. A decreasing trend in some species' mean sizes was observed by comparing new data to the data obtained a year before [5], but the time period was too short to make a reliable conclusion. Although competition catches are influenced by competition rules, and may bear little relation to regular spearfisher catches, it is presumed that such data can be reliable in determing target species and weight per unit effort, and therefore, useful for the management of recreational fisheries [6]. Thus, both competition and recreational spear fishing seem to have an important effect on target fish in the Adriatic, especially for fish which are not targeted by any other gear, e.g. *Labrus merula*.



Fig. 2. Catch per unit effort (CPUE) for different areas and average (g / spearfisher per hour).

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# SHORT-TERM TRENDS IN ANCHOVY AND SARDINE CATCH/DAY IN GREEK WATERS

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#### Abstract

Anchovy and sardine monthly catch per day from Greek waters for the period 1996-2000 were analysed in order to identify significant trends. Catches for both species were found to be declining throughout the study period, following the eutrophic north to south gradient of the Greek waters. Results are discussed in relation to exploitation patterns of the two stocks and some management proposals are suggested.

Keywords : Fisheries, Time Series, Aegean Sea, Ionian Sea.

#### Introduction

Anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) comprise 30% of the total landings and 60% of the total purse seine landings, being the two most important small-sized pelagic species in Greek waters [1, 2]. Despite their importance there has never been a systematic monitoring of their catch per unit of effort. In this study we present the anchovy and sardine monthly catch/day for the period 1996-2000 in order to identify significant trends.

#### Materials and Methods

Since the second half of 1995, fishing effort and corresponding catch per day for a large number of species have been collected by the Institute of Marine Biological Resources (HCMR). Data have been collected on a monthly basis over a network of 21 stations throughout the Greek Seas, by local Fisheries Inspectors [1]. At each station, data were collected from a sample of vessels displaying full activity, generally covering at least 10% of trawlers and purse seiners, and 2% of artisanal boats. Collected data were stratified by vessel size (based on EU regulations). Raw data subsequently grouped into two categories with respect to vessel size: <20 m and >20 m for trawlers, <15 m for purse-seiners, and <10 m and >10 m for artisanal boats. Data were also aggregated for five fishing subareas (N., C. and S. Aegean, Cretan waters and Ionian Sea), which generally differ in terms of biological productivity (see detailed review by [2]).



Fig. 1. Mean monthly catch per day for purse seiners >15 m in Greek waters, 1996-2000. Anchovy catches in (a) the N. Aegean; (b) C. Aegean; (c) Ionian. Sardine catches in (d) N. Aegean; (e) Ionian; (f) C. Aegean. Trend lines with slope significantly (p<0.05) different from zero are also shown.

A detailed description of the available data set, data processing and analy-

sis is given in [1]. These data overcomes various important drawbacks of all other data sources available, notably that fishing effort is expressed as fishing days at sea.

#### Results and Discussion

During 1996-2000, the mean anchovy and sardine catch/day was significantly higher for purse seiners >15 m, operating in the North and Central Aegean Sea and Ionian Sea (anchovy: >370 kg/day, sardine: >140 kg/day) when compared to those of other gears (i.e. trawl, beach-seine, netters) and areas (i.e. South Aegean Sea and Cretan waters) where the mean catch/day was <125 kg/day for anchovy and <108 kg/day for sardine. This agrees to a large extent with the results of the analysis of the National Statistical Service of Hellas data [2]. The main factors contributing to such a geographical differentiation in mean catch/day could be the gradient in eutrophy of the Aegean Sea waters along a NNW to SSE axis [2].

The catch/day time series for anchovy displayed a downward trend (p<0.05) in all three main areas (Fig. 1a-c). For sardine, declining trends were observed only in the Ionian Sea (Fig. 1d-f). The catch/day series in the North Aegean Sea did not display any trend probably because sardine's variability in this area is mainly affected by market demand.

Although additional information might be required together with catch/day series the negative trends identified indicate that pelagic resources are either heavily exploited or overfished. Declining catch/day trends are regarded as strong indicators of overfishing especially in the light of the fact that fishers maintain high catch rates by fishing in "hot spots"[3]. Thus, the regulations currently enforced for small pelagics (i.e., closed seasons, limited issue of licenses, minimum legal landing sizes, mesh size regulations, banning of pelagic trawl, no allowance to fish small pelagics with bottom trawl or with electric light) are inadequate and alternative management options should be considered. For example, it has been suggested that a displacement of the existing closed season from December-March, protecting the sardine spawning stocks with no effect on anchovy, to September-November, will be beneficial to the latter, which exhibited significant declining trends, by protecting the young of the year, as well as to sardine by protecting its stocks at the onset of the spawning period [4].

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# ZOOPLANKTON COMMUNITY CHANGES ALONG THE EUTROPHICATION GRADIENT VARNA LAKES -VARNA BAY (WESTERN BLACK SEA)

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# Abstract

The main objective of the present study is to select amongst the zooplankton community characteristics (diversity, quantitative and taxonomic structure, Rotifers/Copepods/Cladocera ratio) relevant descriptors to eutrophication. Plankton fauna in investigated area manifested dissimilar features which greatly correlated with the eutrophic state of the ecosystems Varna Lakes - Varna Bay. The results of Simper and principal component analyses (PCA) gave arguments to suggest the main zooplankton community characteristics as reliable indicators in biomonitorng schemes.

Keywords : Zooplankton, Black Sea, Eutrophication, Coastal Waters.

Varna Bay is the second largest bay along the Western Black Sea coast, connected via two canals to Varna Lake, further prolonged to Beloslav Lake by navigation canal. The studied coastal area (Beloslav Lake- Varna Lake-Varna Bay) is under various types of human pressure, such as urban pollution, chemical industry, agriculture, maritime transport, harbour and electric power plant activities. From the lakes to the Bay, a gradient of decreasing nutrient load and related effects were prominent [1]. Since 1970s, the ecosystems of the area have undergone noteworthy alterations of plankton communities as a result of eutrophication, oxygen deficiencies, and outburst of invasive species [1, 2, 3]. According to water quality index (WQI), the lakes have been categorized as hyper-eutrophic, with "bad" water quality in respect to primary productivity and biomass, abundance of the blooming species and frequency of blooms, whereas Varna Bay was scaled as highly eutrophicated, "poor"water quality [2]. Seasonal data for temperature (T°C), salinity (psu), oxygen, nutrients (N-NO<sub>2</sub>, NO3, NH4, P-PO4, Si-SiO4), chlorophyll-a concentration, phyto- and zooplankton taxonomic composition, plankton abundance and biomass for the period 1998-2005 were focused on. Species richness (S), Shannon index (H) calculated on abundance and biomass data; TRIX (trophic state index), PCA and simper analyses were applied for differentiation of the environmental characteristics along the eutrophic gradient. Obtained results revealed a decreasing trend of zooplankton quantity from the Lakes towards Varna Bay. Zooplankton numerical abundance was 3-15 fold lower in the Bay compared to the Lakes. The dominant taxonomic group for both lakes was the rotifers. Their density and diversity correlated significantly with trophic state indicators Chl a and nutrients [4]. Maximum values of rotifers were recorded in front of Provadiiska River mouth (Beloslav Lake) and close to the ferry terminal. The abundance ratio of major groups Rotifers/Copepods/Cladocera was 41/4/32 in Beloslav, 17/35/6 in Varna Lake (copepods prevailed), and 13/24/10 in Varna Bay (Cladocera significance). The magnitude of rotifers decreased towards the Bay, where benthic larvae and copepods prevailed. The zooplankton biomass structure was dominated by benthic larvae and copepods. The lowest zooplankton quantity and species diversity were registered at sampling stations close to the Varna West Port, thermoelectric power station and sewage plant. The domination of rotifers in the Lakes suggested a higher reproduction rate as a consequence of the disturbed environment compared to the Bay. Further the great share of small sized species and fine filtrators could be indicative for a high phytoplankton concentration. The results of the applied statistical methods figured out dissimilarities between the sites, due to species presence/absence and species abundance. PCA discriminate the three sites (Cluster A-Beloslav, cluster B-Varna Lake, cluster C-Varna Bay), and reveal ecological significance of zooplankton abundance and biomass (mainly Copepods), species occurrence, phytoplankton, Chl a, total inorganic nitrogen, TRIX index, salinity and biodiversity indices. The results gave grounds to suggest as descriptive the above discussed zooplankton characteristics, which could be exploited in the biomonitoring schemes as reliable indicators of indirect eutrophication impacts and water quality assessment.

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# ZOOPLANKTON COMMUNITY STRUCTURE AND SIZE DISTRIBUTION IN THE SOUTHERN TYRRHENIAN SEA DURING THE 2005 CIESM SUB 1 AND SUB 2 CRUISES

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#### Abstract

The mesozooplankton (>200  $\mu$ m) abundances and biomass spectra and diversity were studied in the southern Tyrrhenian Sea using an image analysis system during two oceanographic cruises. Preliminary results show a clear seasonal cycle of both abundance and biomass structure of the zooplankton community. These are compared to changes in zooplankton biodiversity and environmental conditions. *Keywords : Zooplankton, Tyrrhenian Sea, Copepoda, Circulation.* 

In the framework of the CIESM Zooplankton Indicators program and of the collaboration among the MedZoo group members (http://www.obsvlfr.fr/LOV/ZooPart/MedZoo/), zooplankton spatial distribution was investigated in the southern Tyrrhenian Sea. Eleven stations were visited in July 2005 (cruise SUB 1) and 17 stations in December 2005 (cruise SUB 2). For each station, two replicated samples were collected with a WP2 net by vertical tows in the layers 0-70 m and 0-200 m (figure 1).



Fig. 1. Net sampling stations (square) and CTD stations (cross) during SUB 1 (top) and SUB 2 (bottom).

Samples were analysed using the Zooscan imaging system [1]. This tool enables a fast and reliable enumeration and measurement of zooplankters in preserved net samples. A learning algorithm allows the recognition of some groups as it learns from a training set of different taxa images. In our study, slopes of the biomass spectra [2] are calculated for the meso-zooplankton community and for selected groups such as copepods (450 to 1550  $\mu$ m in Equivalent Spherical Diameter) on 50 samples (more than

50000 individuals measured). The aim was to monitor the spatial distribution of the size spectra of the main zooplankton taxa in the southern Thyrrenian sea, a region that has been seldom studied since the work of 3. Initial results of copepod distributions have shown that both, abundance and size spectra varied within each campaign and were related to the hydrological conditions. Differences were also observed between the two sampling periods. Copepods were more abundant and of a smaller mean size in July than in December. The results indicate that copepods were more abundant in anticyclonic than in cyclonic eddies during both cruises. The higher concentrations in the anticyclonic eddy during SUB 1 can be explained by the retention of organisms in the eddy and/or by the higher phytoplankton resources available for the copepods. Data are still under analysis and will be presented more in details during the congress.

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# MOLLUSCAN DIVERSITY IN THE N. EAST AEGEAN - GREECE

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#### Abstract

The extensive study of the benthic fauna biodiversity in the Greek NE Aegean, using sieves of different mesh sizes, revealed a molluscan community rich in abundance and species in contrast to general notion that tends to regard the area poor in marine benthic fauna. Focusing on the bivalves, seven species were newly recorded for the area and four additional species were reported for the first time in the Greek waters.

Keywords : Aegean Sea, Eastern Mediterranean, Bivalves.

#### Introduction

The traditional approach of regarding the eastern Mediterranean as an area poor in marine fauna [1] has been refuted as research studies carried out in the last two decades have revealed new geographic areas, new bathymetric zones and new species [2]. Focusing on the bivalves of the Greek Seas (territorial waters of the Aegean, Ionian, Cretan and Libyan Seas), and in particular the North Aegean, studies have revealed an increase in reported bivalve species from 212 species in 1995 to 243 species in 2004 [2]. Nevertheless, the North Eastern part of the Aegean Sea (an area of great importance since it is the region where the Black Sea Water enters the Mediterranean through the Dardanelles straits) remains one of the less known seas.

#### Materials and methods

Benthic samples were collected from 26 stations in the course of three cruises (autumns 1998 and 1999 and spring 2000) in the Greek North East Aegean with the aid of Van Veen grab and Box corer samplers. At least three replicates were collected at each station and sieved through 0.5 mm and 1 mm mesh sizes. Molluscan species composition and community structure were analysed separately for the two size fractions (>1 mm, 0.5-1 mm), in order to obtain a more detailed picture of the molluscan diversity in the area, by examining the usually understudied 0.5-1mm fraction. Particularly emphasis was attributed to bivalve species in order to update their inventory in the wider area and across the Greek Seas.



Fig. 1. Species number per increasing sampling area.

#### Results and Discussion

From a total of 105 samples, at depths of 63-1300 m, (sampling area 12.14  $m^2$ ) 3972 molluscs were enumerated, 24.2 % of which were >1mm and 75.8% between 0.5-1mm revealing the dominance of the 0.5-1 mm fraction in benthic studies, a fraction often understudied in the Greek Seas. These numbers represent 19% of the total benthic abundance in the area (a 14% of the fauna >1mm and 22% of the fauna at the 0.5-1mm fraction). Within the Mollusca, Bivalvia accounted for 88.9%, Aplacophora for, 6.5%, Gastropoda for 3.8%, Scaphopoda for 0.6% and Polyplacophora for 0.05%. In the fraction >1 mm 818 Bivalves were counted, 82 Aplacophora, 53 Gastropoda, 9 Scaphopoda and no Polyplacophora, whereas in the 0.5-1mm fraction the numbers were 2716, 179, 99, 14 and 2 respectively, revealing an even distribution of the taxa within the two size fractions.

With regard to the species composition, 124 species were identified, 84 (67.7%) of which were encountered in the >1mm fraction, and 107 (86.3%) in the 0.5-1mm fraction [Fig. 1]. It is interesting that 46 species were found only in the >1mm fraction and 31 only in the 0.5-1mm fraction, thus highlighting the importance of the two fractions in benthic

surveys. The recorded molluscan species represent 20.4% of the total benthic species in the area (17.6% of the species >1mm and 24% of the species at the 0.5-1mm fraction), in accordance to the average contribution of the species abundance and density observed in undisturbed soft bottom macrozoobenthic communities [3].

The expected increase in recorded species number with increasing sampling effort (both in terms of employing two size fractions and increasing the sampling area) is also presented in Fig. 1.

Overall, 83 species of Bivalves were recorded. This number is impressive compared to the 243 species recorded over the entire Greek North Aegean [2], and to the 190 species recorded along the Turkish Aegean Sea [4] areas that include many coastal sites, as opposed to the mainly deep water sites examined here. Among these Bivalve species, seven are new to the fauna of the Greek N. East Aegean waters. The species Coralliophaga lithophagella (Lamarck, 1819), Hyalopecten similes (Laskey, 1811), Propeamussium fenestratum (Forbes, 1844), Scacchia oblonga (Philippi, 1836), Solemya togata (Poli, 1795), Poromya granulata (Nyst & Westendorp, 1839) and Yoldiella lucida (Loven, 1846) are being reported in the Greek North East Aegean for the first time [2]. In addition, Epilepton clarkiae (Clark W., 1852), Haliris berenicensis (Sturany, 1896), Phaseolus ovatus (Seguenza, 1877), and Pholadomya loveni (Jeffreys 1882) are first records of the species in the Greek Seas [2]. The rare E. clarkiae was recorded at 63m depth (northeast of Lemnos island) in sandy bottoms, H. berenicensis at depths of 307 and 135 m (south and southeast of Lemnos island) on soft bottoms characterized by mud and muddy sand respectively, P. ovatus at 151 m in a muddy sand habitat (South east of Lemnos) and P. loveni at 132 m in a sandy mud seabed (South east of Lemnos). The current work of this relatively understudied region of the Greek North East Aegean Sea, covering a variety of bathymetric zones away from the traditional shallow coastal areas has revealed the richness of the molluscan community in the area. An analogous study (28 sites, seasonal sampling, 5 replicates, 0.5 mm fraction) in the south Aegean (Cretan Sea) has revealed a total of 109 molluscan species [5]. This work has added new species to the inventory of the species in the area as well as in Greek waters.

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# PROTECTIVE RESPONSE OF CAULERPA TAXIFOLIA UNDER INTENSE HERBIVORE PRESSURE

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#### Abstract

Our aim was to determine the caulerpenyne production and the antioxidant enzyme activities in *Caulerpa taxifolia* in response to *Bittium reticulatum* feeding. Caulerpenyne production, as well as CAT, SOD and GR activities significantly increased in presence of *Bittium*. *Caulerpa taxifolia* responded to intense herbivorism reducing their palatability and increasing their antioxidant system. *Keywords : Algae, Balear Islands, Bio-indicators, Gastropods.* 

#### Introduction

The seaweed of tropical origin algae *Caulerpa taxifolia* (Vahl) was introduced in the Mediterranean Sea in 1984, covering the infralittoral zone and competing with autochthonous flora [1]. Caulerpenyne is the main secondary metabolite synthesized by Caulerpales, playing a major role in its chemical defense [2]. Cells contain a complex network of antioxidant defence that scavenge or prevent the generation of ROS, and repair or remove the damaged molecules. Small marine herbivores often feed on macroalgae chemically defended against fishes or sea-urchins. In this work, we studied in a controlled environment the antioxidant enzyme response and caulerpenyne production by *Caulerpa taxifolia* under severe herbivorism .

### Materials and Methods

*Caulerpa taxifolia* samples were collected and maintained in two separated aquariums at 24°C. *Bittium reticulatum* were introduced in one aquarium during three days, whereas the other aquarium was considered as negative control. Caulerpenyne contents were measured by HPLC in fronds of *Caulerpa taxifolia* from both aquariums at the end of the experiment [3]. Antioxidant enzyme activities -CAT, GP, SOD and GR were determined in alga homogenates [3].

#### Results and Discussion

In a previous study performed during 2003 and 2004 in the Balearic Islands, we evidenced that *Bittium reticulatum* is one of the most abundant species living in *Caulerpa* meadows. The abundance reached 33 ind/m<sup>2</sup> in *Caulerpa taxifolia*, 133 ind/m<sup>2</sup> in *Caulerpa recemossa* and 208 ind/m<sup>2</sup> in *Caulerpa prolifera*. Herbivorism of *Bittium reticulatum* over *Caulerpa* species was evidenced in the aquarium.

The levels of caulerpenyne were significantly higher in *Caulerpa taxifolia* fronds at the end of the experiment after herbivore exposure compared to the initial values (p<0.05). CAT, SOD and GR activities significantly increased after three days in presence of Bittium *reticulatum* (p<0.05), whereas GP maintained the initial values.



Fig. 1. Caulerpenyne concentration with and without exposure of *Caulerpa taxifolia* to *Bittium reticulatum*.

The presence of *Bittium reticulatum* in the aquarium induces a protective adaptation in *Caulerpa taxifolia* in order to reduce the damage produced by herbivores. The alga responded with an increase in caulerpenyne production in order to protect the algae from herbivorous pressure reducing their palatability. The tissue damage generated by herbivores induces an antioxidant enzyme adaptation, increasing their activities.



Fig. 2. Antioxidant enzyme activities in *Caulerpa taxifolia* with and without exposure to *Bittium reticulatum*.

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# BIODIVERSITY AND VERTICAL DISTRIBUTION OF POLYCHAETES ASSOCIATED WITH MUSSEL BEDS ON ARTIFICIAL HARD SUBSTRATES (ROMANIAN COAST, BLACK SEA)

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# Abstract

Species composition, abundance and diversity of polychaetes associated with rocky mussel biocoenosis of Agigea dyke was analyzed seasonally at 9 different depths. A total of 13 polychaete species belonging to 5 families were identified, including *Eulalia viridis* (Linnaeus, 1767), a new record for the Romanian Black Sea coast. The most abundant polychaete in all seasons was the opportunistic species *Polydora cornuta*, which dominated at depths between 8 m and 16 m. At depths between 0 m and 6 m another species, *Salvatoria clavata*, dominated.

Keywords : Biodiversity, Polychaeta, Black Sea.

#### Introduction

On the Romanian coast of the Black Sea the hard substrate consists of Sarmatian organogenic limestone, covering an area of approximately 70 km<sup>2</sup>. This substrate is of great ecological and economical importance, because it provides high habitat complexity and harbours a rich and diversified fauna [1]. In addition to this natural rocky facies, the hard substrate is also represented by man-made structures such as docks, piers, jetties, breakwaters and shipwrecks. The aim of this study is to assess polychaete species composition and diversity from artificial rocky substrates of the Romanian Black Sea coast and provide information on their seasonal and vertical distribution patterns within these habitats.

#### Material and methods

Seasonal samples ( $16^{th}$  June 2004,  $3^{rd}$  October 2004 and  $16^{th}$  April 2005) were collected by SCUBA divers from the outer part of the southern dyke of Agigea seaport (Fig. 1). Sampling was conducted by scraping off quadrats (400 cm<sup>2</sup> each) along a transect perpendicular to the dyke at 9 different depths (0, 2,4, 6, 8, 10, 12, 14, and 16 m). Samples were washed through a 0.5 mm sieve and the retained organisms were fixed in 10% formalin and then transferred to 70% ethanol. Polychaetes were separated from the other taxa, identified to species level and counted. The community structure of polychaete assemblages was assessed on the basis of Soyer's frequency index (F), Margalef's species richness index (d), Shannon-Wiener's diversity index ( $\log_2$  base, H'), and Pielou's evenness index (J').



Fig. 1. Map of the Agigea seaport on the Romanian Black Sea coast. The Black arrow indicates the location of the study area.

#### Results and discussion

The identification of 8878 polychaete specimens collected provided 13 species belonging to 5 families (Table 1). *Eulalia viridis* (Linnaeus, 1767) is a new record for the Romanian Black Sea fauna. The most abundant species were *Polydora cornuta* (2741 individuals), *Salvatoria clavata* (1667 individuals), *Platynereis dumerilii* (1379 individuals), and *Nean*-*thes succinea* (669 individuals) which accounted for up to 73% of the total number of individuals collected on artificial hard substrates. These four dominant species were also the most frequent species in the mussel beds, occurring in all seasons and at all depths investigated (frequency index F=100%). Other recurrent species within artificial rocky sediments

 $(F \ge 50\%)$  included Harmothoe impar (86%), Prionospio cirrifera (73%) and Syllis gracilis (59%). Nereis zonata (41%) and Eteone picta (32%) were classified as common ( $25 \le F < 50$ ), whereas Nereiphylla rubiginosa (23%), Syllis hyalina (14%), Harmothoe imbricata (13%) and Eulalia viridis (9%) were rare (F < 25).

The community structure of the polychaete assemblages varied among seasons and depths. Number of species tended to increase from spring to autumn and mean abundance was lowest during spring and highest during autumn. The maximum number of species occurred at a depth of 6 m (11 species), whereas the lowest number was found at 0 m (5 species). Total density of polychaetes was highest at 6 m depth (31,325 ind. m<sup>-2</sup>), gradually decreased toward shallower or deeper zones and reached a minimum at 14 m (2375 ind. m<sup>-2</sup>). Margalef's species richness index ranged between 0.90 (in summer at 2 m depth) and 1.76 (in spring at 12 m depth). Shannon diversity index ranged from 1.08 (in summer at 12 m depth) to 2.83 (in spring at 8 m depth) and Pielou's equitability ranged from 0.42 (in summer at 12 m depth) to 0.89 (in spring at 16 m depth).

Tab. 1. Average density of polychaete species (ind.  $m^{-2}$ ) across all seasons, for each of the 9 depths examined.

| Cassian                                        | 192    |      |      | E    | epth (n | n)   |      | 14<br>208<br>8<br>25<br>0<br>32<br>17<br>0<br>667<br>0<br>0<br>558<br>134<br>1458<br>3559<br>1050 |      |
|------------------------------------------------|--------|------|------|------|---------|------|------|---------------------------------------------------------------------------------------------------|------|
| species                                        | 0      | 2    | 4    | 6    | 8       | 10   | 12   | 14                                                                                                | 16   |
| Harmothoe cf. impar (Johnston, 1839)           | 0      | 24   | 25   | 51   | 76      | 142  | 275  | 208                                                                                               | 350  |
| Harmothoe imbricata (Linnaeus, 1767)           | 0      | 0    | 0    | 0    | 0       | 0    | 0    | 8                                                                                                 | 9    |
| Nereiphylla rubiginosa (de Saint Joseph, 1888) | 0      | 0    | 0    | 0    | 12      | 8    | 0    | 25                                                                                                | 18   |
| Bulalta viridis (Linnaeus, 1767)*              | 0      | 0    | 23   | 27   | 0       | 0    | 0    | 0                                                                                                 | 0    |
| Eteone picta Quatrefages, 1865                 | 0      | 0    | 0    | 0    | 10      | 16   | 20   | 32                                                                                                | 59   |
| Syllis gracilis Grube, 1840                    | 12     | 87   | 88   | 76   | 13      | 18   | 16   | 17                                                                                                | 25   |
| Syllis hyalina Grube, 1863                     | 0      | 0    | 63   | 12   | 0       | 0    | 9    | 0                                                                                                 | 0    |
| Salvatoria clavata (Claparède, 1863)           | 1063   | 3288 | 4052 | 5073 | 3500    | 717  | 650  | 667                                                                                               | 542  |
| Syllidae indet.                                | 0      | 0    | 16   | 0    | 0       | 0    | 0    | 0                                                                                                 | 0    |
| Nereis zonata Malmgren, 1867                   | 11     | 225  | 300  | 50   | 150     | 9    | 7    | 0                                                                                                 | 0    |
| Neanthes succinea (Frey & Leuckart, 1847)      | 350    | 987  | 800  | 1482 | 1494    | 792  | 300  | 558                                                                                               | 516  |
| Platynereis dumerilii (Aud. & MEdwards, 183    | 3) 751 | 2074 | 6050 | 3052 | 3023    | 1125 | 209  | 134                                                                                               | 57   |
| Nereididae indet.                              | 838    | 2326 | 2563 | 5575 | 5024    | 1942 | 1425 | 1458                                                                                              | 1016 |
| Polydora cornuta Bosc, 1802                    | 22     | 638  | 2675 | 4887 | 5675    | 3358 | 2972 | 3559                                                                                              | 3865 |
| Prionospio cirrifera Wirén, 1883               | 0      | 0    | 12   | 50   | 26      | 67   | 133  | 1050                                                                                              | 408  |

\* new record for the Romanian Black Sea coast

The results of this study show that the polychaete fauna inhabiting the artificial rocky substrate from Agigea dyke is relatively scarce comparatively to the natural hard seabed from other areas [2, 3, 4]. This is essentially due to the strong influence of the severely polluted and eutrophicated waters of the nearby Agigea seaport and Danube - Black Sea canal.

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# A FUZZY LOGIC RULE-BASED MODEL TO EXAMINE THE SPATIO-TEMPORAL RELATION OF DEMERSAL RESOURCES WITH ENVIRONMENTAL CONDITIONS

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# Abstract

A fuzzy rule-based model was developed and applied on the fishery dataset derived from North Aegean Sea MEDITS Survey, during 1998-2001. The model provides a non-linear relationship between total fish biomass and four fish biomass dependent environmental variables (bottom temperature, bottom salinity, water depth and crustaceans biomass), which improves multiple linear regression approaches, and could be utilised for future fish biomass descriptive and predictive purposes. *Keywords : Demersal, Fishes, Models, Biomass, Aegean Sea.* 

Introduction

Understanding the spatial and temporal variability of demersal resources, and its links to the deep sea environment, appears as an important task for trawl fisheries management. Fuzzy logic techniques have recently been applied in fisheries research [1], improving classical fish landings analysis. Data on the distribution of demersal resources biomass in the North Aegean Sea were collected during MEDITS Surveys (1998-2001), and analysed for species assemblages, patterns in spatio-temporal changes related to environmental factors and ecological species interactions [2]. In this work, a fuzzy logic, rule-based model was developed aiming to provide a non-linear relationship between total fish biomass and environmental variables, as station water depth, bottom temperature, bottom salinity and crustaceans biomass.

#### Materials and methods

Fishery and oceanography data were collected and processed according to standard MEDITS protocol [3], at 64 stations throughout the North Aegean Sea during 1998-2001 (n = 165). Biological variables as total fish biomass (kg/km<sup>2</sup>) and total crustaceans biomass (kg/km<sup>2</sup>), along with environmental variables (sea bottom temperature and salinity) were extracted from the above database. The software DECISIA SPAD 5.5 for Windows was utilized for multiple linear regression analysis and a fuzzy logic model was developed on a simple MS-Excel spreadsheet following Sylaios et al. [4], to derive a complex relation between total fish biomass and the above described environmental factors.



Fig. 1. Scattergram of modeled versus observed Log(Fish Biomass) values.

Results and Discussion

The multiple regression model derived from the data considered was highly significant (p<0.01) but with a poor predictive capability ( $R^2$ =0.33).

Figure 1 illustrates the scattergrams of fuzzy estimated fish biomass versus the observed fish biomass values imported in the model. A linear regression equation formed as:

Recorded Data [log(Fish Biomass)] = 1.00103 \* Fuzzy Model Results [log(Fish Biomass)] - 0.0026

produced a line which coincides with the best-fit line (1:1 slope), as shown

in Figure 1. Fish biomass values produced by the model were slightly overestimated with the slope  $\gamma$  obtaining a value of 1.009. The squared correlation coefficient of modelled and observed data obtained adequately high values ( $R^2 = 0.751$ ), while the Sum of Squared Errors was 7.77 and the Root Mean Squared Error was 0.217. Figure 2 compares the observed and predicted fish biomass values time series, for the different data points considered, showing good agreement.



Fig. 2. Comparison between recorded and modelled fish biomass (in  $\mbox{kg/km}^2).$ 

According to our results fuzzy modelling improved the multiple linear regression approach in describing the variation of fish biomass according with the variables considered. Biologically, bottom temperature, bottom salinity and water depth should be considered as principal constrains in the biomass carrying capacity of demersal environment. Furthermore, fish and crustaceans dependence may be explained either in terms of predator-prey relationships or in terms of environmental niche siilarities.

Fuzzy modelling shows potential for the fisheries domain, but its predictability must be demonstrated with further studies.

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# VARIATIONS IN GROWTH AND LIFE HISTORY TRAITS OF SAND-SMELT, *ATHERINA BOYERI*, POPULATIONS FROM DIFFERENT WATER BODIES OF TURKEY: INFLUENCE OF ENVIRONMENTAL FACTORS

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#### Abstract

The present study describes variations in biological and ecological features of sand smelt in three different ecosystems (fresh, brackish and saline-marine waters). Otolith analysis indicated that lifespan was three years in all study areas. Length-at-age data showed that sand smelt grew better in Ömerli Reservoir rather than in Homa Lagoon and İzmir Bay. Life history variables were relatively similar, although the spawning duration was more extended and GSI higher in Ömerli Reservoir. Differences in growth and life history traits of sand smelt from different water bodies could be attributed to variation in environmental factors.

Keywords : Fishes, Reproduction, Growth, Lagoons.

The sand smelt , *Atherina boyeri* (Risso 1810), is a small, short-lived, euryhaline teleost fish of faunistic importance in coastal, estuarine and lagoon habitats, salt marshes, and, inland waters, forming large local populations. Sand smelt fisheries are among the most common and important in the Mediterranean countries and represent one of the main fishing resources. In Turkey, even though this species is not consumed by people, it is exported to some Mediterranean countries. However, there is no information about its environmental biology in Turkish waters. In this study, we provide basic information about some biological parameters of sand smelt for the fresh, brackish and marine waters from Turkey, which will be useful for its management.

Sand smelt were collected from Ömerli Reservoir (Anatolian part of Istanbul), Homa Lagoon (İzmir), and İzmir Bay using gill-nets, beach-seines and trawls between September 2003 and August 2004. In the laboratory, the fish were measured for total length (TL) to the nearest 1 mm and for wet body weight (TW) to the nearest 0.1 g. Sex was determined by visual examination of the gonad either by naked eye for larger fish or with the aid of a lens (x16) for smaller fish. Gonad weight (GW) was measured to the nearest 0.001 g. Age was determined from the otoliths. The gonadosomatic index (GSI) was calculated as: GSI = (GW/TW) x 100. The overall ratio of males to females was examined with the chi-square ( $\chi^2$ ) test. Mean length-at-maturity was calculated using non-linear regression [1].

A total of 378 individuals from Ömerli Reservoir, 605 individuals from Homa lagoon, and 966 individuals from İzmir Bay were caught. Otolith analysis indicated that maximum age was three years old from all study areas. Minimum length was 2.4 cm in İzmir Bay and 12.9 cm in Ömerli Reservoir (Fig. 1). GSI of sand smelt peaked between April and July in Homa lagoon and İzmir Bay. However, this period was a bit longer in Ömerli Reservoir which extended to September. The length at first maturity was 4.1 cm, 4.6 cm and 5.1 cm for Ömerli Reservoir, Homa Lagoon and İzmir Bay, respectively. Corresponding ages were 1 year for the three areas. The male:female ratio was 1:12.5 for Ömerli Reservoir, 1:1.28 for Homa Lagoon and 1:1.96 for İzmir Bay which deviated statistically from 1:1 (P<0.0001).

In the three studied areas, the life cycle of sand smelt was short, with only three age groups being evident. This is in agreement with the general pattern observed in most other sand smelt populations previously studied throughout their distribution range [2, 3]. [4] showed that sand smelt can adapt its life history and morphology to environmental conditions with a trend to reduced growth and length-age data along an oceaniccoastal-estuarine-freshwater habitat range. However, this trend has been conversely occurred in the present study. Length-at-age data showed that sand smelt grew better in Ömerli Reservoir rather than Homa Lagoon and İzmir Bay. A positive effect of temperature and food on growth of fish has been well documented. However, temperature regimes are quite similar in these locations and had probably no considerable impact on growth differences. We suggest that the presence of large sand smelt in Ömerli Reservoir is attributed to the lack of large predatory fishes in the reservoir and to the lack of fishing which is prohibited by local authorities throughout the year.

Life history variables were relatively similar, with some slight differences, namely extended spawning and higher GSI in Ömerli Reservoir. This may be ascribed to phenotypic adaptation to the environment with an increase in reproductive effort with increasing environmental variability. Since the Ömerli Reservoir is used as a source of drinking water for the İstanbul metropolitan area, an average of 872,000 m<sup>3</sup> water per day is discharged from the reservoir which leads to very unstable water level. Furthermore, algicide (copper sulphate) treatments are applied to the reservoir to decrease cyanobacterial blooms, which influence water quality negatively and cause severe fish kills. High dominance of females to males in the reservoir supported this suggestion.



Fig. 1. Length-at-age data for Atherina boyeri from Ömerli Reservoir, Homa Lagoon and İzmir Bay.

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# A RARE BROWN ALGA IN THE MEDITERRANEAN SEA: COMPSONEMA SAX ICOLA (KUCKUCK) KUCKUCK (PHAEOPHYCEAE, SCYTOSIPHONACEAE)

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#### Abstract

*Compsonema saxicola* (Kuckuck) Kuckuck (Phaeophyceae, Scytosiphonaceae) is reported for the first time in the Aegean Sea (Turkey). It was collected growing as an epiphyte in the midlittoral zone (-0,5 m) from Ayvalik (eastern Aegean Sea, Turkey) and identified with its usual distromatic base. Only unilocular sporangia were observed. *Keywords : Aegean Sea, Algae.* 

#### Introduction

The genus *Compsonema* was established by Kuckuck [1] and *Compsonema gracile* Kuckuck [= *Compsonema minutum* (C. Agardh) Kuckuck] is the type species of the genus. *Compsonema saxicola* has been first described as " *Myrionema saxicola* ?" from Helgoland in the North Sea [2], and it was subsequently transferred to the genus *Compsonema* [3]. *C. saxicola* (Kuckuck) Kuckuck has been reported from the Adriatic Sea and from the Gulf of Trieste (northern Adriatic, Italy) in the Mediterranean Sea till now.

The genus *Compsonema* has been assigned to the Ectocarpaceae [3], the Myrionemataceae [4], and more recently to the Scytosiphonaceae [5, 6]. The justification for placing this genus in the Scytosiphonaceae is based upon evidence form culture studies that demonstrate it to be a phase in the life history of *Petalonia* or *Scytosiphon* [5, 6]. *Compsonema minitum* shows two features which are characteristic for the Scytosiphonales [5]:

1. The presence of a single large lobed chloroplast per cell with a large pyrenoid in a pyrenoid sac.

2. A partly parenchymatous prostrate system morphologically similar to the knot filaments in the comparable thallus parts of *Scytosiphon* and *Petalonia*.

#### Material and Methods

*Compsonema saxicola* was collected in the midlittoral zone, as an epiphytic on *Chaetomorpha aerea* (Dillwyn) Kützing from Ayvalik (Aegean Sea, Turkey) in February 2005 and was preserved in 4% Formaldehyde in seawater. The identification of the this alga was made according to the accounts in Kuckuck [2], and Fletcher [4].

#### Results

Compsonema Kuckuck 1899: 58

Compsonema saxicola (Kuckuck) Kuckuck 1953: 343

(Myrionema saxicola Kuckuck 1897: 381)

Thalli were epiphytic on *Chaetomorpha aerea* (Dillwyn) Kützing, 0,5 mm diameter, spherical and dark brown. In a squash preparation the thallus is seen to consist of a distromatic basal layer (Fig 1a). Phaeophycean hairs, unilocular sporangia and erect filaments arise from the basal cells. The erect filaments are simple, uniseriate, up to 10-15 cells long, the cells 7-11  $\mu$ m long, 8-10  $\mu$ m broad, and each cell contains one plate-like chloroplast with one pyrenoid. Unilocular sporangia are common, oval, 35-40 x 20-25  $\mu$ m, borne directly from the basal cells, sessile or 1-celled stalks (Fig 1b). Plurilocular sporangia are unknown in this species. The plants were observed occurring at a water temperature of 10 °C.

*Compsonema saxicola* has been reported from the Helgoland, England and Ireland, Scandinavia, the Azores, Italy and the Aegean Sea coast of Turkey (this paper).

#### Discussion

*Compsonema saxicola* was characterized as being lithophilic or saxicolous. But Turkish plants were determined as epiphytic on *Chaetomorpha aerea* in the midlittoral zone.

It has been showed a connection between a minute *Scytosiphon* (*Scytosiphon pygmaeus* Reinke) with *Compsonema sporangiiferum* Setchell *et* Gardner and *Streblonema anomalum* Setchell *et* Gardner. It has been reported that the Atlantic *Compsonema saxicola* is very similar to the Pacific *Compsonema sporangiiferum*. *C. sporangiiferum* was reported first time as epiphytic on *Nereocystis luetkeana* (Mertens) Postels *et* Ruprecht from Neah Bay (Washington, USA). *C. saxicola* was studied in culture by P.M.

Pedersen (unpubl.) and he reported that a connection with a parenchymatous, erect phase was not shown.

*Compsonema saxicola* is probably a summer annual, and it was recorded from April to October from England and Ireland [4]. It has been reported that the erect thalli were poorly developed in culture but were recognisable as like *Petalonina* or *Scytosiphon* [4]. It was also called that the environmental conditions played role, particularly temperature and photoregime in the relationship between the *Compsonema* microthalli and the erect macrothalli and *Compsonema*-like thalli showed maximum development in warm temperature/long day conditions.



Fig. 1. *Compsonema saxicola*. a) Distromatic basal layer; b) nilocular sporangia and erect filaments.

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# CONTRIBUTIONS TO SPECIES KNOWLEDGE OF AMPELISCA GENUS AT THE BLACK SEA ROMANIAN LITTORAL

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# Abstract

Based on the detailed analysis of a huge material collected on the sedimentary bottoms (1-25 m depths) from the Romanian continental shelf during the period 2005-2006, the authors establish, for the first time in the Black Sea, the presence of the amphipod *Ampelisca sarsi*. The paper brings some arguments, which prove the presence on the shallow sedimentary bottoms of the Romanian shelf, of the species *A. sarsi*, which probably had been incorrectly identified before (unfortunately, checking material was not possible, due to the absence of any amphipod collections in the past decades).

Keywords : Crustacea, Biodiversity, Black Sea.

In the latter half of the 20th century the Black Sea benthos fauna was relatively well studied, considering particularly the spreading and abundance of populations. With rare exceptions, the issues of systematics were in the background, at that time researchers making use of the few existing identification books, taking the information from the predecessors and keeping the species nomenclature. This situation requires the revision of almost all groups of organisms in the Black Sea. The case analysed in this paper refers to the crustacean amphipod genus *Ampelisca*.

Ampeliscidae represents the genus prevailing in the benthic communities dwelling the sedimentary substrata from the temperate region up to the polar one. In the Black Sea, four species were identified: *Ampelisca diadema*, A. (*aff. spinipes*) [1], *A. pseudospinimana* (Turkish littoral) and *A. brevicornis* (Bulgarian littoral). The presence of the *A. diadema* was signalled for the majority of sectors, the rest of species having a strictly limited distribution. The high numerical abundance of the genus populations in the Black Sea, comparable with that of the populations formed by similar species living the European seas, as well as its spreading up to the oxic/anoxic zone, compensates for its reduced diversity.

Analysing some *Ampelisca specimens* from the shallow Romanian waters and comparing the results with the data of the literature, a few differences regarding the external morphologic features were observed: form of cephalic extremity, length and number of articles of AI, form of telson, presence and disposition of setae on the surface of each lobe.

It was established that all the more than 1 000 individuals collected in the Romanian littoral inshore waters (1 to 25 m depths), pertained to the *Ampelisca sarsi* (Chevreux, 1888), not to *Ampelisca diadema* as it had been quoted before.

A simple analysis of the species shows important differences comparatively with the classic species quoted at the Romanian littoral - *A. diadema*. The main elements, differentiating the two species are (Table 1) [2].

Tab. 1. Identifications elements of the species A. diadema and A. sarsi.

| Identification features                     | Ampelisca diadema                                                                                    | Ampelisca sarsi                                                                                                                                                     |
|---------------------------------------------|------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cephalic part (female)                      | Oblique truncate                                                                                     | Elongated and narrower in<br>anterior part                                                                                                                          |
| Length AI (female)                          | = or > then peduncle AII                                                                             | < then peduncle AII                                                                                                                                                 |
| Number of articles<br>flagellum AI (female) | 14                                                                                                   | 4 - 5                                                                                                                                                               |
| Telson (female)                             | Elongated, devoid setae<br>on dorsal surface with 4<br>pairs of distal and<br>subdistal small spines | Triangular with 2-3 simple<br>small setae on the surface of<br>each lobe, 2 pairs of<br>plumose setae disposed<br>lateral-basal and 1 distal<br>spine for each lobe |

However, some external morphologic features of the individuals from the northern sector in front of the Danube Delta and Constanta - Eforie Nord present a few differences comparatively with the species described for the Mediterranean Sea. The individuals collected from the southern sector (Mangalia) totally correspond to the classic description, without evident morphologic differences. The differences identified at the individuals collected in Sf.Gheorghe - Constanta and Eforie Nord areas consist in: variation in number of flagellum articles from antenna I (5-8); presence of different number (among 2 and 4 pairs) of setae and distal and subdistal spines of telson comparatively with only 1 of the Mediterranean species; existence of minor differences between morphology of uropod U3 of female and male (both sexes have plumose setae); both female and male

have always 2 pairs of plumose setae on lateral-basal part of the telson, and 2-3 pairs simple setae on dorsal surface (Fig. 1).



Fig. 1. Morphologic variation of telson at *Ampelisca sarsi* (a - female (f) from Mediterranean Sea [2]; b - female for Romanian southern sector (Mangalia); c, d - female and male (m) for Romanian northern sector (Sf.Gheorghe - Constanta) (original).

The issue of replacement of *A. diadema* with *A. sarsi* described for the Romanian marine waters seems to be very difficult, remaining still an open issue. Our explanation is that either the species was incorrectly determined for NW sector of the Black Sea or a gradual replacement of one species with another one occurred along the last decades. Taking into consideration the references, in the NW Black Sea, the actual presence of *A. diadema* in the benthic biocoenosis is constant. The co-habitation of the two species in mixed populations might be possible, which has to be checked in future. Recently, the analysis of samples collected from 60 m depths bottoms at the Romanian shelf has led to the identification of *A. sarsi* at these depths too, while *A. diadema* was absent.

Thus the presence of the species in NW Black Sea has to be very carefully checked both for the Ukrainian and Bulgarian littorals. The absolute dominance of on a large area of the Romanian shelf represents an element, which gives birth to the following remarks: 1. the difficulty of quick reorganization of the genus in NW Black Sea; 2. an incorrect identification of the amphipod species; 3. the uncertainty of being a new species introduced into the Black Sea and 4. necessity for more attention paid to taxonomy/systematics of benthic species.

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# FECUNDITY OF RED MULLET (*MULLUS BARBATUS* L., 1758) ALONG THE TURKISH COASTS OF THE MEDITERRANEAN SEA

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## Abstract

A total of 194 red mullets, *Mullus barbatus*, were sampled for fecundity studies by bottom-trawl along the Turkish coasts of the North Aegean Sea during Summer 1991 and Spring 1992 and of the Northern Levant Sea in Spring 1992. The mean batch fecundity was 7023 eggs in summer and 7960 eggs in spring for the North Aegean Sea. The mean fecundity estimates were higher in the Northern Levant Sea, being 11180 and 13000 eggs for the western and eastern regions, respectively.

Keywords : Aegean Sea, Eastern Mediterranean, Levantine Basin, Reproduction.

## Introduction

Red mullet (*Mullus barbatus*, Linnaeus 1758) (Pisces Mullidae) is one of the most valuable demersal fish species in the Mediterranean trawl fishery. Therefore, its biology and population dynamics have been widely studied in several regions of the Mediterranean Sea. However, previous investigations concerning the reproduction characteristics of the red mullet are limited, and only one study [1] provides information about its fecundity in Turkish coasts.

The main objective of this study is to present data on the fecundity of red mullet in the Mediterranean Turkish waters (North Aegean and Northern Levantine Seas).

#### Material and Methods

A total of 194 red mullet specimens with matured ovaries were used for fecundity estimation in this study. These fish were selected from the random subsamples of red mullets caught during the bottom trawl surveys conducted with R/V *K. Piri Reis* along the Turkish coasts of the North Aegean Sea in Summer 1991 and Spring 1992, and the Northern Levantine Sea in Spring 1992.

The fork length (mm) and total body weight (g) of each fish were measured on board, and gonad weight (g) and fecundity estimations were done in the laboratory.

Batch fecundity was determined using the hydrated oocyte method [2]. The relationship between batch fecundity and fish fork length (mm) was based on the function of  $Y=a10^{bX}$ , where the dependent variable (Y) is the batch fecundity and the predictor (X) is the fork length. This function was transformed to a linear form by taking logarithms, i.e.  $log_{10}(Y)=log_{10}a+bX$ . The linear regression analysis was used to fit this relationship to the data [3]. ANCOVA was also carried out to detect possible spatial differences in the values of the slopes b. Batch fecundity was divided by the ovary free weight of female fish in order to estimate relative fecundity (eggs/g). ANOVA was used to check if mean relative fecundity values differed spatially [3].

#### Results and Discussion

The fork length of the specimens caught ranged from 94 to 220 mm and the mean fecundity calculated was 7030 eggs in the North Aegean Sea during summer. A higher mean fecundity (7960 eggs) was found for the same region in spring. The mean fecundity estimates were 11180 and 13000 eggs for North-western and North-eastern Levantine Sea, respectively. The results of the regression analyses are given in Table 1. These analyses showed that batch fecundity increased with fork length. Larger red mullets have a significantly higher annual fecundity (per unit body weight) than younger ones. The slopes of the regression lines (all b values) were homogenous (according to the ANCOVA results). ANOVA and Tukey's HSD test showed that mean batch fecundity was significantly higher in the North-eastern Levantine Sea than in other areas. According to the results of ANOVA and Tukey's HSD test, there was a significant (P<0.05) difference in mean relative fecundities in the North Aegean Sea in Summer 1991 and Spring 1992 (Table 1). The mean relative fecundity was also significantly (P<0.05) higher in the North Aegean Sea in Spring 1992 than those estimated for the Northern Levant Sea (Table 1).

Tab. 1. Results of regression analyses by sampling area in Summer 1991 and Spring 1992. Here, n, min and max denote numbers of fish used in the analyses, and minimum, and maximum fork lengths, respectively. Estimated mean batch fecundities (BF) and their standard deviations (SD), and mean relative fecundities (RF) and their standard deviations (SD) are also given.

|                | 0.05400-             |    | Fork Length |      |     |     | Coefficients |      |       |      |     |    |
|----------------|----------------------|----|-------------|------|-----|-----|--------------|------|-------|------|-----|----|
| Season         | Area                 | n  | min         | mean | max | a   | b            | 12   | BF    | SD   | RF  | SD |
| Summer<br>1991 | North Aegean         | 60 | 115         | 159  | 205 | 173 | 0.010        | 0.50 | 7030  | 4564 | 128 | 45 |
|                | North Aegean         | 42 | 101         | 137  | 173 | 287 | 0.010        | 0.60 | 7960  | 4038 | 216 | 75 |
| Spring<br>1992 | North-Western Levant | 20 | 115         | 152  | 212 | 112 | 0.012        | 0.73 | 11180 | 7576 | 156 | 57 |
|                | North-Eastern Levant | 72 | 94          | 160  | 220 | 391 | 0.009        | 0.36 | 13000 | 7293 | 173 | 64 |

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# STRUCTURE ET ORGANISATION DES MACROINVERTEBRÉS DE LA LAGUNE NORD DE TUNIS (TUNISIE)

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# Résumé

L'étude des maroinvertébrés benthiques de la lagune nord de Tunis fait apparaître des peuplements prospectés qui dénotent d'une diversification spécifique et une régression notable des espèces indicatrices de forte pollution. Les facteurs hydrodynamiques (marée, courant ...) et édaphiques (pollution) paraissent dominants dans l'organisation et la répartition de cette macrofaune. *Mots clès : Zoobenthos, Biodiversity, Lagoons.* 

Situé à l'est de la capitale, le lac nord de Tunis a été sujet à une forte perturbation anthropique. Pour remédier à cet état critique, le lac a été restauré dont le but d'améliorer son hydrologie et sa sédimentologie. Cette étude a pour objectif la caractérisation et la détermination de l'organisation des peuplements macrobenthiques du lac après son aménagement.

Cinq stations de la lagune nord de Tunis (A1, A2, B, C1 et C2) ont été échantillonnées saisonièrement entre novembre 1997 et novembre 1998. Les prélèvements ont été réalisés au moyen d'un quadrat de 0.5 m de côté et de 0.2 m de long. Ils ont été triés à l'aide d'un tamis de 1mm de vide de maille, fixés dans une solution de formol salée à 10% et identifiés jusqu'à l'espèce puis dénombrés.

La classification hiérarchique ascendante et l'analyse factorielle des correspondances ont été effectuées à partir de l'abondance moyenne de chaque espèce sur les quatre relevés saisonniers.

L'ensemble des relevés permet de recenser 90 espèces de macroinvertébrés qui se répartissent en six taxons zoologiques (Mollusques, Crustacés, Cnidaires, Annélides et Ascidiacés) avec une nette prédominance numérique des Mollusques.

La comparaison de la valeur estimée de la richesse spécifique à celle trouvée par Zaouali et Baeten [1] avant l'aménagement du lac, suggère que le nombre d'espèces dans la lagune a largement doublé et que certaines espèces ont disparu telles que les espèces de Polychètes opportunistes. Toutefois la dominance des espèces tolérantes à l'excès de matières organiques constatée dans cette lagune, semble traduire un certain déséquilibre de ce biotope.

Le regroupement des stations sur la base de la distance euclidienne en fonction de leurs abondances macrozoobenthiques (Fig. 1), permet de repérer trois secteurs lagunaires. Le premier secteur comporte la station B, et le second couvre le secteur sud; il est constitué des stations C1 et C2. Enfin, un troisième secteur rassemble les autres stations (A1 et A2).



Fig. 1. Classification ascendante et hiérarchique des stations (B, C1, C2, A1 et A2 : stations).

Concernant l'AFC appliquée à ces prélèvements, nous retenons le plan factoriel F1xF2 (Fig.2). Le pourcentage d'inertie du premier axe F1 est de 47.1 % et celui du second F2 est de 28.8 %, soit 75.5 % au total. L'axe F1 oppose la station A2 à la station C1. Il paraît exprimer les variations horizontales du facteur hydrodynamique. L'identification du second axe F2 permet de séparer la station A2, à substrat sablovaseux, pauvre en matières organiques, de la station B pourvue d'un substrat vaseux noir, très riche en matières organiques. Cet axe semble exprimer une zonation selon les facteurs édaphiques notamment la pollution organique.

Cette analyse révèle une répartition différentielle des espèces macrozoobenthiques en fonction à la fois des facteurs hydrodynamiques et édaphiques qui sont eux-mêmes en relation avec d'autres facteurs environnementaux (climatiques, hydrologiques, profondeurâĂę). Ainsi, Les stations étudiées forment trois groupes, le premier est formé par les stations A1 et A2, le second par la station B et le troisième par les stations C1 et C2.



Fig. 2. Plan F1/F2 de l'analyse factorielle des correspondances (AFC) (A1, A2, B, C1, C2: stations).

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# STOMACH CONTENT OF HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) FROM THE TURKISH WESTERN BLACK SEA IN SPRING AND EARLY SUMMER

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## Abstract

The study was based on stomach content from 42 harbour porpoises bycaught or stranded between April to June in 2002 and 2003, on the Turkish western Black Sea coast. Seven fish species were identified. Sprat and whiting were the most important fish species in the diet by frequency of occurrence (64.1% and 23.6%, respectively). Besides fishes, crustaceans, pieces of algae, molluscs, bivalves, sand and plastic debris were also recorded.

Keywords : Cetacea, Diet, Black Sea, Plastics.

#### Introduction

There are three cetacean species living in the Black Sea, namely, bottlenose dolphin (Tur s iops truncatus), short-beaked common dolphin ( Delphinus delphis) and harbour porpoise (Phocoena phocoena). One of the important threats to these cetaceans, especially harbour porpoises, is bycatch in turbot fisheries in the Black Sea. The Turkish western Black Sea traditionally includes fishing grounds for turbots, Psetta maxima, P.m.maeotica and Scoptalmus maeoticus, which have high economic value. Many harbour porpoises and bottlenose dolphins die as the result of incidental catch in turbot and sole fishing nets in April, May and June [1-4]. Understanding feeding habits is one of the key factors in considering the protection measures for cetaceans. There have been some studies on the stomach contents of Black Sea cetaceans complited by [5]; but few on the Turkish coast [3]. The aim of the study is to identify food components of the spring diets of the Black Sea harbour porpoises on the Turkish coast as basic information to elaborate proper protection measures for the Black Sea cetaceans.

#### Materials and Methods

A total of 42 stomachs of harbour porpoise (33 female, nine male) were analyzed. Forty individuals were bycaught in turbot nets and two individuals were found stranded, in April - June in 2002 and 2003, in the western coast of Turkey [4, 6]. All stomach compartments were examined and stored in a freezer at -20 °C. Samples were thawed later; the contents removed, washed and sieved in a  $200\mu$  mesh size sieve and stored in 70% ethanol. Prey remains consisted principally of otoliths and bones of fish and rostrum and other body parts of crustaceans, which were identified using reference materials and published guides [7-8].

#### Results and Discussion

Food remains were found in 90.4% of the stomachs but only one individual contained decomposed fish remains. The stomach contents of the 42 porpoises included 3304 otoliths, of which 1935 (>1mm) were identified. These were from seven fish species, which were sprat ( S. sprattus), whiting (M. merlangus euxinus), sole (Solea (spp.)), gobies (Gobiidae (spp.), European hake (M. merluccius), anchovy (E. encrasicolus) and red mullet (M. barbatus) (Fig.1). Remains of 26 crustacean individuals (nine Crangonidae (spp.), seven Decapoda (spp.), seven Crustacea (spp.), three Caridae (spp.)) were also found in six stomachs, while the fish remains were found in 88,1%. Meanwhile, in another five stomachs, plastic debris was found. Pieces of algae, molluscs, bivalves and sand were also recorded. The debris in one of the bycaught individual (female, 130cm) stomach consisted of plastic bags and sheeting with dry weight of 40,9 g. Ingestion of plastic or other marine debris has been documented for 26 species of odontocetes and this is the fourth reported case of plastic ingestion by a harbour porpoise according to [9]. Benthic fish including whiting, and gobies; and pelagic schooling fishes such as sprat and anchovy, composed the basic diet of harbour porpoises in the Black Sea [5], [3]. Protection measures for harbour porpoises in the Black Sea, therefore, should be elaborated taking such information into consideration.

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Fig. 1. Fish composition stomachs of the harbour porpoises. (Others: European hake, anchovy, Pleuronectiformes and red mullet).

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# STOMACH CONTENTS OF BYCAUGHT HARBOUR PORPOISES (*PHOCOENA PHOCOENA*) FROM THE MARMARA SEA

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## Abstract

The study was based on stomach content of four harbour porpoises bycaught in the coastal fishery in 2004 and 2006, on the Marmara Sea coast. Three fish species, horse mackerel (*Trachurus trachurus*), sprat (*Sprattus sprattus*) and gobies (*Gobiidae* sp.) were identified. Horse mackerel and sprat were the most important fish species in their diet. *Keywords : Cetacea, Diet, Marmara Sea.* 

## Introduction

The Turkish Straits System (TSS), namely the Istanbul Strait (Bosphorus), the Marmara Sea and the Canakkale Strait (Dardanelles), constitute a biological corridor for dolphins as well as for pelagic fish between the Black Sea and Mediterranean Sea [1]. In the Marmara Sea, three cetacean species; bottlenose dolphin (*Tursiops truncatus*), short-beaked common dolphin (*Delphinus delphis*) and harbour porpoise (*Phocoena phocoena*), are known to occur. Harbour porpoise strandings have been reported from the TSS [2]. The aim of the study is to identify food components of harbour porpoises, as the first information on their feeding preference in the Marmara Sea.

#### Materials and Methods

Three porpoises were bycaught in the bottom gillnets for whiting and the trammel net for soles, one nautical mile off Yalova in 2004 and 2006 (Fig. 1). The fourth porpoise was found floating at sea by the fishermen and had clear net marks on it. All stomach compartments of individuals were examined. The contents were removed, washed and sieved in a  $200\mu$  mesh size sieve and stored in 70% ethanol. Prey remains consisted principally of otoliths and bones of fish which were identified using reference materials and published guidebook [3].



Fig. 1. Location of Yalova where the bycatch of harbour porpoises occurred

#### Results

The stomach contents of three porpoises included 153 otoliths, of which 148 (>1mm) were identified. These were from three fish species, which were horse mackerel (*Trachurus trachurus*), sprat (*Sprattus sprattus*) and gobies (*Gobiidae* sp.) (Table 1). In the stomach of porpoise no.1, half-decomposed horse mackerels (15 individuals) were found, but in the stomach of porpoise no.4, only a fish vertebra and crustacean body parts were found.

Tab. 1. Bycatch date, sex, length(cm) of porpoises, and fish otoliths in the stomach contents. (N: no, L.: length(cm), Hm.: Horse mackarel, S.: Sprat, Gob.: Gobies, Clu.: Clupeidae spp., m: male, f: female)

| N | Date     | L.  | Sex | Hm. | S.             | Gob. | Chı.           | Total      |
|---|----------|-----|-----|-----|----------------|------|----------------|------------|
| 1 | 26.03.04 | 116 | m   | 76  | 8. <del></del> | 4    | 5. <del></del> | 80         |
| 2 | 07.04.04 | 110 | m   | 14  | 17             | 3503 | 2.7            | 31         |
| 3 | 22.10.04 | 117 | f   | -   | 35             | 2    | 2              | 37         |
| 4 | 29.09.06 | 106 | m   | 32  | 81<br>1        | 222  | 8 <u>1</u>     | 9 <u>1</u> |

#### Discussion

Benthic fish, such as whiting, European hake and gobies, and pelagic schooling fish, such as sprat and anchovy, composed basic diet of harbour porpoises in the Black Sea [4], [5]. In this study, a very few species were found to be prey species which may be due to the small number of samples. However, it was documented for the first time that the porpoises do feed on horse mackerels in the Marmara Sea. Horse mackerels had not been found as prey species for the porpoises in this basin, although they are widely distributed in the Black Sea as well. Harbour porpoises in the Marmara Sea may conflict with coastal fisheries because they compete for the same resources, such as horse mackerels.

The occurrence of the harbour porpoise was first described as "sometimes" in the Marmara Sea and "very rare" in the Mediterranean by [6]. In the TSS three cetacean species were observed at most in April and October [7]. However, due to the heavy marine traffic and other ecological stress in the Istanbul Strait, their migration does not occur regularly [1]. In the two surveys of cetaceans in the TSS in 1997 and 1998 using line transect methods, no porpoise was observed [8]. A few harbour porpoises have been recorded in the northern Aegean Sea; their genetic signatures and small size suggest that these individuals originated from the Black Sea [9]. Resident populations of harbour porpoises have not yet been determined in the Marmara Sea. In this respect, these bycatch cases off Yalova in spring and autumn, can be considered as the result of the porpoise movements although it rarely occurs at present between the TSS and Black Sea. More specimens and detailed studies are needed for better understanding of the occurrence of the harbour porpoises in the Marmara Sea.

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# INVESTIGATION ON THE MACROZOOBENTHIC INVERTEBRATE FAUNA IN THE NORTH AEGEAN SEA

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## Abstract

Macrozoobenthic invertebrates were collected by bottom trawl at 13 stations in Thirteen locations off the Turkish coasts of the North Aegean Sea. A total of 9561 specimens were identified to 61 taxa. *Stichopus regalis* was present in 11 of the stations, *Penaeus kerathurus* and *Parapenaeus longirostris* were both common and abundant. *Keywords : Aegean Sea, Biodiversity, Zoobenthos.* 

Introduction

At the North Aegean Sea the thermophilic fauna of the Mediterranean Sea meets psychrophilic fauna of Black Sea origin [1]. Knowledge of the Aegean Sea is comparatively scarce [2]. Some of the earliest studies of the Mediterranean marine biota were carried off the Turkish Aegean coast by Forbes (1848), Colombo (1885) and Ostroumoff (1896) [3]. However, most studies in the Aegean Sea were limited to particular taxa, Gastropoda [4], teuthofauna [5] and sponges [6][7]. The aim of this study was to understand the vertical and geographical distribution of the macrozoobenthic invertebrate fauna off the Turkish Aegean coast.

## Materials and Method

Thirteen stations spread between Edremit Bay and Saros Bay, at depths between 40 and 480 m, were sampled by bottom trawl between 1-19 August 2001. Stations 1, 3, 6, 9, 12 and 13 were deeper than 300 m; stations 4, 5 and 12 between 100 - 300 m and 2, 7, 8 and 10 less than 100 m deep (see Fig 2). Each sample was counted and weighed after the identification. The abundance, presence and dominance were calculated. The abundance (A) is the mean number of the individuals from the total number of samples; presence (P) the number of observations of a species from the total number of samples, e.g. a "P" value of 11 indicates 11 stations. Dominance (D) is the proportion of the total number of one species to the total number of all organisms.



Fig. 1. The number of specimens in the various groups sampled from the stations in the North Aegean Sea.

#### Result and Discussion

A total of 9561 specimens were identified to 61 taxa. *Stichopus regalis* (Cuvier, 1817) was present in 11 of the 13 stations. *Penaeus kerathurus* (Forskål, 1775) has the highest dominance (55.726 %) and abundance (409.85) with 5328 specimens. *Parapenaeus longirostris* (Lucas, 1846) was present in 8 stations; abundance 87.15 and dominance 11,850 %. Crustaceans were the most presence and abundant group. Similar result was given by [1]. The specimens were mostly from stations 3 and 10 which were around 250-300 m deep. The highest values of species diversity were found in the deep water (250 m to 400 m) stations 3, 6, 9, 11 and 13. All groups were sampled at stations 2 and 8, 40-45 m deep. According to our data, the most abundant groups, crustaceans and mollusks, were sampled from deep water with the most abundant specimens (*P. kerathurus* and *P. longirostris*), but all groups were present in shallow waters (see

Fig.1). As a result, the species diversity was higher in shallow water than deep water and the species abundances were higher in the bottom water than the upper layer in the North Aegean Sea.



Fig. 2. The sampling stations.

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# LUNAR CYCLES OF OTOLITH GROWTH IN THE JUVENILE SILVER SCABBARDFISH ( $L\!EPIDOPUS$ CAUDATUS)

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# Abstract

Otolith analysis was performed on the silver scabbardfish (*Lepidopus caudatus*) in the northern Aegean Sea in order to examine whether the growth zones that appeared between the nuclear area and the otolith edge in fish aged less than a year old, are related to the lunar cycle. The number of these zones ranged between 1 and 13 and was highly correlated with fish length. The periodicity of the zone formation was attributed to the lunar cycle. This hypothesis was validated by comparing the assigned birth of each fish to the spawning of adult population.

Keywords : Aegean Sea, Teleostei, Growth, Deep Waters, Fish Behaviour.

#### Introduction

The silver scabbardfish, *Lepidopus caudatus*, is a benthopelagic species living along the continental shelf and upper slope. It is a schooling species that lives close to the bottom during the day and migrates into midwater at night [1]. Growth analysis on the northern Aegean population of the species using otolith reading revealed that, in fish up to one year old, a series of opaque and translucent zones appear between the nuclear area and the otolith edge (Torre *et al.*, unpublished data) (Figure 1). The aim of the present work is to examine whether these zones are related to the lunar cycle.



Fig. 1. Translucent zones checked in 0+ specimen of the silver scabbard-fish (*Lepidopus caudatus*) in the northern Aegean Sea.

#### Materials and methods.

A total of 370 otolith of fish up to 1 yr old (TL range: 85-700 mm; mean TL=  $487.5\pm12.54$  mm) were seasonally sampled (summer 2003-summer 2005) with bottom trawling. Otoliths were observed under a light microscope. The number of translucent zones, their distances from the otolith nucleus, and otolith radius were recorded.

#### Results and discussion

The number of growth zones checked, varied between 1 and 13 and a highly significant linear correlation between the number of translucent zones (N) and otolith radius (OR) was observed (N = 7.94 OR - 0.94; R<sup>2</sup>=0.97, n=370, p<0.01). The fact that in 1 yr old fish the number of growth zones was 13 suggested that growth zones followed a lunar periodicity (13 cycle x 28 days = 364 days  $\approx$  one year). Thus, for each specimen, a date of birth was assigned. The peaks of birth (summer and autumn-winter) coincided with the reproductive peaks of the species in the area (Torre *et al.*, unpublished data) and hence indirectly validated the ageing method.

Accordingly, the number of translucent zones recorded, was age transformed (month) to formulate an age-length key. Total length at age data were statistically analyzed using non-linear regression analysis. The data were best fitted by the logistic model ( $R^2 = 0.87$ , Figure 2): TL = La(1/(1+exp(-r(t-a)))) where TL is the total length (mm), La the asymptotic length (in mm), t the age (in months), r the growth coefficient (in months<sup>-1</sup>) and a is a parameter (in months) equivalent to the age at 1/2 La. The parameters computed were:  $La = 702.19 \pm 43.28$  mm (p<0.01),  $a=7.33\pm0.41$  months (p<0.01),  $r=0.34\pm0.04$  months<sup>-1</sup> (p<0.01).

The growth of the otolith daily increments is slower during the full moon in deep water species following the same daily migratory behavior [2, 3]. This is probably caused by the possible dispersion of zooplankton during full moon [2]. Euphausiid crustaceans are the main prey of the silver scabbard fish [4] and their diel vertical migration may be influenced by moonlight [5]. Assuming that the silver scabbardfish may also be a nocturnal feeder, changes in prey availability related to the lunar cycle, may influence its feeding activity and consequently its growth rate. Hence, the lunar cycle may influence the growth patterns of the silver scabbardfish otolith.

Further studies on the daily feeding and migratory behavior of the silver scabbardfish coupled with otolith microstructure analysis may clarify this hypothesis. Moreover, the possibility of detecting lunar phases by otolith reading instead of using the time consuming daily increment analysis may be an useful tool in ageing of fish.



Fig. 2. Logistic model applied to total length (TL, mm) at age (months) data for silver scabbardfish (*Lepidopus caudatus*) in the northern Aegean Sea.

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# DISTRIBUTION OF DEMERSAL FISHES IN THE NORTH AEGEAN SEA, GREECE

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## Abstract

The summer demersal fish density was assessed at 64 stations in the northern Aegean Sea sampled using a bottom trawl (1996-2001). Five high density regions were observed with the biomass density presenting a north/south and an inshore/offshore gradient. The biomass variability was explained by the mixing of the prevailing water masses, the water circulation of the northern Aegean Sea and the upwelling systems.

Keywords : Aegean Sea, Demersal, Fishes, Crustacea.

#### Introduction

The northern Aegean Sea is an area of complex bathymetry with an extended continental shelf. Although the landings are dominated by small pelagic fish, some demersal fish species (e.g. the European hake, *Merluccius merluccius*) constitute a significant part of the commercial catch in the area. The overall biomass of demersal fishes in the northern Aegean Sea has never been evaluated. The aim of the present work is to assess the demersal fish distribution and their biomass in the northern Aegean Sea and to explain the parameters that may are responsible for such variability.

## Materials and methods

The summer fish species density was calculated using the swept area method based on data from 64 stations of the northern Aegean Sea. Sampling was performed using a bottom trawl during the Mediterranean International Trawling Survey (MEDITS) program between 1996 and 2001 [1]. The duration of each haul was 30 or 60 min, depending on the sampling depth and the vessel speed was kept constant during hauling (at 3 knots). The gear used was the same for each haul (GOC 73) with a codend stretched mesh size of 20 mm and a vertical mouth opening of about 2 m. The swept area method is based on the analogy between the sampled area (estimated by the trawl opening, the speed and the duration of each haul) and the entire stock area [2]. The fish density was estimated by simply dividing the weight (kg) of fish caught in each haul by the sampled area (km<sup>2</sup>). No error estimates are available for these calculations.

Sea surface and bottom temperatures ( $^{\circ}$ C) were recorded *in situ*. MapInfo Professional 8.0 was used to show the fish biomass in the area and principal component analysis (PCA) to determine the factors (sea surface and bottom temperature, depth, longitude, latitude, cephalopod and crustacean biomass) that better explained the fish distribution variability.



Fig. 1. Average demersal fishes density in the North Aegean showing demersal resources high density spots (MEDITS 1996-2001 data). TS : Thracian Sea, TG : Thermaikos Gulf, EG : Evoikos Gulf, TI : Thassos Island, SI : Sporades Islands, EI : Evoia Island, LI : Lesvos Island, CI : Chios Island.

#### Results

The biomass density presented a north/south and an inshore/offshore gradient with the coastal regions being richer in terms of biomass than the open sea ones, as it has been previously pointed out for zooplankton [3]. We observed 5 high-density regions persistent over the 5 years (Fig. 1): Thracian Sea (TS), Thermaikos Gulf (TG), South of Chios Island (CI), Evoikos Gulf (EG) and the area 25 km west of Lesvos Island (LI). The PCA showed that there was a correlation between fish biomass and crustacean biomass, explaining 30.14% of the system's variance. No other correlations were found.

#### Discussion

Three main areas were previously distinguished in the northern Aegean Sea based on their particular environmental conditions [4]: TG, TS and central Aegean Sea. These areas are also highlighted in this study, with TG and TS being biomass-rich areas. TG and TS are shallow areas influenced by the less saline and nutrient-rich riverine input and the Black Sea water [5]. These water and nutrients fluxes tend to explain the biomass abundance and the north/south gradient. EG is a particularly deep (about 500 m) with the lowest bottom water temperature in the entire northern Aegean Sea. Yet, it is a productive area, exhibiting high fish biomass which remains unexplained.

The zone located to the west of LI belongs to the generally biomasspoor central Aegean and yet shows a high fish biomass. An upwelling/downwelling system [6] that brings nutrient-rich water offshore may explain this phenomenon. The west CI high density area may be also due to Ekman transport leading to water mixing [6]. The Ekman transport and the subsequent upwelling/downwelling is greatly related to the northerly winds blowing during the summer in the Aegean Sea and, to a large extent, is seasonally confined. Hence, the overall demersal fish distribution pattern refers to summer conditions only.

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# PRELIMINARY ANALYSIS OF THE HABITAT CHARACTERISTICS OF ANCHOVY ANDSARDINE IN THE AEGEAN SEA IN RELATION TO FISH SIZE

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# Abstract

The present work examines the size specific distribution of anchovy and sardine in the Aegean Sea (Eastern Mediterranean basin) during early summer. Data from pelagic trawl hauls, multivariate methods, certain satellite environmental data and area topographic characteristics were used in order to identify the parameters that could discriminate the spatial distribution of the juveniles and the adults of both species *Keywords : Aegean Sea, Eastern Mediterranean, Pelagic.* 

## Introduction

Considering the general lack of information on the size related distribution of small pelagic fish in the Eastern Mediterranean basin, we examined the spatial changes in the length frequency distribution of anchovy and sardine populations, in the main fishing grounds of Aegean Sea, during June. Catch data from pelagic hauls were used and multivariate methods were applied separately for anchovy and sardine, in order to examine the classification of the pelagic trawl hauls in respect to fish size. Furthermore, certain satellite environmental data and area topographic characteristics were used to identify the parameters that could discriminate the resulting size-related groups.

#### Materials and methods

Data on catches from 132 pelagic hauls of 6 research surveys (1998-2006) on board the R/VPHILIA carried out in Aegean Sea during June, were analyzed in order to explore the spatial changes in the size distribution of anchovy (data from 99 hauls) and sardine (data from 78 hauls). Mean total length and fish abundance per hour and 0.5 cm length class were estimated for each haul. This weighted length frequency distribution was analyzed with the non metric Multi Dimensional Scaling (MDS) using a Bray-Curtis similarity matrix, in order to identify haul groups based on fish size.



Fig. 1. MDS results for sardine. Juveniles: hauls with mean length of the catch <110mm; Adults: hauls with mean length of the catch >110mm.

In order to determine if the groups defined by the MDS could be distinguished in terms of certain environmental characteristics a stepwise backward Discriminant Function analysis (DFA) was applied. The F-statistic was used to test the significance of the group centroid differences [1]. Satellite and topographic data were used. The satellite data (mean weekly values of sea surface temperature-SST in °C, chlorophyll-a CHLA in mg/m<sup>3</sup>, sea surface salinity-SSS, sea level anomaly-SLA in cm, photosynthetic active radiation-PAR in Ein/m<sup>2</sup>/day) were estimated by GIS techniques [2]. Regarding topographic data, the study area was divided into 6 sub areas and the Enclosure Index (EI) as well as the size of each sub-area (in  $\rm Km^2$ ) were estimated as described in [3], in order to take into account the peculiar topography of the Aegean Sea that is consisted of variable sized, open as well as semi-enclosed areas.

Tab. 1. DFA results for anchovy and sardine. EI: Enclosure index, SST: Sea surface temperature, CHLA: Chlorophyll-a, PAR: photosynthetic active radiation, SLA: sea level anomaly.

|         | Varia-<br>bles            | Wilks'<br>λ | p-<br>value | Correct<br>assignments |
|---------|---------------------------|-------------|-------------|------------------------|
| Anchovy | EI<br>SST<br>CHLA         | 0.83        | 0.000       | 81.82%                 |
| Sardine | SLA<br>CHLA<br>SST<br>PAR | 0.83        | 0.009       | 73.08%                 |

### Results and Discussion

The MDS analysis showed that hauls characterized by mean length less than 110 mm for both species were mainly grouped together indicating groups of juveniles and adult individuals (Fig.1). This length is close to the size of first maturity for both anchovy and sardine in the Aegean Sea [4]. Table 1 shows the results of the DFA analysis on the environmentalvariables used. The differences between the two groups were in all cases highly significant as shown by the Wilks' statistic and its correspondent F-statistic. The high percentages of correct assignments of hauls to the groups (>73%) indicated satisfactory discrimination between adults and juveniles (Table 1). DFA revealed that theparameters, mostly responsible for the spatial separation of the juveniles and the adults were EI, SST and CHLA regarding anchovy andS ST, CHLA, PAR and SLA regarding sardine (Table 1). These preliminary results indicate that juveniles and adults of both anchovy and sardine are spatially separated which seems to be related to certain environmental parameters. The use of data from additional areas and years will further highlight the habitat characteristics of juveniles and adults. This information could be coupled with GIS techniques for mapping the potential habitat of juveniles and adults.

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# DEMERSAL-PELAGIC RATIO IN GREEK FISH LANDINGS (1964-2003)

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## Abstract

The demersal/pelagic (D/P) ratio was assessed in different Greek fishing regions for the period 1964-2003. In eastern/southern Aegean region and in western/central Aegean and Ionian region, the D/P ratio decreased significantly (P<0.05) during 1964-2003. In contrast, in the northern Aegean such a trend was present only for the period 1990-2003. These trends indicate that fisheries in these regions are increasingly relying on the smaller, short-lived pelagic fishes.

Keywords : Aegean Sea, Demersal, Pelagic, Fisheries, Ionian Sea.

### Introduction

The annual landings of the Greek commercial fishing fleet have been routinely recorded since 1964 by the National Statistical Service of Greece (NSSG) for 16 fishing subareas [1]. Landings data refer to the legal and reported large- and small-scale fisheries, excluding recreational or sport fishing.

The aim of the present work was to assess the demersal/pelagic ratio (D/P) in groups of fishing subareas based on their fish landings composition for the period 1982-2003. The D/P ratio is used in fisheries science as an indication of the effect of fishing on marine ecosystems [2].

#### Materials and methods

Non-parametric multidimensional scaling (NMDS) using the Bray-Curtis similarity measure was applied to the average (1982-2003) landings of 66 per species (or groups of species) for each Greek fishing subarea. NMDS was used to identify groups of fishing subareas having similar landings composition. Stress values <0.15 indicate a good representation of data in two dimensions [3]. Consequently, we estimated the D/P ratio, for the groups of subareas indicated by NMDS, for the period 1964-2003. Demersal and pelagic species were defined based on FishBase (www.fishbase.org).

#### Results and discussion

The application of NMDS revealed the existence of three groups (Figure 1): (A) the northern Aegean subareas 13 and 14, including the Pagassitikos Gulf, subarea 11; (B) the Ionian (subareas 3, 4, 5 and 6) and western/central Aegean (subareas 8, 9, 10 and 12); and (C) the eastern/southern Aegean subareas (7, 15, 16, 17 and 18). This grouping was also confirmed by cluster analysis (results not shown). The two dominant pelagic and demersal species per group are shown in Figure 1.



Fig. 1. NMDS of Bray-Curtis similarities from standardised mean catch data per species (1964-2003) showing the 16 Greek fishing subareas [for the location see figure 3 in (1)] assembled in three groups. The dominant pelagic (P) and demersal (D) taxa landed in each area are also shown.

The mean D/P ratio differed with group of subareas (ANOVA, P<0.05; A:  $0.364\pm0.001$ ; B:  $0.848\pm0.004$ ; C:  $2.27\pm0.014$ ), being higher for southern Aegean, thus indicating the predominance of demersal species in this region when compared to the northern Aegean the landings of which are dominated (>45%) by anchovy and sardine. The D/P ratio declined

significantly with time in the eastern/southern Aegean and in the western/central Aegean and Ionian Sea group (C and B respectively: Figure 2), a fact showing that fisheries in these areas are increasingly relying on the smaller, short-lived fishes from the lower part of marine food webs because the demersal stocks are depleted and the large pelagic ones are either declining or remain stable. Although the D/P showed no significant trend with time in the northern Aegean Sea for the entire period, it declined significantly (P<0.05) for the 1990-2003 period (Figure 2: bottom line, black circles).



Fig. 2. The D/P ratio for Greek landings (1964-2003) in the three groups of subareas shown in figure 1. Regression for Group A refers to the 1990-2003 period.

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# THERMAL THRESHOLD OF THE ONSET OF MATURATION IN CLUPEID FISHES USING QUOTIENT ANALYSIS

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# Abstract

The quotient rule analysis was applied to assess the preferred ranges of sea surface temperature for sardine (*Sardina pilchardus*) and round sardinella (*Sardinella aurita*) spawning which was associated with temperatures  $<16^{\circ}$  C for the former and  $>21.5^{\circ}$  C for the latter. *Keywords : Spawning, Fishes, Temperature, Aegean Sea.* 

## Introduction

The psychrophilous European sardine (*Sardina pilchardus*) and the thermophilous round sardinella (*Sardinella aurita*) are the most important, in terms of biomass landed, clupeid fishes in the Aegean Sea. Despite the close taxonomic relationship, they exhibit different reproductive strategy in the Mediterranean Sea with the European sardine spawning over an extended period during the winter (see [1] and references therein) and round sardinella spawning over a relatively short period during the summer (see [2] and references therein). The aim of the present work is to assess the thermal threshold which determines the onset of gonadal maturation using an empirical method and the two clupeid fishes as case studies.

#### Materials and methods

Samples were collected monthly onboard the northern Aegean purse seine commercial fleet for the period September 2000-August 2002. Sea surface temperature was measured using a CTD probe. The annual reproductive allocation index (ARA), which describes the relative size of gonads and is used as an indicator of reproductive activity was calculated monthly based on the gonad and somatic weights [3].

A quotient-rule analysis [4] was applied to assess the preferred ranges of sea surface temperature for sardine and round sardinella spawning. For each species, the ARA value corresponding to each class was expressed as a percentage of the total ARA values added together (% ARA) and was divided by the percentage frequency of occurrence of each class (% SST) giving the quotient values (Q) for each temperature class [4]: Q= (%ARA)/(%SST). Quotient values >1 indicate preference to a specific range of variable, while those <1 indicate avoidance of the specific class [4]. Quotient curves were generated from smoothed (using a 6-point running mean) quotient values and were plotted against variables.

#### Results and discussion

The quotient curve plots for sardine (Figure 1) and round sardinella (Figure 2) showed their preferred ranges of SST. The quotient values >1 that are indicative of the onset of reproductive activity, were associated with temperatures >21.5 °C for round sardinella, and with temperatures <16 °C for sardine. The results coincide with the reported onset of gonad maturation for the two species at the northern Aegean Sea. Round sardinella has been reported to start spawning in May/June at temperatures exceeding 20 °C. Similarly the European sardine spawns between October and March, i.e., the beginning of gonad maturation occurs at around 16-17 °C.



Fig. 1. Quotient curves for European sardine (*Sardina pilchardus*) annual reproductive allocation (ARA) with sea surface temperature (SST, °C). Note the reverse order of x-axis data.

This method is of high importance in fisheries management because it allows a quick pre-estimation of reproductive activity for species whose spawning is largely depended on environmental and/or climatic factors [2, 5]. However, this method needs to be tested for other species and variables to ensure its efficiency in predicting the onset of spawning based on environmental data.



Fig. 2. Quotient curves for round sardinella (*Sardinella aurita*) annual reproductive allocation (ARA) with sea surface temperature (SST, °C).

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# DIEL FLUCTUATIONS OF A SHALLOW-WATER FISH ASSEMBLAGE IN PRAPRATNA BAY (SOUTHERN ADRIATIC, CROATIA)

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## Abstract

The shallow-water fish assemblage from Prapratna Bay was sampled with a small beach seine at 4-h intervals over 24-h periods between April 2003 and March 2004. A total of 51802 individuals from 58 species (55983,27 g) were caught. The dominant species (*Boops boops*, *Atherina boyeri*, *Sardina pilchardus* and *Sarpa salpa*) were caught in consistently higher numbers and biomass in different times of the diel period. At the assemblage level, generally more species were caught during daytime wheraeas a larger number of individuals and biomass were caught during night.

Keywords : Fishes, Biodiversity, Adriatic Sea.

#### Introduction

Coastal shallow-water areas are important feeding and nursery grounds for many fish species. In these areas there is usually a distinct periodicity to the catch rate over the 24 h period [1]. In part, this reflects net avoidance, as fish can see the net in daytime and avoid it [1,2]. This can also be due to real changes in the abundance and structure of the fish assemblage. Diel changes in assemblage structure, which are superimposed on the seasonal one could have a profound effect on the perception of a fish assemblage [2]. The present study provides data on the diel changes in catches of shallow-water fish community in the Prapratna Bay, southern Adriatic Sea.

### Material and methods

Monthly samples were collected with a small beach seine (mesh size 8 mm in outer wings and 4 mm at the bag end, knot to knot) between April 2003 and March 2004, every 4-h over a 24-h period (daily samples were taken at 08.00, 12.00, 16.00h; night samples at 20.00, 24.00, and 04.00h) in the Prapratna Bay, southern Adriatic Sea (N  $42^{\circ}$  48' 58.1"; E  $17^{\circ}$  40' 50.6"). Sampling depth ranged from 2.5 to 0 m. The substratum is clean sandy bottom sporadically overgrown by *Cymodocea nodosa* beds. Collected material was kept on ice and returned to the laboratory for identification. Species were identified according to [3]. Data were analysed using PRIMER [4]. Data were transformed for presence/absence and the Bray-Curtis similarity matrix was used to generate a 2-dimensional plot with the non-metric multidimensional scaling (nMDS) technique.

#### Results

Over the sampling period a total of 51802 individuals and 55983.27 g of fishes, belonging to 24 families and 58 species, were caught. The dominant species with respect to both numbers (57.21%) and weight (49.90%) were Boops boops. Except in April, the greater numbers of species were caught during night and there was also a significant higher number of individuals (p=0.002) and biomass (p=0.031) during night. Boops boops (57.21%), Atherina boyeri (19.70%), Sardina pilchardus (6.82%) and Sarpa salpa (6.60%) made a significant contibution to the overall number of individuals (92.48%) or biomass (70.56%). With respect to both numbers of individuals and biomass Boops boops, Pagellus acarne, Sarpa salpa, Atherina boyeri had higher catches during night and Mullus barbatus during day. The other species did not show any strong diurnal or nocturnal tendency in catches. Community parameters fluctuated during the diel period and was higher during the daytime. Results of the ANOSIM test for the two-way crossed analysis showed that there was significant difference in species assemblages among seasons ( $\rho_{av}$ =0.118, P=0.017), but there was no significant difference in those catches between day and night. The nMDS plot showed that there is a clearly visible overlapping of the day and night samples (Figure 1).

#### Discussion

Diel fluctuations in fish communities are a summation of the diel fluctuations of the component species [2]. Over the diel cycle in the Prapratna Bay, there were fluctuations in both number of individuals and number of species. The dominant species were either primarly diurnal or nocturnal and it is the relative abundance of these species in each period which determines the assemblage structure during day or night. The greater number of species caught at night was similar to that of other studies [5]. However, the greater number of individuals and biomass caught during the night in the Prapratna Bay differs from that in the Azores [2]. Differences in catches between day and night can have a profound effect on the perception of a fish community and it is apparent that a full description of an asemblage or assemblages within an area must incorporate both time periods. The Prapratna Bay fish assemblage is typical of many marine fish assemblages with relatively few species constituting the majority of individuals and biomass [2,5]. In general, the fish assemblage at Prapratna Bay were dominated by juveniles. One might expect that an assemblage with such a high proportion of juveniles may be a nursery area. Shallowwaters are often utilised as nursery areas as they provide suitable food, shelter and reduction in predation [1,2,5].



Fig. 1. Non-Metric Multidimensional Scaling ordination plot for fish assemblages in Prapratna Bay for day and night sampling: D=day, N=night

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# DECAPODA CRUSTACEA FAUNA GRADIENT FROM CYPRUS AND THE SOUTH TURKISH COAST TO THE BLACK SEA

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## Abstract

Analysis of literature information and the examination of decapod collections permitted the creation of updated checklists of the decapod species from Cyprus, the south Turkish coast, the Aegean and the Black Seas. These checklists are presented and the decapod faunas of these areas are compared in order to assess the gradient of decapod diversity from Cyprus towards the Black Sea. As it results from this study, there is a decrease in the number of lessepsian decapod species from the south Turkish coast towards the Black Sea, implying an attenuation of the lessepsian immigratory current in this direction.

Keywords : Decapoda, Aegean Sea, Black Sea, Eastern Mediterranean.

#### Introduction

There is a significant body of literature providing information on the decapod fauna of the Eastern Mediterranean [reviewed by 1]. The decapod fauna of this area is also enriched with lessepsian immigrants and with Atlantic tropical species that enter the Mediterranean Sea through the Straits of Gibraltar [2].

The aim of the present study is to provide updated checklists and information on the diversity of the decapod faunas of Cyprus, the south Turkish coast, the Aegean and the Black Seas, and assess the gradient of decapod diversity along these certain areas.

## Materials and Methods

Based on a detailed review of the relevant literature and the examination of large collections of decapods, collected by different kinds of gears, detailed checklists of the decapod species were created for Cyprus, the south Turkish coast, the Aegean Sea and the Black Sea.

#### Results and Discussion

Figure 1 demonstrates the distribution of the decapod species number in the certain territorial areas of the Eastern Mediterranean and the Black Sea. Based on Figure 1, data on the Mediterranean water circulation [3] and geographical aspects, the following considerations can be made:

Cyprus (145 decapod species, 6 of these are lessepsian immigrants): In respect of the Cypriot coasts, the number of decapod species is slightly lower to that reported from the south coast of Turkey. Furthermore, the number of lessepsian decapod species is significantly lower in relation to that reported from the south Turkish coast, although Cyprus is located closer to the Suez Canal. This could be mainly attributed to: a) the reduced sampling effort in this area and b) the fact that the Cypriot coasts are considerably distant from the neighboring continental Asian coasts and are surrounded by very deep waters, which possibly prohibit the lessepsian decapod species to reach this area.

South Turkish coast (152 decapod species, 28 of these are lessepsian immigrants): The number of known decapod species is slightly higher than that of Cyprus. Moreover, the known lessepsian decapod species number in this area is much lower than the respective total Mediterranean number (43). This implies an attenuation of the lessepsian immigratory current in this area.

Aegean Sea (263 decapod species, 12 of these are lessepsian immigrants): The total decapod species number of this region is the highest among the studied areas. This could be possibly attributed to the high diversity and complexity of habitats of the Aegean Sea but also to the more intensive sampling effort that has been carried out in this area. The number of lessepsian decapod species is much lower than that from the south Turk-ish coast, indicating a further attenuation of the lessepsian immigratory current in the Aegean Sea, mainly due to the different hydrographic conditions prevailing in these two regions (e.g., the wider ranges of temperature and salinity of the Aegean Sea).

Black Sea (36 decapod species): The Black Sea demonstrated the lowest species number among the studied areas. This should be mainly attributed to the peculiar oceanographic conditions prevailing in this region, especially the low salinities and temperatures [4]. As it results from the present study no lessepsian decapod species have reached the Black Sea.

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Fig. 1. Known decapod species number in the certain geographical areas of the eastern Mediterranean and the Black Sea. The black part of each column represents the number of lessepsian decapod species known from the certain area. The arrow indicates the movement of the lessepsian decapod species and its width in each area is proportional to the lessepsian species number that has reached this region. At the area of the Suez Canal, the number 43 represents the total number of lessepsian decapod species reported so far from the Mediterranean. CY, Cyprus; ST, South Turkish coast; AS, Aegean Sea; BS, Black Sea.

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# LENGTH AND GROWTH PARAMETERS OF SCALDFISH (*ARNOGLOSSUS LATERNA* (WALBAUM, 1792)) IN IZMIR BAY, AEGEAN SEA

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## Abstract

Length frequency distribution and growth parameters of the scaldfish (*Arnoglossus laterna* (Walbaum, 1792)) were investigated based on samples collected monthly in Izmir Bay (Aegean Sea) between January 2005-May 2006. Fork length and total weight ranged from 4.5 to 14.9 cm and from 0.68 to 24.53 g respectively. The length-weight relationships were W=0.0081\*L<sup>2.986</sup>, W=0.0093\*L<sup>2.925</sup> and W=0.0087\*L<sup>2.949</sup>, and the von Bertalanffy growth parameters were  $L_{\infty}$ =16.34, 14.07 and 16.70 cm; k=0.388, 0.212 and 0.392 t<sub>0</sub>=0.502, 0.980 and 0.494 for females, males and sexes combined, respectively.

Keywords : Aegean Sea, Fishes, Growth.

## Introduction

The scaldfish, *Arnoglossus laterna*, is a small bothid flatfish whose geographical distribution extends from the Black Sea and the Mediterranean along the west coast of Europe to Norway [6]. It is a bentic species which extends from the shallow sublittoral zone down to about 200 m. The biology of scaldfish was investigated by Gibson and Ezzi [3] on the west coast of Scotland. Deniel [2] studied its growth in Brittany. Karakulak et al. [4] and Çiçek et al. [1] examined its length-weight relationship in Northeastern Mediterranean and Aegean Sea, respectively. The present study provides preliminary information on the biology of scaldfish in Izmir Bay.

### Materials and Methods

A total of 1274 specimens were caught during trawl surveys carried out monthly between January 2005 and May 2006 in Izmir Bay. Individuals were measured in mm (fork length, FL), and weighed to the nearest 0.01 g (total weight, W), and dissected in the laboratory. Sex and maturity stages were determined macroscopically. von Bertallanfy growth parameters  $L_{\infty}$  and k were estimated by analyzing monthly length frequencies with the ELEFAN I routine incorporated in the FISAT II Software. to was estimated using the empirical equation of Pauly (7) for growth fitting; Log ( $-t_0$ ) = (0.03922) - 0.2752 logL $\infty$ -1.038 log k. The length-weight equation, W=a.L<sup>b</sup>, was estimated [8], where W is the total weight (g), L is the total length (cm), and a and b are the regression coefficients. Growth performance index (logk +  $2log_{\infty}$ ) values were computed with FISAT II software.

#### Results and discussion

The sex composition for the 1274 specimens sampled was 25.31% females, 43.42% males and 31.27% undetermined sex. Females ranged from 6.0 to 14.9 cm in size and from 4.8 to 13.5 g in weight. Males ranged from 4.8 to 13.5 cm in length and from 0.78 to 22.88 g. The most abundant size class was 8 cm and 9 cm for females and males, respectively (Figure 1).



Fig. 1. Montly length frequency distributions of scaldfish in Izmir Bay.

The von Bertalanffy growth parameters for females, males and combined sexes were:  $L_{\infty}$ = 16.34 cm, 14.07 cm and 16.70 cm; k= 0.388, 0.212 and 0.392 year<sup>-1</sup>, t<sub>0</sub>=0.502, 0.980 and 0.494 years. The length-weight reationships were: W=0.0081\*L<sup>2.986</sup>, W=0.0093\*L<sup>2.925</sup> and W=0.0087\*L<sup>2.949</sup>, for females, males and sexes combined respectively. Positive allometric growth was observed in all cases. The growth performance index was 2.015, 1.623 and 2.039 for females, males and sexes combined, respectively.

Length-weight relationships for different studies are shown in Table 1. The b values in the present study are lower than those in Italian waters.

Tab. 1. Length - weight relationship coefficients of scaldfish in different localities.

| Author                  | Area                                      | Ν   | a          | b     | r     |
|-------------------------|-------------------------------------------|-----|------------|-------|-------|
| Matta (1959) (5)        | Tuscan archipelago<br>(Italy)             | -   | 0.00000046 | 3.534 | -     |
| Çiçek et al. (2006)     | Babdillimani Bight<br>(NE Meditterranean) | 594 | 0.0080     | 3.007 | 0.986 |
| Karakulak et el. (2006) | Northern Aegean Sea                       | 8   | 0.0150     | 2.747 | 0.995 |
| This study (2006) F     | Izmir Bay                                 | 323 | 0.0081     | 2.986 | 0.974 |
| М                       | (Aegean Sea)                              | 554 | 0.0093     | 2.925 | 0.980 |
| Т                       |                                           | 877 | 0.0087     | 2.949 | 0.980 |

N, number of specimens; a, intercept of the relationship; b, slope of the relationship; r, corelation coefficient.

The  $L_{\infty}$  values were 16.34 cm and 14.07 cm for females and males. For the West Coast of Brittany Deniel [2] calculated  $L_{\infty}$  values as 15.8 and 15.2 cm. When we compare the growth performance index values estimated in the present study with those from other studies, our data (2.015 and 1.623) are lower than those reported by Deniel [2] (2.322 and 2.377).

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# A STUDY ON DIEL VARIATION IN TRAWL CATCHES IN THE EDREMIT BAY (NORTH-EASTERN AEGEAN SEA)

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## Abstract

Diel variability in bottom trawl catches carried out by R/V K. Piri Reis during two 24-h surveys conducted in 1-2 and 30 September 1999 in the Edremit Bay (North-eastern Aegean Sea) were analysed. Maximum total catch was observed in the early morning and tended to decrease progressively towards the night period in 1-2 September 1999. While small variations were observed in total catch rate during the day, the minimum catch was observed at midnight in 30 September 1999.

Keywords : Trawl Surveys, Fish Behaviour, Aegean Sea.

Trawl surveys are used worldwide to estimate the abundance of demersal fish species [1]. Efficiency of trawl surveys depends on the ability of the gear to catch the available fish and further, the availability of target species to the trawl [2]. The occurrence and distribution pattern of a species in a given habitat depend on factors such as food availability, salinity, temperature, time of the day, and light intensity. These factors may change throughout a 24-h period [3]. Consequently, studying diurnal variation in bottom trawl catches, allow us to understand behavioural ecology of demersal organisms and also to estimate the abundance more accurately. This is the first study to examine diel variation in the bottom trawl catches from the Eastern Aegean Sea.

Trawl catch data were collected with R/V K. Piri Reis during two 24-h surveys conducted in 1-2 and 30 September 1999 in the Edremit Bay (North-eastern Aegean Sea). This particular area has been closed for commercial trawlers since 1995. In each survey, a total of 8 trawls were hauled consecutively in the same area with 3 h intervals at depths from 40 to 80 m. Trawl duration was 20 min but standardised to 1 h for subsequent calculations and evaluations.

Hake, *Merluccius merluccius*, red mullet, *Mullus barbatus*, and poor cod, *Trisopterus luscus capelanus*, were the dominant fish species in most of the trawl compositions. They were also the main target fishes for the demersal trawl fishery in the region.

A total of 46 species were sampled during 1-2 September 1999. Hake (20.7%, mean: 5.8 kg/h, min: 1.3 kg/h, max: 10.3 kg/h and SD: 3.14 kg/h), red mullet (11.5%, mean: 3.2 kg/h, min: 0.4 kg/h, max: 6.0 kg/h and SD: 2.35 kg/h), and poor cod (7.05%, mean :1.96 kg/h, min: 0.91 kg/h, max: 3.47 kg/h and SD: 0.85 kg/h) constituted 39.2% of the total catch during the 24 h sampling survey period. Total catch rate varied between 8 and 56 kg/h. Maximum total catch rate was observed in the early morning and tended to decrease progressively towards the night period (Fig 1).



Fig. 1. Diel variations in catch rates on 1-2 September 1999.

In 30 September, 50 species were caught in the sampling area. Hake (32.9%, mean: 21.6 kg/h, min: 11.3 kg/h, max: 29.7 kg/h and SD: 5.56 kg/h, red mullet (13.5%, mean: 8.9 kg/h, min: 4.4 kg/h, max: 15.9 kg/h

and SD: 2.35 kg/h), and poor cod (5.1 %, mean: 3.3 kg/h, min: 1.9 kg/h, max: 5.5 kg/h and SD: 1.11 kg/h) constituted 51.5% of the total catch. Total catch rate was higher than the previous sampling and ranged between 31 and 80 kg/h. Small variations were observed in the total catch rate during the day period (Fig 2). A similar distributional pattern was also determined for the dominant fishes, especially for hake.

30 September 1999



Fig. 2. Diel variations in catch rates on 30 September 1999.

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# ANNUAL CYCLE OF ZOOPLANKTON OFF SINOP, THE SOUTHERN BLACK SEA, IN 2003-2004

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# Abstract

Monthly changes in zooplankton abundance, biomass and taxonomic composition off Sinop (southern Black Sea, Turkey) were studied during January 2003-December 2004. Cladocerans, the appendicularian, the chaetognath and copepod *Centropages ponticus* dominated the autumn and summer communities, whereas meroplankton and the other copepod species were more pronounced in winter and spring months. Copepods were the most abundant zooplankton group in 2003, whereas *Noctiluca scintillans* was the most dominant species in 2004.

Keywords : Black Sea, Zooplankton, Biomass.

Zooplankton is the principal trophic link between primary production and higher trophic levels, (i.e. in many cases the fish), and hence studying their abundance and distribution is important [1]. In the southern Black Sea, there are only a few published studies about distribution of zooplankton population, and regular annual studies only made after the year 1990. In comparison with the other basins in the Black Sea, even less work has been devoted to the plankton of Sinop region [3]. This study aims to evaluate seasonal mesozooplankton structure of the southern Black Sea.

The sampling station  $(35^{\circ} \ 09' \ 32"E-42^{\circ} \ 00' \ 21"N)$ , a mile off-shore off Sinop (southern Black Sea, Turkey) having a 50 m bottom depth, was sampled monthly from January 2003 (except August 2003) to December 2004. The sampling of the zooplankton was carried out from 50 to 0 m (surface) for vertical tows using plankton net (50 cm diameter mouth opening and 210 mm mesh size) with the "Arast Irma" research vessel. The samples were preserved with borax buffered formalin solution (final concentration 4%). The analyses of samples were carried out using sub-samples with a Stempel pipette. The results were then averaged and extrapolated to the whole sample. Biomass transformations were based on wet individual weights [2].

In the present study, the annual total zooplankton ranging between was 4800 - 204 500 ind.m<sup>-2</sup> in 2003 and 13 300 - 198 900 ind.m<sup>-2</sup> in 2004. In terms of either in abundance and biomass the highest values were recorded in February, April, September and November 2003; May and August 2004. Zooplankton biomass showed a clear peak in May 2004, mostly due to the dinoflagellate *Noctiluca scintilans*.

Copepods (maximum: 172 200 ind.  $m^{-2}$ ) of annual abundance was the dominant group in 2003. *N. scintillans* was the most abundant of zooplankton group with a share of 49.6% (max: 172 000 ind.  $m^{-2}$ ) in 2004. All mentioned groups exhibited clear seasonality. This was especially apparent for cladocerans and appendicularian; which occurred in autumn, and for meroplankton, which were more abundant during spring months. *S. setosa* showed a summer-autumn distribution which closely coincided with the pattern of appendicularian and cladocerans. Amongst cladocerans, *Penilia avirostris* was dominant during summer and early autumn.

In this study, six copepods species were identified. Surprisingly, there were no *Acartia tonsa* in subsamples. *Acartia clausi* (65% in 2003 and 43% in 2004) was the most dominant copepod which was followed *Pseudocalanus elongatus* by in two years. *Acartia clausi* showed its remarkable existence in November 2003 and August 2004. *Calanus euxinus*, *P. elongatus*, *Oithona similis* and *Paracalanus parvus* was more pronounced cold months and *Centropages ponticus* was distinct summer and early autumn.

In this study, we observed that there was no significant alterations between the annual temperature mean changes within 2003-2004 (P>0.05). This situation reflected stable composition biomass and abundance of zooplankton between the years. Except Appendicularian, there were no statistically significant differences in abundance of different mesozooplankton groups between two consecutive years. It is especially interesting to note the dramatic decline in the abundance of all zooplankton groups in the period of peak *Noctiluca*. Same situation was observed by Unal (2002). We expect that these results will have importance in explaining oscillations in plantivorous fish catches from the region.

#### Acknowlegements

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# DENDROPOMA PETRAEUM (MONTEROSATO, 1884): A MEDITERRANEAN SPECIES COMPLEX BASED ON REPRODUCTIVE CHARACTERISTICS?

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# Abstract

The reproductive characteristics of the northern Israeli population of the Mediterranean endemic reef-building gastropod *Dendropoma petraeum* were examined. The species is apparently gonochoristic, with a peak of gonad activity from October to May. In June only hatching was observed. Histological examination revealed hermaphroditism and males with parasitic infestation. The characteristics studied (female/male ratio, gonad activity period, size and number of egg capsules and number of eggs per capsule) are markedly different from those reported from Spain.

Keywords : Endemism, Gastropods, Levantine Basin, Reproduction.

The reef-building vermetid *Dendropoma petraeum* (Monterosato, 1884), a species endemic to the Mediterranean Sea, forms dense aggregations along the northern shores of Israel. These reefs protect the shoreline from erosion by waves and support a high biodiversity community [1]. During the 1960s and 1970s living *Dendropoma* mollusks constituted 30% of the reefs [1], whereas current estimation is 1% for most of the sites (Galil, unpublished). We set out to continue and expand prior research on the reproductive period of the mollusks and their fecundity.

A total of 285 specimens of *D. petraeum* were collected in Shikmona  $(32^{\circ}49'N, 34^{\circ}57'E)$  from January 2003 to May 2004, in monthly or bimonthly intervals. The samples were divided according to their reproductive stages: resting phase, maturation, active mature and degenerating gonad.

900 egg capsules were harvested in April and June 2003 and analyzed for size, number of embryos/eggs and the developmental stages of the embryos.

Of the 285 mollusks collected, 152 were females, 106 - males, 22 were unidentifiable and 5 were hermaphrodites with developed gonads of both sexes (Fig. 1). In 7 females captured sperm mass was identified within the mantle cavity. In 12 males it was observed that the retained spermatozoa degenerated to dense balls within the testes, half of them were parasitized. Mature males were found from October to May, mature females from December to May. In June no gonad activity was observed, though embryo maturation continued within the female mantle cavity. The resting phase lasted from late June to September, with the gonads degenerating, and histological sex recognition impossible.



Fig. 1. A hermaphroditic gonad, showing oocytes (A) and spermatozoa (B).

Mean capsule size in April 2003 was  $0.91 \times 0.7$  mm, in June 2003 -  $0.99 \times 0.74$  mm. Up to 17 egg capsules per female were recorded (mean=4.67), containing a maximum of 10 eggs/embryos (mean=2.3), see example in Fig. 2. In April the capsules contained pre-hatchlings (24% of embryos), veligers (24%), trochophores (31%) and ova (21%). By comparison, in June the pre-hatchlings constituted 93% of the embryos, veligers - 6%, trochophores - 3% and no ova were observed. The data indicate a single period of reproductive activity. Gonad maturation in males and females began simultaneously. Males matured earlier than the females, since oogenesis proceeds slower than spermatogenesis. We recorded larger capsules, more eggs/embryos per capsule and less capsules brooded simultaneously than described for the Spanish population of *D. petraeum* [2]. Moreover, the female/male ratio is lower and the repro-

ductive period in Israel, though of same duration, began in October rather than March. The temperature difference between Israel and Spain may be offered as an explanation. However, these findings also strengthen the hypothesis of a genetic difference between the two populations, reported in [3].



Fig. 2. An egg capsule, containing 5 veligers (photo by A. Klerman).

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# STOCK ASSESSMENT AND GENETIC DIVERSITY OF THE EDIBLE ASCIDIAN *MICROCOSMUS* SABATIERI ROULE, 1885 IN THE SOUTH AEGEAN SEA

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## Abstract

The spatial variation in population density of the edible ascidian *Microcosmus sabatieri* Roule, 1885 was studied in the Dodecanese complex (south Aegean). Sampling included the random collection of specimens during a 50 min dive with SCUBA apparatus. Mean population density was  $156 \pm 53$  individuals/20-min. Additionally we examined its genetic polymorphism using RAPD markers. Data imply high genetic diversity between populations with a rather complex clustering of a southeastern to northwestern pattern in the Aegean Sea. Thus, its fishery should be treated as complicated stocks, which respond independently to exploitation. *Keywords : Aegean Sea, Genetics, Population Dynamics, Stock Assessment.* 

#### Introduction

Ascidians are among the most important members of the benthic assemblages in the Mediterranean Sea. *Microcosmus sabatieri* Roule, 1885 is an endemic species known from Adriatic and Western Mediterranean basin. It is an edible and of commercial interest species in many Mediterranean areas. However, few data exist on its population structure and even fewer in the South Aegean [1]. This study presents preliminary data on spatial variation of its population density in South Aegean, where it has been traditionally harvested. We also determined its genetic structure using RAPD fingerprinting [2]. The results were used to investigate the differentiation between six Aegean populations and provide information to assist management and conservation on this marine species. No studies on genetic structure of the species in question are available in the bibliography.



Fig. 1. Spatial population density of *M. sabatieri* over nine sampling sites in the Dodecanese complex.

#### Materials and Methods

In the south Aegean, overall sampling of 1,513 specimens was carried out with SCUBA diving at nine coastal stations (Fig. 1), at depths between 20 and 60 m in September 2005. Specimens of M. sabatieri were randomly collected during a 50 min dive and counted in the field with a tapeline to the nearest mm (total length of the tunic and maximum diameter of the tunic). Population density was estimated as the number of individuals collected per 20 min dive (N/20-min). The null hypothesis of no significant differences in the mean length (or diameter) of M. sabatieri specimens among stations was tested with one-way ANOVA, after an initial logarithmic transformation of the data to meet the assumption of the analysis. Seventy eight (78) samples from Astypalea Island along with 28 from Trikeri (central Aegean), 61 from Platanias (central Aegean), 20 from A. Nikolaos (central Aegean) and 27 from Maliakos Gulf (central Aegean) were used for the genetic screening. Eight RAPD primer markers were found to produce well-amplified and reproducible electrophoretic bands. In total 22 loci were observed and scored. Genetic statistical indeces were calculated according to [2].

#### Results and Discussion

Mean population density, over all sites, was  $156 \pm 53$  individuals/20-min. Increased stocks were found at three stations (St1, St3, St8), while at St4 and St7 few specimens were caught (Fig. 1). One-way ANOVA showed significant spatial differences on mean tunic length (F=9.82 p<0.05) and diameter (F=10.99 p<0.05). Both characters varied in a similar way, showing maximum values at St4 and St6 and minimum at St2. Large sized specimens were also caught from St1, St3 and St5, while the specimens from St7, St8 and St9 were smaller, for both dimensions. Total  $H_e$ =0.499 was higher, but not statistically significant, than  $H_o=0.311$ , implying a heterozygote deficit on the sampled populations. Total  $F_{IS}$ =0.492 was high enough and statistically significant on the  $P_{99}$  criterion, indicating a possible presence of local sub-populations. Studied populations either do not follow Hardy-Weinberg law, or are not yet in genetic equilibrium, so there is evidence to reject random mating within them. Total  $F_{ST}$ =0.286was high enough and pairwise  $F_{ST}$  values were statistically significant for all populations at all loci on the  $P_{99}$  criterion. Data imply high genetic diversity among populations, since a quite low  $N_m$ =0.046 migrants per generation, was observed. Furthermore, one could observe a rather complex, but not statistically significant, clustering pattern of southeastern to northwestern populations in the Aegean Sea, by using the stepwise method [3]. Even if fishing pressure becomes intensive, natural stocks of *M. sabatieri* tend to recolonize the substratum from deeper populations; in any case its high local population diversity is preserved.

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# EVALUATION OF THE PERFORMANCE OF FISHERY INDICATORS IN THE AEGEAN SEA

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## Abstract

Fishery indicators were calculated from data derived through a monitoring program of trawl catches from 1995 till 2005 in the Aegean Sea. Size-based indicators were highly correlated with each other and with the mean trophic level of the demersal assemblages of the study area. Mean trophic level seemed to constitute a useful indicator since it offered powerful detection of existing trends with sampling sizes of a relatively smaller time interval.

Keywords : Bio-indicators, Fisheries, Demersal, Eastern Mediterranean.

Trawlers have dramatic effects on the ecosystem including physical damage to the seabed and the degradation of associated communities, the overfishing of demersal resources, and the changes in the structure and functioning of marine ecosystems derived from the depletion of populations and the huge amount of by-catches and associated discards. In the Mediterranean, bottom-trawling fisheries are essentially multi-species, carried out in a wide range of depths and affecting different bottoms and communities. Moreover, the large number of landing harbours makes it difficult to gather long and reliable series of trawl fisheries data, which are necessary for the development of appropriate indicators contributing to track the impact of trawling on the ecosystem. In this study we discuss the performance of fishery indicators calculated from data derived through a monitoring program of observers recording catches on-board commercial trawlers during an eleven years period in the Aegean Sea. The aim is to evaluate which are more powerful in detecting trends on the state of demersal fish assemblages in eastern Mediterranean waters, being thus more useful for monitoring community/ecosystem changes.

From 1995 to 2005, on a seasonal basis, observers on-board commercial trawlers followed fishing operations and recorded data from hauls in the central Aegean Sea, considered to be among the most important fishing grounds for trawl fisheries in Greece. In a representative sample from each haul, the various species were sorted out, the number of individuals per species and their total weight were noted, while total length of each individual was also recorded. Based on these data three of the so-called size-based indicators, i.e. the mean length, the mean weight, as well as the mean maximum length of the Aegean demersal assemblages, were calculated in each haul. Then, the mean trophic levels were estimated by assigning trophic levels to individuals of the various species on the basis of their length, using relationships between length and trophic level as determined by [1]. Finally, Hill's first and second diversity numbers (i.e. N1 and N2: [2]) were used as overall measures of species diversity, as they are less sensitive to the dominant species and to the sampling effort. The overall performance of the indicators was evaluated through correlation analysis and power analysis [3].



Tab. 1. Pearson correlation coefficients between all indices' time series in the Aegean Sea.

\*\*. Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

From Table 1 it is obvious that most indicators are positively correlated to each other. Highly significant positive correlations existed between the various pairs of size-based indicators, as well as between the mean trophic level and each of the size indicators. For powerful detection of a relatively small ecosystem change (<5% of the mean value of the series) a sample exceeding 20 years is needed for all indicators calculated in the present study except for the mean trophic level; the latter appeared to offer powerful detection of possible trends with sampling sizes covering smaller time intervals (Fig. 1). It should be noted, however, that no single tropho-dynamic indicator can track the complexity of the possible changes in fisheries and ecosystems and any change must be interpreted in the light of other complementary indicators. In fact, the present study based on data of a rather limited spatio-temporal coverage could be considered as indicative and has a preliminary role, while the clarification of the observed patterns will be derived only through long-term retrospective analyses, which would also allow correct interpretation of possible trends.



Fig. 1. Power versus sample size (in years) of all indicators' time series in the Aegean Sea. The hypotheses tested a detection of a linear trend (in terms of absolute value of slope)  $\leq 5\%$  of the mean value of the series.

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# OYSTER TRANSFERS: A MAJOR VECTOR FOR MACROPHYTE INTRODUCTIONS

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# Abstract

Oyster transfers, as a vector of primary introduction and secondary dispersal of exotic macrophytes, were assessed on the basis of (i) two major French aquaculture sites: the Thau Lagoon and the Arcachon Basin; (ii) a bibliographical analysis of 34 Mediterranean coastal lagoons; and (iii) an experimental simulation of oyster transfers. The resultsconfirmed the tremendous efficiency of the vector. The oyster trade is by far the main vector of macrophyte introduction into the Mediterranean Sea, ranking above the shipping and the opening of the Suez Canal.

Keywords : Algae, Aquaculture, Lagoons, Strait Of Messina.

#### Introduction

Transfers of oysters for aquaculture purposes (both importation from exotic areas and livestock transfer between basins; i.e. primary and secondary vectors) have resulted in the introduction of a number of pathogens, parasites and pests [1]. Elton argued that 'The greatest agency of all that spreads marine animals to new quarters of the world must be the business of oyster culture' [2]. 46 % of the exotic marine species in northern Europe and 20 % in Australia probably arrived via oyster imports [3]. However according to [4], shellfish transfers rank below shipping (hull fouling and ballast waters) for the introduction of species. As a part of the European ALIENS program, we investigated the shellfish transfer vector (http://www.uniovi.es/ecologia/aliens/E-aliens.htm).

#### Results

In the Mediterranean, Crassostrea gigas production is wholly dependent on spat or adult importation. In France, massive importations from the northern Pacific occurred during the 1970s. Nowadays, only the spat produced in the NE Atlantic is authorized, but livestock transfers between basins frequently occur to ensure an optimum growth.

In the Thau Lagoon (Mediterranean), 25 % (57 taxa) of the total number of macrophyte species were identified as introduced. Introduction by shipping, via the harbour of Sète, is likely for only a few species. 89% of taxa may originate from the northern Pacific, introduced either directly via importation or indirectly via shellfish transfers (fixed on oysters, mussels, clams and the packing materials) from other aquaculture basins.

In the Arcachon Basin (NE Atlantic), 19 exotic macrophytes were identified [5]. Oyster transfers to and from the other European basins regularly occur [6]. Again, with the exception of the oldest introductions for which shipping cannot be ruled out as a vector, shellfish transfer and the Pacific appear as the most probable vector and origin, respectively, for introduction.

In the 34 Mediterranean coastal lagoons we studied, 67 exotic macrophytes (78% from the Pacific and 94% via shellfish transfer) have been reported, with the lowest number  $(1 - 2 \tan a)$  in the lagoons without aquaculture facilities, and the highest in the major aquaculture basins: Mar Piccolo (10 taxa), Salses-Leucate (11 taxa), Venice (25 taxa) and Thau (57 taxa).

The experimental simulation of transfer showed that oyster shells cleaned out (visually without epibionts) can still bear a high diversity of viable native and exotic macrophyte propagules (41 and 16 taxa, respectively). The abundance of propagules may be due to the fact that after cleaning, the oysters are re-immersed for two weeks before each transfer.

#### Discussion and conclusion

The ALIEN program has evidenced oyster transfer as the most efficient vector for macrophyte introduction into the Mediterranean. In addition, our census probably represents only the tip of the iceberg because the exotic cryptic species and gene introductions from remote populations are very difficult to detect. The conditions of livestock transfers appear as very favorable for the survival of the organisms with fewer constraints hindering the introduction than for the other vectors (hull fouling, ballast waters, Suez Canal) [7]. Within Europe, large amounts of shellfish are being transported from one basin to another and the European authorities even encourage this practice [1]. However, the inadequacy of current legislation is such that these transfers still result into species introductions. The adoption of comprehensive guidelines for preventing the introductions [8,9].

Guidelines to reduce the unintentional introductions by shellfish aquaculture.

- Awareness of farmers concerning the risks associated with uncontrolled importation has to be increased.

- Aquaculture has to be based on native, local stock whenever possible. Imports and transfers of livestock have to be minimized, thoroughly inspected, and quarantined for an appropriate observation period.

- Special attention has to be paid during aquaculture trials with new exotic species (even with livestock from hatcheries).

- Non-native livestock for introduction has to be produced in hatcheries.

- Live products destined for consumption, processing, and aquarium or display must not be placed into the natural environment.

- In the case of livestock transfers (including interregional ones), decontamination processes and/or quarantine as proposed by ICES have to be followed.

- Efficient treatments (e.g. hot-seawater for oysters) to avoid introduction or secondary dispersal of exotic or native species have to be carried out prior to each transfer, i.e., after the period of re-immersion preceding the transfer, and have to be repeated on arrival.

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# THECOSOME PTEROPOD ON THE BOKA KOTORSKA BAY (SOUTHERN ADRIATIC)

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# Abstract

Thecosome pteropods were collected monthly since 2003 at seven stations with different hydrographic characteristics at Boka Kotorska Bay in Southern Adriatic. At the same time the basic ecological parameters were measured. This paper presents the first data on thecosome pteropods in Boka Kotorska Bay. We recorded 7 species: *Cymbulia peroni* Lamarck, *Creseis acicula* Rang, *Creseis virgula* (Rang), *Limacina inflata* d'Orbigny, *Limacina bulimoides* d'Orbigny, *Pneumodermopsis conephora* Pruvot-Fol i *Atlanta helicinoides* Souleyet. *Keywords : Adriatic Sea, Zooplankton.* 

### Introduction

Thecosome pteropods were not previously studied at Boka Kotorska Bay, so the data presented in this paper are the first for this group in this biotope. [5] in epipelagial, at two stations 3NM and 10NM in front of entrance to Boka Kotorska Bay, recorded 6 species with the percent participation of 0.63% in total zooplankton. [3] cites 10 species and their percent participation in eastern coastal waters of Adriatic. The dominant species was Creseis acicula with participation of 94.3% in total the cosome pteropod fauna for the studied period. [1] in the vicinity of Dubrovnik recorded 12 species, while in mid January Limacina inflata, Creseis virgula and Creseis acicula had more than 85% of participation in total pteropod fauna. [2] recorded 10 species of the cosome pteropods in waters of deep Southern Adriatic during the yearly cycle of 1993/94, with a great abundance in April 1993 and June 1994 in euphotic zone (0m-100m), matching the large concentration of Chl a. The pteropods seem to be characterized by great variability; they may appear in large numbers in plankton or completely disappear [4].

#### Material and Methods

Our observations were based on the analysis of zooplankton samples collected monthly during 2003 on three shallow stations near the seafood farming areas (P-M, P-O and P-IBM) and 4 stations in the middle of each bay within Boka Kotorska Bay (P-1, P-2, P-3, P-4 or Kotor, Risan, Tivat and Hercegnovi bays, respectively). Zooplankton was collected with Nansen net (100 and 150 microns). In the same time, other factors were measured: T  $^{\circ}$ C, Sal psu, pH, O<sub>2</sub>, transparency by Secchi plate, color of the sea with Forel scale I-XXI. Zooplankton samples were used to determine presence and abundance of the cosome pteropod in all research stations.

## Results and Discussion

The studies have shown that Boka Kotorska Bay is a specific biotope in the southeastern part of Adriatic. That specificity is caused not only by the geographic position but also by special biotic and abiotic environmental factors. Living conditions at Boka Kotorska Bay are very different than those at the open sea. The basic ecological factors (temperature, salinity and density) are under a strong influence of hydrometeorological conditions, which are specific and susceptible to numerous local changes. This has an important role impacting life histories and distribution of organisms. Boka Kotorska Bay shows characteristics of a shallow closed sea at the eastern coastline of Adriatic. At one hand it is influenced by influx of fresh water from surrounding mainland (coastal rivulets and springs at the sea bottom), and on the other hand it is under impact of open sea which is indicated by hydrographic and planktological data. According to the collected data and citations by other authors, Boka Kotorska Bay is not a homogenous area in thermal sense. The maximal temperatures were recorded in July and minimal in January. Data on salinity clearly indicate the strong influence of influx of fresh water, especially in the surface layer and in shallow habitats along the shore.

Thecosome pteropods were not previously studied at Boka Kotorska Bay, so the data presented in this paper are the first for this group in this biotope. We have recorded 7 species: *Cymbulia peroni, Creseis acicula, Creseis virgula, Limacina inflata, Limacina bulimoides, Pneumodermopsis conephora* and *Atlanta helicinoides*.

*Limacina inflata* d'Orbigny was the most abundant, with maximums in April and July. It was recorded throughout the year at all the stations, and its percent participation in the group was 70.6%.

*Limacina bulimoides* d'Orbigny is represented at all the stations throughout the year, and its percent participation in the group was 27.1%. Abundance maximum was recorded only in July.

*Limacina inflata* and *Limacina bulimoides* are the most abundant species of the cosome pteropods during the study at Boka Kotorska Bay, and their percent participation in the group is 97.7%.

*Cymbulia peroni* Lamarck was recorded in vicinity of the Institute (P-IBM) at Bay of Kotor in May, as several specimens. *Creseis acicula* Rang, known as a species appearing in warmer period of the year, was not very abundant in the study year, and its participation in total pteropod fauna was 1%. *Creseis acicula* is the commonest pteropod and at the same time one of the commonest species of Adriatic Sea [3].

Following species were recorded sporadically, in insignificant numbers or as single individuals: *Creseis virgula* (Rang), *Pneumodermopsis conephora* Pruvot-Fol and *Atlanta helicinoides* Souleyet.

Percent participation of the cosome pteropods when compared to other groups of zooplankton was: at Bay of Kotor 0,08%, at Bay of Risan 0,39%, at Bay of Tivat 0,94% and at Bay of Herceg Novi 1,15%.

The regularity observed in horizontal distribution of the cosome pteropods was in increase in number of species and biomass longitudinally from the inner waters of the Bay (Bay of Risan and Bay of Kotor) toward the outer stations under the direct influence from the open sea (Bay of Tivat and Bay of Herceg Novi).

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# FOLLOWING THE FOOD CHAIN - AN ECOSYSTEM APPROACH TO PELAGIC PROTECTED AREAS IN THE MEDITERRANEAN BY MEANS OF CETACEAN PRESENCE

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## Abstract

Based on the correlation between cetacean distribution patterns and oceanographic features, this paper opens discussions about possibilities to define multidimensional pelagic habitats in order to link these discussions to the ongoing debate about the efficiency of Marine Protected Areas as a tool for conservation, and proposes ways to proceed towards marine biodiversity conservation. *Keywords : Cetacea, Biodiversity, Food Webs, Pelagic.* 

The effectiveness of the IWC pelagic protected areas for whales has been recently questioned by Gerber et al. [1]. On the basis of existing knowledge about marine protected areas and cetacean biology, they point out four main limitations: arbitrary boundaries, narrow focus, lack of an adaptive population design and needs for baseline. The multidimensional nature of the problems related to marine environment protection needs a multidimensional approach to be understood and solved [2]. The typical solution in the ocean governance is to establish boundaries, mainly from legal perspective, because the clarity of boundaries would improve governance. Unfortunately, from an ecological point of view, this is a frustrating task due to the high variability of the omni-directional relationships among ocean habitats, species, land and atmosphere. These aspects are enhanced in the pelagic environment because its stability can be evaluated only through long term global scale measures of its dynamic structured habitats.

One possible solution could be to identify one or more species which food web can summing up the results of all the derived effects from the natural and anthropic induced variability of the pelagic environment. Obviously this group of species have to be long living, high-level predators, high biomass consumers with high energy budget needs: cetaceans seems to be the most suitable group of marine organism for this purpose. To evaluate this hypothesis, the relatively small pelagic domain of the Mediterranean Sea because of its oceanographic features, large cetacean populations and strong human impact, could be a reliable test to establish dynamic pelagic protected areas for several reasons.

The total area of the Mediterranean is more than  $3.000.000 \text{ km}^2$  (including the Black Sea). Because of the limited extension of the continental slope, the pelagic domain covers about 70%, corresponding to 96% of the total water volume. The Mediterranean Sea is a mid-latitude partially enclosed sea but, even if semi-isolated, can be considered an oceanic system. Processes which are fundamental to the general circulation of the world ocean also occur within the Mediterranean, identically or by analogous mechanisms.

The Mediterranean Sea exchanges water, salt, heat and other properties with the North Atlantic Ocean, which is known to play an important role in the global thermohaline circulation. The effects encompass the Atlantic, Southern, Indian, and Pacific Oceans [3], thus the salty water of Mediterranean origin may affect water formation processes and even the stability of the global thermohaline equilibrium state. The picture of the Mediterranean general circulation which is now depicting is complex, even if the Atlantic water jet is the main basin scale feature, from Gibraltar to the Levantine, with its instabilities, bifurcations, and multiple pathways, also cold wind stress, intermediate heat fluxes and other hydrodynamic movements, due to freshwater income and to evaporation loss, contribute to the general circulation pattern [4].

Too rough generalisations on oligotrophy of this flow affected the general believe on the trophic potential of the Mediterranean Sea: nevertheless the presence and abundance of large predators such as cetaceans drives to reconsider the oligotrophy paradigm [5]. Rather recently the classic scheme of marine food webs has been revised and the role of microorganisms has been reconsidered under various aspects: CO2, organic into inorganic, but also as food when they aggregate as rods or in a synergetic action with jelly macroplancton through the water column [6]. Now it is recognised that in some oligotrophic sea bacteria can constitute 70-80% of the biomass.

The abundance of cetaceans in the pelagic Mediterranean incites other consideration related to upper trophic levels than the primary production, particularly about the timing of the energy turn over through the biomass formation and transportation from the surface to the deep bottoms and vice-versa. Hundred thousands tonnes per year of euphausid krill can be consumed by the Mediterranean fin whales and ten thousands tonnes of various pelagic and bathy-pelagic cephalopods are eaten by odontocetes. Thus new ideas about the trophic potential of the pelagic ecosystem have to be developed not only to explain the top predator biomass but also the prey biomass formation and turnover in a relatively short time period.

The bottom morphology and hydrodynamic features of the Mediterranean Sea explain the organic matter flow from the coastal zone to the pelagic one, from the surface to the bottom and from deep waters to the entire water column, but the reasons why the energy flow through the biomass formation is so fast have, in turn, to be sought within the food webs. Mediterranean cetaceans show various degrees of prey selection but, in general, the most abundant species, such as striped dolphin and fin whale, seem to be rather opportunistic, they fully exploit this potential, moving and concentrate time by time where food is abundant. Nevertheless their opportunism has to be better defined because all the Mediterranean cetaceans, with the only exceptions of bottle-nose dolphin (Tursiops truncatus) and common dolphin ( Delphinus delphis), feed on short living species such as ammoniacal cephalopods (Histioteuthis), myctophids ( Diaphus) and glass shrimps (Pasiphaea) moving from the bathyal grounds up to the surface [7]. The effect of the very fast biomass formation by these prey on the energy flow is enhanced through the space by the amplitude of their daily vertical migrations.

These factors affecting the cetacean distribution patterns can be relatively well defined, but are not constant on the time-space domain, as is generally believed. Not always and not everywhere the crossing over of strong temperature gradient (frontal zone) and depth or bottom morphology (slope gradient, canyons, sea-mounts) determine the prey presence and abundance, but when this happens the cetaceans are there, as indicators of a past or actual particular oceanographic and biological condition. Based on the above, to define ephemeral pelagic habitats suitable for protection could be more efficient for conservation than permanent Marine Protected Areas and a way to proceed towards marine biodiversity conservation.

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# SPAWNING SEASON OF THE LIZARDFISH SAURIDA UNDOSQUAMIS (RICHARDSON, 1848) AND SYNODUS SAURUS (LINNAEUS, 1758) IN ANTALYA BAY ON THE EASTERN MEDITERRANEAN COAST OF TURKEY

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## Abstract

Saurida undosquamis and Synodus saurus had ripe gonads all year round. The spawning season of S. undosquamis is from April to September. For S. saurus, the spawning season is from March to October. Keywords : Demersal, Eastern Mediterranean, Fishes, Spawning.

The lizardfish, *Saurida undosquamis* (Richardson, 1848) has a wide Indo-Pacific distribution from Japan and the Philippines through the Indian Ocean to the Red Sea [1]. The first report in the Turkish Seas was by Kosswing (1951) [2]. *Synodus saurus* (Linnaeus, 1758) occurs in Madeira, the Canaries, Cape Verde, the Mediterranean, and off the Moroccan coast. In the western Atlantic, it is known from Bermuda through the Bahamas and Lesser Antilles (the Leeward Islands) [3]. The objective of this research is to study the spawning season of these two species of lizardfish in Antalya Bay on the eastern Mediterranean coast of Turkey.

Fishes from the present study were randomly collected from the fish markets, bazaars and fishing port of Antalya on a monthly basis between April 2002 and August 2003, but some samples were obtained from the small fishing boats fishing by gillnets/longline due to the bottom trawl being forbidden in Antalya Bay from April to August. Length measurements were made by considering fork length (FL) and a 1 mm. sensitivity fish measuring ruler was used. Also scales with 0,1 g and 0,01 g. sensitiveness were used in measuring whole body weight (W) and the gonads. Sex was established by macroscopic examination of gonads. To determine the spawning season a gonadosomatic index (GSI=(gonad weight (GW)/ (the total fish weight (TW)-GW))\*100) was calculated [3]. Temperatures of sea water values were obtained from the Republic of Turkey Ministry of Environment and Forestry and the Turkish State Meteorological Service. Of the total of 738 specimens of S. undosquamis that were dissected. 437 (59%) were females and 301 (41%) were males. In S. saurus 230 (42%) out of 546 sexed specimens were females and 316 (58%) were males. The spawning season of both species as indicated by the year-round GSI is long [Figure 1].



Fig. 1. Gonadosomatic index (GSI) variation of *S. undosquamis* and *S. saurus* during sampling period, with temperature of sea water

The lizardfish had ripe gonads during the sampling period. The maximum values of GSI of *S. undosquamis* were found between April and September. For *S. saurus*, the maximum values of GSI were determined between March and October.In the present study, the spawning of *S. undosquamis* and *S. saurus* was affected negatively during winter when the temperature decreased in the Mediterranean, although both species had ripe gonads throughout the year [see figure 1]. The intensity of spawning in each month during the sampling period showed that most *S. undosquamis* spawn between April and September. The monthly gonado somatic index

of *S. saurus* revealed that most of this species spawn between March and October. For *S. undosquamis*, the results of this study are similar to the results of many studies about the spawning season [1, 2, 4, 5, 6, 7]. Golani (1993) reported that the spawning season of *S. saurus* was from February to August on the Mediterranean coast of Israel. Sousa et al. (2003) found that the most intensive reproduction period of *S. saurus* was during Spring and Summer in the Azores, and this species had an asynchronous posture. The results of these studies are similar to the results of our study.

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# LONG TERM TRENDS IN THE DISTRIBUTION OF *MNEMIOPSIS LEIDYI*, AGASSIZ 1865, IN THE SEA OF MARMARA

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## Abstract

The distribution of *Mnemiopsis leidyi* Agassiz, 1865 in the Sea of Marmara was examined in 1995-2006. It has been observed that biomass and abundance of *M. leidyi* decreased sharply at the end of the decade. *Keywords : Sea Of Marmara, Zooplankton, Ctenophora.* 

The ctenophore *Mnemiopsis leidyi* Agassiz, 1865 was introduced to the Black Sea in ballast waters in the early 1980s [1] and adversely affected the Sea of Marmara ecosystem [2]. This study investigated the long term distribution of *M. leidyi* in the Sea of Marmara. Samples were collected at 63 stations in the Sea of Marmara between 1995 and 2005, using a Nansen closing net (1 m diameter, 500  $\mu$ m mesh) vertically. At the end of each tow, the ctenophores were sorted, counted and their volume measured using an Imhoff cone. *Mnemiopsis leidyi* was considered the main reason for the collapse of Black Sea ecosystem in mid 1980s. Its distribution decreased significantly in the years 1995-2005 (Fig. 1). The monthly biomass and average volume of individuals increases in July and reaches its highest values in September (Fig. 1). The number of large individuals was higher in October and November (Fig. 1). The species distribution is usually limited to the upper water layer of the Sea of Marmara.



Fig. 1. A) Abundance and biomass distribution of *M. leidyi* in different years; B) Monthly changes in biomass and average individual volume of M. leidyi.

The highest density was found around Istanbul Strait, Dardanelles and Erdek Bay in 1995. However, in 1996 high densities were observed through the basin (Fig. 2). The stocks decreased significantly in 2000s and they were mostly confined to north part of the basin. The highest frequencies were observed between 1995 and 1997. Significant decrease in abundance and frequency was detected in the end of August 2000, and decreased further to less than %5 in 2005. Values decreased more than 300 times between March 1996 and March 2006 (Fig. 1, 2). Additionally abundance of *M. leidyi* decreased 73 times between December 1996 and December 2006 (Fig. 2).



Fig. 2. Distribution of M. Leidyi per unit area in different years.

The sharp collapse in demersal fish stocks in the Sea of Marmara in 1994 has been associated with enormous increase of M. *leidyi* [3]. Mesozooplankton and ichthyoplankton was adversely affected [2]. Eggs of the planktivorous anchovy were at the lowest levels in 1994 [4]. It has been also noted that the abundance and number of ichthyoplankton species increased rapidly following the sharp decline in M. *leidyi* density [4].

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# MONTHLY SIZE FREQUENCY DISTRIBUTION OF *MNEMIOPSIS LEIDYI* AGASSIZ, 1865 IN THE SEA OF MARMARA

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## Abstract

This study has been performed monthly at two stations in the Northern Sea of Marmara between 1997 and 1998. Results showed that abundance and biomass of *Mnemiopsis leidyi* Agassiz, 1865 increased in summer. The size frequency data indicated that small individuals were abundant through out the year, while highest increase has been observed in July-September, when water temperature was higher. *Keywords : Ctenophora, Sea Of Marmara, Biomass.* 

Gelatinous macrozooplankton constitute a common group of marine ecosystem. Rapid augmentation of gelatinous macrozooplankton with selective feeding [1] decreases zooplankton stocks and this interruption of food chain influence fish stocks [2]. Drastic effects of *M. leidyi* invasion have been observed at the Sea of Marmara [3]. Present study examined recruitment of *M. leidyi* abundance and biomass in relation to water temperature at the Sea of Marmara.

Vertical plankton samples were collected monthly from the upper and intermediate layers, using a Nansen closing net (1 m diameter, 500  $\mu$ m mesh). The haul depth has been chosen by examining the salinity and temperature profiles recorded by a CTD system prior to the sampling. Species were immediately sorted, counted and volume of each species was measured by an Imhoff cone.

Average individual volume (AIV) and abundance of *Mnemiopsis leidyi* in relation to water temperature indicated that AIV is reduced in warm periods while abundance increased. In cold periods a reverse structure has been observed (Figure 1, 2).



Fig. 1. Monthly changes on abundance and biomass of *M. leidyi* in relation to water temperature.

Although smaller individuals were abundant through the year, highest percentage of small individuals (0.1-0.5 ml) in samples was detected in September (47.8 %), when water temperature was the highest. Second recruitment period started in July in smaller magnitude. Another important observation is the increase in the number of large individuals prior to the months of population increase. Frequency of individuals between 3-8 ml particularly increased during these periods and the largest individual (48 ml) was detected in August 1997 (Figure 2).

Results point out that recruitment occurred in 18-25 °C water temperature in sampling area. According to periodical data, abundance of *M. leidyi* peaked in July and September (Figure 1, 2). Another important characteristic of 1997 is the lack of its predator (*Beroe ovata*) in the ecosystem.

*M. leidyi* abundance was higher in the upper layer in 1997. Highest abundance has been detected in September 1997 (127.4 ind.m<sup>-2</sup>) and water temperature at 5 m was ~20 °C. Although abundance increased at the intermediate layer despite of low water temperature at the upper layer,

during warm periods (17-27  $^{\circ}$ C) upper layer values were higher than the intermediate layer. This situation can be explained with reduced stocks in upper layer and some changes in ecological conditions such as increase in predators or decrease in zooplankton biomass.



Fig. 2. Monthly size frequency distribution of M. leidyi.

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# INTERACTION ENTRE LE GRAND DAUPHIN *TURSIOPS TRUNCATUS* ET LA PÊCHE À LA SENNE EN MÉDITERRANÉE MAROCAINE : EXPERIMENTATION D'UN RÉPULSIF ACOUSTIQUE ET EVALUATION DES RÉPERCUSSIONS

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## Résumé

La présente étude a porté sur l'expérimentation d'un appareil acoustique, pour dissuader le grand dauphin *Tursiops truncatus* de s'approcher des senneurs lors des opérations de pêche. Elle porte aussi sur une analyse économique pour évaluer l'impact de cette interaction sur la pêcherie en question. Cette expérimentation a été réalisée au niveau de la zone sud-ouest de la Mer d'Alboran, pendant les mois d'avril, mai et juin 2005. Les principaux résultats montrent une réduction des attaques sur les filets de pêche que ce soit en nombre ou en intensité ; l'efficacité de l'appareil a été jugée significative à près de 90%. L'utilisation de ce répulsif acoustique dans les mêmes conditions d'expérimentation, permettrait de réduire les pertes en Valeur Ajoutée, évaluées actuellement à18%, à un niveau de 1,8% seulement. *Mots clès : Acoustics, Alboran Sea, Cetacea, Fisheries.* 

## Introduction

Les interactions entre les pêcheries et les cétacés sont reportées dans toutes les régions méditerranéennes[1]. Au Maroc, ce phénomène cause un sérieux problème pour les pêcheurs à la senne (150 unités de pêche) ; ces derniers subissent une réduction de leurs revenus, à la suite de l'endommagement des filets de pêche par le grand dauphin *Tursiops truncatus* qui cherche la prédation du poisson capturé [2]. Ce problème qui est devenu de plus en plus fréquent, risque de pousser les pêcheurs à la lumière des actions néfastes envers ce cétacé [2]. De ce fait, et à la lumière des recommandations de certains Organismes Régionaux (AC-COBAMS) qui conviennent que la solution à ce problème se trouve en grande partie dans l'utilisation saine de l'acoustique, l'Institut National de Recherche Halieutique (Maroc) a appuyé cette étude qui porte sur l'expérimentation d'un appareil acoustique répulsif désignée par (HIS), et sur l'évaluation technique et économique du niveau d'interaction.

#### Matériel et méthodes

La zone d'étude se situe entre le détroit de Gibraltar et Oued Laou (sudouest de la mer d'Alboran), connue par les niveaux élevés des attaques du grand dauphin sur les filets des senneurs [2]. La mise à essai du HIS s'est déroulée du 27 avril au 15 juin 2005. Le dispositif expérimental comprend d'une part, 3 senneurs équipés en appareils répulsifs, et d'autre part, 40 senneurs témoins non équipés. Les ondes acoustiques émisent par les HIS(s) ont une portée de plus de 250 m à la ronde, un niveau sonore de 155 dB et un niveau de fréquence allant de 5 à 160 KHz. L'efficacité de l'appareil a été évaluée en comparant les résultats obtenus pour chacun des deux groupes de senneurs, moyennant la formule suivante Efficacité =  $[1-(Frq_e*I_e)/Frq_ne*I_{ne})]*100$ , avec Frq: fréquence des opérations de pêche positives attaquées par le cétacé ; I : intensité des attaques exprimée en nombre de ramendeurs employés pour réparer les filets ; e : senneurs avec HIS ; ne : senneurs sans HIS. Les résultats obtenus ont été validés statistiquement avec un seuil de signification de 0.05. L'évaluation économique de l'utilisation de ce répulsif, a été faite par la Méthode du Budget Partiel qui a mis en considération les pertes avec et sans utilisation de l'appareil ; Les pertes économiques prises en compte dans cette étude sont la réduction des captures en valeur, les charges suplémentaires de réparation et d'amortissement des filets de pêche, et le manque à gagner issu de la réduction de l'activité de pêche.

### Résultats et discussion

Les opérations de pêche positives, réalisées sans utilisation du HIS, ont connu dans 15 % des cas, des attaques du grand dauphin sur les filets de pêche, alors que les bateaux équipés en HIS ont enregistré seulement une fréquence des attaques de l'ordre de 4,6% (Figure 1); la Méthode Exacte de Fisher conclue que cette différence est significative.

Par ailleurs, le nombre de ramendeurs employés pour réparer les filets endomagés, est moins important pour les bateaux équipés (2 ramendeurs) que pour ceux qui ne le sont pas (6 ramendeurs) (Figure 2); le Test de Student confirme cette différence, et donc, on peut considérer que l'utilisation du HIS réduit significativement l'intensité des attaques.

La combinaison entre la fréquence et l'intensité des attaques pour les deux groupes de bateaux, nous donne une efficacité du HIS de l'ordre de 90%.



Fig. 1. Fréquence des opérations de pêche attaquées par le grand dauphin.





À l'échelle économique, ce phénomène d'interaction engendre une perte économique globale -pour l'ensemble des senneurs durant la période d'étude- de l'ordre de 167.400 Euros, équivalents à une réduction en Valeur Ajoutée de près de18%. Dans la considération des résultats obtenus lors de notre étude (90% d'efficacité), l'utilisation du HIS permettrait de récupérer un manque à gagner de près de 158.100 Euros. Conclusion

L'utilisation du HIS pour limiter l'interaction entre le grand dauphin et la pêche à la senne au sud-ouest de l'Alboran, a montré des résultats très encourageants, avec une efficacité de près de 90%. Cependant, il est un peu tôt pour préconiser l'utilisation de ce répulsif acoustique. En effet, l'appareil n'a pu être expérimenté que durant une courte durée et en une période de l'année, et nous ne pouvons être sûrs de la non adaptation du mammifère aux ondes émises, qu'après une longue durée d'observation. Par ailleurs, des études sont vivement sollicitées, afin d'évaluer l'impact réel des ondes émises par les HIS(s) sur la conservation des cétacés et sur l'écosystème marin en général.

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# CONTRIBUTION À L'ÉTUDES PEUPLEMENTS ACTUELS DES SUBSTRATS SOLIDES DE L'ÉTAGE MÉDIOLITTORAL DE LA MÉDITERRANÉE MÉRIDIONALE

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## Résumé

Les observations faites au niveau de l'espace médiolittoral de substrat dur, aussi bien à Zarzis (sud tunisien) qu'à Tripoli (Libye), nous ont permis de mettre en évidence des biocénoses d'installation récente typiques des littoraux de la mer Rouge et de la zone nord ouest de l'Afrique.

Mots clès : Species Introduction, Western Mediterranean, Coastal Systems.

Cinq espèces nouvelles pour les eaux libyennes et tunisiennes dont 3 nouvelles pour les eaux méditerranéennes ont été récoltées en nombre important sur substrat rocheux dans la zone intertidale proche des installations portuaires de Zarzis (Tunisie) et Tripoli (Libye).

## Espèces sessiles et/ou peu mobiles

La première est une patelle qui est présente, à la fois, sur les quais du port de commerce de Zarzis et sur des roches proches de la zone portuaire de Tripoli. Les individus récoltés ont des tailles allant de 17 à 29 mm à Tripoli et de 20 à 29 mm à Zarzis. Leur observation a permis de les classer dans la famille des Nucellidae et de les identifier en tant que Cellana radiata radiata (Born, 1778) synonyme de Cellana rota Gmelin, 1791. Cette espèce (Fig. 1), largement répandue dans tout le Pacifique, a été signalée en Méditerranée orientale en 1961 sur les côtes israéliennes, elle a, depuis, été mentionnée en Egypte (1994) et en Grèce, 1999 [1]. Sa présence, en quantité abondante à quelques 300 km de distance au niveau de la grande et petite Syrte montrerait qu'elle s'est, ces dernières années, très bien acclimatée dans les eaux de la Méditerranée méridionale. La seconde espèce est un polyplacophore. Elle n'a été trouvée qu'à Tripoli. Les individus récoltés sont de taille allant de 33 à 47 mm. Leur observation a permis de les identifier en tant qu' Acanthopleura gemmata (de Blainville, 1825) synonymes Acanthopleura vaillanti de Rochebrune, 1882 et Acanthopleura haddoni Winckworth, 1927. Cette espèce, largement répandue dans tout le Pacifique, n'a pas, jusqu'à aujourd'hui, été signalée en Méditerranée, la citation la plus proche étant faite en mer Rouge dans le golfe d'Aqaba par Hullings [2]. La troisième espèce est une balane. Comme Acanthopleura gemmata cette espèce nouvelle en Méditerranée, n'a été trouvée que dans la seule zone de Tripoli. Les individus récoltés mesurent entre 9 et 32 mm à la base. Ils appartiennent à l'espèce d'origine indo-pacifique Tetraclita squamosa rufotincta Pilsbry, 1916.



Fig. 1. *Cellana radiata radiata*, à gauche, spécimen de Zarzis, au centre et à droite, spécimen de Tripoli.

#### Espèces mobiles

La première est une ophiure indo pacifique appartenant au genre *Ophiocoma*. *Ophiocoma scolopendrina* (Lamarck, 1816) présente dans le golfe d'Aqaba [3] n'a jamais été signalée en Méditerranée (Fig2a). Nous ne l'avons trouvé (diamètre du disque des oscillant entre 17 à 21 mm) que dans la région portuaire de Tripoli. La seconde, présente à la fois à Tripoli et à Zarzis, est le crabe Grapsidae *Plagusia tuberculata* Lamarck, 1818 (Fig. 2b). Les individus récoltés mesurent entre 12 et 22 mm (largeur du bouclier thoracique). Cette espèce, considérée à ce jour comme très rare avec une seule signalisation en 1981 au Liban [4], a donc trouvé, en Méditerranée méridionale, un biotope nettement favorable à son installation.



Fig. 2. a) Ophiocoma scolopendrina, Tripoli; b) Plagusia tuberculata, Zarzis.

L'ensemble des observations faites à Tripoli et à Zarzis met bien en évidence le rôle fortement "colonisateur" des espèces originaires du Pacifique dans cette partie méridionale de la Méditerranée et la "tropicalisation" du milieu ambiant se traduisant par une synergie dans la dynamique d'installation des peuplements littoraux.

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# SARDINELLA AURITA EGG AND LARVAL DISTRIBUTIONS AND SEA TEMPERATURE IN THE TUNIS GULF

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# Abstract

*Sardinella aurita* eggs and larvae were investigated in the Tunis Gulf by four seasonal surveys from the summer 2002 to the spring 2003. This species spawns mainly in summer, when the sea surface temperature  $(25.5^{\circ}C)$  and the water stratification were maximal. In this period, eggs were concentrated in the south of Zembra Island and in the west of the Gulf. However, the larvae were concentrated in the centre of the Gulf and in the north of Cape Fartas.

Keywords : Temperature, Spawning, Ichthyoplankton.

#### Introduction

Sardinella aurita is the second most important small pelagic species in Tunisian waters. Indeed, it represents 17.5% (16 000 t) of the small pelagic exploitable biomass [1]. In spite of the fishery importance of the species, there is no information on its early life stage in Tunisian waters. Indeed, this work investigated Sardinella aurita egg and larval distributions in the Tunis Gulf in relation to hydrographical conditions.

#### Material and Methods

Four ichthyoplankton surveys were conducted in the Tunis Gulf, one in each season: summer (August 2002), autumn (October 2002), winter (February 2003) and spring (April 2003). Samples were taken on a grid of 29 stations. Temperature and salinity was measured at each station. CTD profiles were obtained using a Sea-Bird911+. Plankton samples were taken by oblique tows with a 60 cm mouth diameter Bongo gear, fitted with nets of 335  $\mu$ m mesh size and a HydroBios flowmeter. Following each tow, the plankton samples were preserved in 4% formaldehyde solution.

#### Results and Discussion

In summer, the sea surface temperature (SST) ranged between 25.1 and  $26.2^{\circ}$ C with an average of  $25.5^{\circ}$ C. A patch of warmer waters was detected near Cape Sidi Bou Said. Column water was stratified and the thermocline was localized between the depths 25 and 45 m. Autumn distribution showed some heterogeneity. The patch of the relatively colder water (20°C) was found near Cape Sidi Bou Said and the patch of warmer waters (22.6°C) was in the south-west of Zembra Island. In winter, surface waters were cold with an average of  $13.4^{\circ}$ C. The heterogeneity was important and the spatial difference was around  $4.2^{\circ}$ C. Between the winter and spring (16.1°C) there was a light enhancement of temperature equal to  $2.7^{\circ}$ C.

Sardinella aurita eggs were found in the Tunis Gulf only in summer and autumn with average abundances 35 eggs/10 m<sup>2</sup> and 2 eggs/10 m<sup>2</sup>, respectively. In the main spawning period (summer), the highest abundances (221 eggs/10 m<sup>2</sup>) were obtained in the south of Zembra Island (fig. 1) that extend to the north of Cape Fartas and in the west of the Gulf (116 eggs/10 m<sup>2</sup>). We note that no eggs were collected in the Bay and in the western coasts. In autumn, only low abundances were localised from Cape Sidi Bou Said to Majreda mouth, in the north of the Gulf and the north of Cape Fartas.

The larvae were most abundant in summer (27 larvae/10 m<sup>2</sup>). In this season, the highest concentrations (118 larvae/10 m<sup>2</sup>) were in the north of Cape Fartas and the centre of the Gulf. In autumn, low abundances were localised in the north of Cape Fartas to the north of the Gulf and near Sidi Daoud. However, in winter high abundance (117 larvae/10 m<sup>2</sup>) was found in the south of Majreda mouth.

In conclusion, there is no significant spatial correlation between the distributions of eggs and larvae and SST. However, our results agree with the studies in the Mediterranean [2, 3] that this species spawns mainly in summer, with maximal SST and water stratification.



Fig. 1. Sardinella aurita eggs and larval distributions in the Tunis Gulf.

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# RESEARCHES ON UPPER INFRALITTORAL ALGAE SOUTH OF GOKOVA SPECIALLY PROTECTED AREA

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# Abstract

In the present study the species composition and biomass of upper infralittoral macroalgal communities in the south part of Gokova Specially Protected Area, were studied. Thirty macroalgal species were identified in the study area. The mean biomass per station was  $2641,65 \pm 2023,30$  gram/m<sup>2</sup>.

Keywords : Algae, Biomass, Aegean Sea.

## Introduction

Marine macroalgae, better known as seaweeds, are classified according to their pigmentation into brown (Heterokontophyta), red (Rhodophyta), and green (Chlorophyta) seaweeds. They are widely used as food, as ingredients in cosmetics and fertilizers, and in hydrocolloid production (e.g. agar and alginate). Seaweeds are of ecological importance because they assist in supplying oxygen to the sea and act as one of the primary producers in the marine food chain. Some seaweeds have the capacity to remove heavy metals from the water and can potentially be used in biomonitoring and in the bioremediation of such pollutants. Seaweeds also possess excellent survival strategies to withstand the many environmental stresses that they are exposed to. For all these reasons, together with their unique life-cycle and physiology, seaweeds are interesting study subjects [1].

#### Material and Method

The study was carried out in the south of the Gokova Bay (Aegean Sea, Turkey). Sampling was done randomly at 24 stations in 20 June - 5 July 2005. Samples were collected at upper infralittoral zone (0,3-0,5m) by scraping off all attached vegetation within 25x25 cm quadrate. At each station two quadrates were taken. Samples, fixed in 4% formaldehyde seawater solutions, were sorted in laboratory for both taxa identification and biomass determinations. Wet weight of each macroalgal species was calculated.

## Results and Discussion

A total of 30 taxa were identified including 14 Rhodophyta (*Florideophyceae*), 11 Heterokontophyta (*Phaeophyceae*) and 5 Chlorophyta (*Ulvophyceae*) (Table 1).

Tab. 1. List of species, their mean biomass  $\pm$  standard deviation (expressed as wet weight).

|                                                                             | Biomass (gram/m <sup>2</sup> ) |         |  |  |
|-----------------------------------------------------------------------------|--------------------------------|---------|--|--|
| Species                                                                     | Mean                           | SD      |  |  |
| Chlorophyta                                                                 |                                |         |  |  |
| Acetabularia acetabulum (Linnaeus) P.C. Silva                               | 62,11                          | 304,05  |  |  |
| Anadyomene stellata (Wulfen) C. Agardh                                      | 10,12                          | 18,22   |  |  |
| Cladophora coelothrix Kützing                                               | 4,85                           | 23,76   |  |  |
| Dasycladus vermicularis (Scopoli) Krasser                                   | 36,74                          | 180,00  |  |  |
| Valonia utricularis (Roth) C. Agardh                                        | 24,32                          | 70,47   |  |  |
| Heterokontophyta                                                            |                                |         |  |  |
| Dictyota dichotoma (Hudson) J.V. Lamouroux                                  | 12,01                          | 48,63   |  |  |
| Dictyota fasciola (Roth) J.V. Lamouroux                                     | 3,66                           | 8,73    |  |  |
| Dictyota spiralis Montagne                                                  | 7,00                           | 34,29   |  |  |
| Cystoseira amentacea var. stricta Montagne                                  | 309,16                         | 637,61  |  |  |
| Cystoseira barbata (Stackhouse) C. Agardh                                   | 39,29                          | 114,61  |  |  |
| Cystoseira compressa (Esper) Gerloff & Nizamuddin                           | 2,75                           | 8,10    |  |  |
| Cystoseira corniculata (Turner) Zanardini                                   | 1473,98                        | 2237,42 |  |  |
| Cystoseira elegans Sauvageau                                                | 373,93                         | 723,80  |  |  |
| Padina pavonica (Linnaeus) Thivy                                            | 26,86                          | 70,10   |  |  |
| Sargassum vulgare C. Agardh                                                 | 1,38                           | 6,78    |  |  |
| Sphacelaria cirrosa (Roth) C. Agardh                                        | 1,36                           | 3,00    |  |  |
| Rhodophyta                                                                  |                                |         |  |  |
| Amphiroa rigida J.V. Lamouroux                                              | 9,07                           | 26,66   |  |  |
| Callithamnion corymbosum (J.E. Smith) Lyngbye                               | 0,01                           | 0,05    |  |  |
| Chondria capillaris (Hudson) M.J. Wynne                                     | 0,07                           | 0,35    |  |  |
| Dasya rigidula (Kützing) Ardissone                                          | 1,24                           | 3,68    |  |  |
| Falkenbergia hillebrandii (Bornet) Falkenberg                               | 0,03                           | 0,12    |  |  |
| Ganonema farinosum (J.V. Lamouroux) K.C. Fan & Y.C. Wang                    | 3,01                           | 14,73   |  |  |
| Gelidium spinosum (S.G. Gmelin) P.C. Silva var. hystrix (J. Agardh) Furnari | 0,91                           | 4,47    |  |  |
| Haliptilon virgatum (Zanardini) Garbary & H.W. Johansen                     | 22,27                          | 103,10  |  |  |
| Herposiphonia secunda (C. Agardh) Ambronn                                   | 0,00                           | 0,01    |  |  |
| Jania longifurca Zanardini                                                  | 17,13                          | 78,36   |  |  |
| Laurencia obtusa (Hudson) J.V. Lamouroux                                    | 148,96                         | 372,42  |  |  |
| Liagora viscida (Forsskål) C. Agardh                                        | 47,29                          | 231,46  |  |  |
| Lomentaria clavellosa (Turner) Gaillon                                      | 1,34                           | 3,12    |  |  |
| Wrangelia penicillata (C. Agardh) C. Agardh                                 | 0,80                           | 3,90    |  |  |

*Cystoseira* and *Dictyota* were the genera with the highest number of taxa. Among these species, three brown algal species (*Cystoseira corniculata* (Turner) Zanardini, *Cystoseira elegans* Sauvageau and *Cystoseira amentacea* var. *stricta* Montagne) exhibited the highest mean biomass values. The maen number of species per stations was  $6 \pm 3,8$ .

In the upper infralittoral zone (0-1m depth) of the Mediterranean coasts, the species of the genus *Cystoseira* are usually the dominant element of the benthic vegetation on unpolluted hard substratum [2]. In this study, it's clear that *Cystoseira* spp. communities have a significant distribution in the Gokova Specially Protected Area and they support a rich associated flora on hard substrata. Among the 30 species *Cystoseira amentacea* var. *stricta* Montagne (Figure 1) has been listed as a protected species in "Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean" and this have a great importance for protection and conservation of natural habitats in Gokova Specially Protected Area.



Fig. 1. Cystoseira amentacea var. stricta Montagne.

#### Acknowledgements

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# A STUDY ON THE STOCKS OF THE DEEP-WATER PINK SHRIMP (*PARAPENAEUS LONGIROSTRIS* LUCAS, 1846) IN THE MARMARA SEA

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## Abstract

In this study, the biomass of the deep-water pink shrimp (*Parapenaeus longirostris*), which was commercially caught with bottom trawl and beam trawl nets in the Marmara Sea, in 2001-2002, was estimated by depth and season. The average biomass per unit area was higher for the beam trawl than the bottom trawl. Comparisons with previous studies showed that its biomass has increased in the last decade in the Marmara Sea.

Keywords : Crustacea, Biomass, Sea Of Marmara.

#### Introduction

Shrimp is the most abundant species in the benthic fauna of the Marmara Sea. Currently in Turkey, 72% of the shrimp production is providing from the shrimp stocks in this sea. In Turkey, shrimp fishing increased since the beginning of the 1980's and catches increased to a maximum of 8380 t in 1989 [1]. However, catches decreased below to 1000 t in the beginning of the 1990's because of the increase in the fishing effort and illegal trawl fisheries. The decreasing catch was consistent with the results of the study on the biomass, which was carried out by JICA (1993) in 1991-1992 [2].

### Materials and Methods

This study was carried out in five stations at depths of 20 to 200 m. Sampling was carried out seasonally (autumn, winter, spring and summer) in 2001-2002. Samples were collected by commercial fishing vessels. Bottom trawl and beam trawl were used for sampling. The head-rope lengths of the bottom trawl and the beam trawl nets were 37 and 6 m, respectively. Each trawl was equipped with 20 mm mesh size (knot to knot) at the codend. Trawling duration (per haul) was limited to one hour. Trawling speed was 2.4-2.7 knots for the bottom trawl and 1.5-1.8 knots for the beam trawl. Biomass estimation were calculated with the swept area method "per stratum" [3]. The catchability coefficient was considered as q=1 for the trawl net. The head rope mouth opening ratio was considered 0.5 for the bottom trawl and 1 for the beam trawl [4].

#### Results and Discussion

In total, 43 samplings for the bottom trawl and 50 samplings for the beam trawl were carried out during the survey period. The average biomass per unit area of deep-water pink shrimp obtained from the bottom trawl and the beam trawl nets were estimated as  $229.8\pm57.3$  kg/km<sup>2</sup> and  $409.3\pm152.1$  kg/km<sup>2</sup>, respectively. The maximum average biomass was estimated for the winter and at the 50-100 m depth zone for both fishing gears (Fig. 1). The differences between winter and the remaining seasons may be the result of migration and thermocline layer changes [5].



Fig. 1. Biomass distribution of *P. longirostris* estimated by bottom trawl and beam trawl nets according to depth and season.

By comparing the two gears according to the average biomass per unit area, it became apparent that the beam trawl was more advantageous. The biomass of *P.longirostris* has increased slightly since the mid-1990's in the Marmara Sea (Fig. 2). In the ealry 1990's, the average biomass of trawling at depths 20-100 m was 88.9 kg/km<sup>2</sup>[2], however, in the mid-

1990's it was 127.3 kg/km<sup>2</sup>[6]. These two previous studies were carried out in the same ground and depth and used the swept area method for the calculation of the average biomass. In this study the average biomass was 172.1 $\pm$ 44.3 kg/km<sup>2</sup>. There are many factors that can be related with such a linear increase in the *Plongirostris* biomass: (a) the short population doubling time, (b) the fact that spawning takes place twice a year, and (c) the recruitment age of +1 yr [7]. Better oceanographic conditions which occurred in the Marmara and Black Seas in recent years might have also played an important role in the increase of the deep-water pink shrimp stocks during the last decade [1, 6].



Fig. 2. Temporal changes in biomass estimates of *P. longirostris* in the Marmara Sea.

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# ANNUAL VARIATIONS OF ZOOPLANKTON BIOMASS AND ABUNDANCE IN MERSIN BAY (NE MEDITERRANEAN SEA)

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# Abstract

Annual changes in zooplankton abundance, biomass and group composition were studied monthly at a coastal (20m) and an open (200m) stations between December 2004 and January 2006 in Mersin Bay, NE Mediterranean Sea. Zooplankton biomass and abundance were determined for four size fractions: 112-200, 200-500, 500-1000 and >1000  $\mu$ m. Surface seston chlorophyll-a, lipid, protein and carbohydrate concentrations were also measured. Zooplankton abundance was correlated with chlorophyll in the coastal station (p<0.05). Significant correlation was observed between total zooplankton biomass and total particulate organic matter (p<0.01) in coastal station. *Keywords : Biomass, Zooplankton, Eastern Mediterranean*.

## Introduction

The Eastern Mediterranean Sea is an oligotrophic sea with poor nutrient concentration leading to low plankton biomass and production ([1]). Zooplanktonic organisms play a key role in the pelagic food web by controlling phytoplankton production and shaping pelagic ecosystems ([2]). Studying zooplankton communities are especially important for understanding the functioning of coastal ecosystems because of both land and ocean based environmental factors ([3]). The aim of the study is to provide information on the zooplankton annual cycle in relation to the influence of environmental parameters on them.

### Material and Methods

Zooplankton sampling were carried out monthly at two stations; one representing coastal (36°33'58N, 34°15'68E; 20m depth) and the other representing open waters (36°26'N, 34°21'E; 200m depth) characteristics, from December 2004 to January 2006 in Mersin Bay, NE Mediterranean Sea. Samples were collected with Nansen net (70 cm mouth diameter with 112  $\mu$ m mesh) and fractionated into 112-200, 200-500, 500-1000 and >1000 $\mu$ m size groups for biomass (dry weight) estimation and major taxonomic group identification. Zooplankton samples were preserved in 5% borax-buffered formaldehyde for quantitative taxonomic analyses. Temperature and salinity profiles were obtained with a CTD-probe. Surface seawater samples were collected with niskin bottles for chlorophyll-a, lipid, protein and carbohydrate measurements. Correlates with zooplankton parameters.

## Results and Discussion

Very low chlorophyll concentrations in the open station (0.02-0.35  $\mu g$  $L^{-1}$ ) can be compared with those observed in the NW Levantine Sea  $(0,10-0,47 \ \mu g \ L^{-1},[4])$ . Chlorophyll maximum occured in spring and autumn for both stations. Highest chlorophyll-a concentration  $(2.5 \mu g$  $L^{-1}$ ) were observed in March at coastal station due to the input of Lamas River nearby. Total particulate organic matter (POM) (sum of total lipid, protein and carbohydrate) varied from 42.1  $\mu$ g L<sup>-1</sup> (in January) to 1082  $\mu$ g L<sup>-1</sup> (in March) and 53.7  $\mu$ g L<sup>-1</sup> (in January) to 246  $\mu$ g L<sup>-1</sup>(in May) in coastal and open station, respectively. Total POM decreases with increasing distance from the coast which then reflects the spatial pattern of phytoplankton biomass and zooplankton biomass ([5]). Mediterranean zooplankton is characterized by two abundance maxima: one in late winter or early spring and a second peak in autumn ([6], [7]) as shown in the figure 1. Average zooplankton abundance in coastal station was about ten times more abundant than the open station throughout the year. 112-200 and 200-500  $\mu$ m size groups were the dominant groups in the coastal station and only the 112-200  $\mu$ m size group in the open station. Copepods were the main group in total zooplankton abundance; 65% of the coastal zooplanktonic groups and 76% of the open station within the year, thus this group plays an important role in the annual changes of zooplankton. After copepods, crustacea nauplii and appendicularia were the dominant groups both in the coastal and open stations. Throughout the year, average zooplankton biomass in coastal station was about nine times higher than the open station. Highest biomass was observed in June at coastal station, and in November at open station. 200-500 $\mu$ m size group constituted the majority of the average zooplankton biomass in coastal station within the year, on the other hand open station is constituted by >1000 $\mu$ m size group. Zooplankton abundance was correlated with chlorophyll in the coastal station (p<0.05) and significant correlation was observed between

total zooplankton biomass and total particulate organic matter (p<0.01) in coastal station. Acknowledgement The present study was supported by METU-BAP-2005-07-01-01 project. We would like to thank to Doruk Yilmaz for his assistance in biochemical composition of particulate organic matter measurements and to Dr. Dilek Ediger for helping in chlorophyll-a measurements.



Fig. 1. Annual changes in zooplankton biomass (mg  $m^{-3}$ ) and abundance (ind.  $m^{-3}$ ) at coastal and open stations.

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# BIOMETRIC CHARACTERISTICS OF EUROPEAN GLASS EEL DURING THE MIGRATION SEASON ALONG THE WESTERN GREEK COAST

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# Abstract

Biometric characteristics and developmental stages of glass eels (*Anguilla anguilla* L., 1758) collected from November 1999 to March 2000 were studied in two areas along the western part of Greece (Ionian Sea). Despite the fact that glass eel size from Greek coast was smaller compared to those reported for the Atlantic zone, similar temporal changes in the pigmentation stages of the glass eels were observed.

Keywords : Biometrics, Ionian Sea, Migration, Pigments.

#### Introduction

European eel is a species of great economical and ecological importance for the west coasts of Atlantic Ocean and the Mediterranean Sea. Glass eels are harvested during their mass migration into European rivers for either direct consumption or aquaculture purposes. Glass eel migration dynamics in the E. Mediterranean coast has scarcely been described [1].

#### Materials and Methods

Glass eels were collected from November 1999 to March 2000 at the marsh of Sagiada near the mouth of Kalamas river  $(39^{\circ}37'500 \text{ N} \text{ and } 20^{\circ}11'200 \text{ E})$  and at the mouth of Alfios river  $(37^{\circ}36'500 \text{ N} \text{ and } 21^{\circ}26'300 \text{ E})$  using fyke nets (total length 1.35 m, mouth 40 cm wide, mesh 1.5 mm). Fyke nets were installed at noon, mouth oriented downstream and withdrawn the following morning. Glass eels were daily collected, weighed and afterwards transported for rearing experiments. Total length and weight were measured on freshly caught individuals once per week. Pigmentation stages were identified as defined in [2, 3].



Fig. 1. Mean monthly total length and body weight of glass eels. Vertical bars indicate standard errors.

#### Results and Discussion

The seasonal changes in mean total length and weight of glass eels are presented in Fig. 1. Glass eels (mean length±sd: 5.92±0.29 cm; mean weight±sd: 0.177±0.036 g) seem to be smaller compared to those reported for the W. Mediterranean region [4] and for the Atlantic coast [5]. This smaller mean size of glass eels could be linked to the prevailing oligotrophic conditions in the Mediterranean Sea. The observed sizes of transparent glass eels VB stage (mean length±sd: 5.88±0.29 cm; mean weight±sd: 0.181±0.036 g) seem also to be smaller than those of the Atlantic coast [5, 6]. There were no marked differences in the mean weight of the glass eels from the two areas (Mann-Whitney test, U=671261, p>0.05) but differences were detected in mean glass eel length (t-test, t=4.59, p<0.05) with mean length of glass eels collected from the Sagiada marsh being slight greater than those in the Alfios river. A significant decreasing trend in mean weight of glass eels from Sagiada with season was observed (ANOVA, F=55.99, p<0.05, r<sup>2</sup>=0.95). The decreasing trend in mean weight with advancing season is consistent with previous studies in W. Mediterranean [4] and the Atlantic coast [6]. A progressive increase in the proportion of advanced stages through the season was also observed (Fig. 2). In the Sagiada marsh, the level of glass eels pigmentation changed significantly over the season (contingency table:  $X^2$ =85.39, p<0.05). Similar results were observed for glass eels of the Alfios river (contingency table: X<sup>2</sup>=203.15, p<0.05). Such seasonal changes in the pigmentation have been also pointed out for the European Atlantic coast [6].



Fig. 2. Seasonal changes in the pigmentation stages of glass eels.

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# REPRODUCTIVE CYCLE OF THE SPHYRAENA CHRYSOTAENIA FROM THE GULF OF GABES (TUNISIA)

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# Abstract

Reproduction of *Sphyraena chrysotaenia* from the Gulf of Gabès was investigated. Monthly variation of gonadosomatic index (GSI %) and hepathosomatic index (HSI %) revealed that the species reproduces between May and November and spawning takes place between August and November.

Keywords : Fishes, Gulf Of Gabes, Migrant Species, Reproduction.

#### Introduction

The lesspsian fish species *Sphyraena chrysotaenia* was observed for the first time in Tunisia in December 2002 when it was fished by bottom trawlers in the Gulf of Gabès [1]. Since then, it became relatively abundant but its landing were irregular. This species found new feeding habitats and adapted to new areas. This study provides data on its reproductive period.

#### Material and Methods

Biological data was collected monthly from 955 specimens purchased from commercial catches made in the Gulf of Gabes between August 2003 and February 2005. Total length (TL) in the nearest 1 mm and total weight (W) in the nearest 0.01g were recorded for each specimen. The sex of all individual was determined by macroscopic examination of the gonads of mature specimens but microscopic examination was used for differentiating sex in juveniles. Gonads and liver were weighted (Wg and Wf respectively) with an accuracy of 0.01 g. Mean monthly gonado-somatic (GSI) and the hepato-somatic indices (HSI) were calculated for all sexually identified specimens (GSI = 100 Wg/W and HSI = 100 Wf/W).

## Results and Discussion

It is well known that the gonads in fish show a seasonal variation which might vary within the same species in different geographic localities in response to environmental factors which affect the physiological activity of the fish [2]. The GSI of Sphyraena chrysotaenia attained a maximum in July for males (4.691) and in August for females (11.199), followed by a rapid decrease in September following egg deposition (Fig. 1). The female GSI was higher than that of males; but both displayed nearly the same cyclic trend during the period of study. From December to April, the GSI reached the lowest average values in both sexes. Reproduction is concentrated in May and October and spawning took place between August and November with fish in spawning condition only being observed during this period. This is confirmed by an examination of the ovaries and the GSI for each female: by October, 70% of the females had terminated their reproduction, and by November the reproduction was completed. Similarly, in the Egyptian Sea the breeding season extends from May to October with analysis of the monthly distribution stages.

The HSI for females, during the more intensive reproduction period, increased with GSI with a peak in July and started to decrease in August when GSI was highest, suggesting that the liver had a weight loss, which may indicate the mobilisation of hepatic reserves for oocytes maturation. For males, HSI peaked during September, suggesting that liver reserves may not be used in the final maturation stages [3].



Fig. 1. Monthly variations in the gonadosomatic index and hepatosomatic index for female and male *Sphyraena chrysotaenia* in the Gulf of Gabès.

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# CARACTÉRISTIQUES BIOMÉTRIQUES DE *STEPHANOLEPIS DIASPROS* (FRASER-BRûNNER, 1940) (POISSON TELEOSTEEN) DES CÔTES DU GOLFE DE GABÈS

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## Résumé

La morphologie de *Stephanolepis diaspros* du golfe de Gabès a été décrite par 10 caractères métriques et 5 caractères méristiques. L'accroissement des différentes parties du corps montre une forte corrélation avec la longueur totale. La relation taille-masse montre une allomètrie minorante.

Mots clès : Biometrics, Gulf Of Gabes, Fishes, Eastern Mediterranean.

#### Introduction

*Stephanolepis diaspros*, immigrant de la Mer Rouge et du Golfe d'Arabie via le canal de Suez, est la première espèce lessepsienne apparue en Tunisie. Elle a été signalée dans le Golfe de Gabès en 1966 [1]. Cette espèce démérsale dans les eaux littorales et récifales des mers tropicales et tempérées chaudes, est devenue très abondante sur nos côtes. Nous nous intéressons dans ce travail à la description de la morphologie de cette espèce et au suivi de la croissance massique et la croissance relative des différentes parties de son corps.

#### Matériel et méthodes

Les relevés biométriques ont été réalisés à 0,01 mm prés sur un échantillon de 328 individus de *S. diaspros* de longueur totale (LT) comprise entre 4,8 et 22,4 cm collectés durant la période allant de mai 2003 jusqu'au juillet 2005.

Pour l'étude de la croissance massique, nous avons examiné 1030 spécimens de longueurs totales comprises entre 3,7 et 23,7 cm. Pour chaque spécimen, et après la détermination du sexe, nous avons relevé la masse totale (M) au centième de gramme le plus proche.

A partir de ces mensurations, nous avons estimé la croissance relative de différentes parties du corps par une fonction de la forme  $y = ax^b$ , où y = longueur du caractère considéré, x = LT (longueur de référence) ; a et b sont des constantes. Ces dernières sont estimées par la méthode des moindres carrés. Nous avons estimé aussi la croissance pondérale par une fonction de type puissance:  $M = a LT^b$ ; où b exprime le taux de croissance. Pour apprécier le degré d'allomètrie entre les deux variables, nous avons comparé les valeurs du coefficient d'allomètrie "b "à 1 pour les caractères métriques et à 3 pour la relation taille-masse en appliquant le test "t "de Student à 5%.

#### Résultats et discussions

La première nageoire dorsale de *S. diaspros* consiste en une forte épine barbelée située au-dessus de la moitié postérieure de l'ÅŞil. Le nombre de rayons mous de la deuxième dorsale varie de 28 à 32 avec une moyenne de 30,3 et un mode situé au niveau de 31. Le deuxième rayon mou de cette nageoire dorsale est toujours prolongé chez les mâles. Le nombre des rayons mous à l'anale varie entre 28 et 31 avec une moyenne de 29,5 et un mode au niveau de 30. La nageoire pectorale, courte, est constituée de 12 à 13 rayons mous avec une moyenne de 12,82 et un mode de 13, alors que le nombre des rayons ramifiés de la nageoire caudale est 12 (Tableau 1).

Le nombre total des branchiospines varie entre 17 et 30 avec une moyenne de 22 et un mode situé au niveau de 24. Malgré ces grandes variations, nous n'avons pu montrer aucune corrélation entre le nombre de branchiospines et la longueur du poisson.

Les résultats de l'analyse de l'allomètrie des différents caractères métriques de *S. diaspros* par rapport à la longueur totale sont consignés dans le tableau 2.

L'analyse des relations taille-masse du poisson plein chez les deux sexes séparés et confondus de *S. diaspros* nous permet de constater que les valeurs du taux de croissance "b "sont inférieurs à 3 (2,7892 pour les 2 sexes confondu; 2,8184 pour les femelles et 2,7849 pour les males) et les coefficients de corrélations "R "sont proches de 1. Les deux variables sont donc bien corrélées et l'allomètrie est donc minorante. Ceci est prouvé par le test "t "de Student au seuil de 0,05 qui ne montre aucune différence significative chez les deux sexes séparés et confondus.

Ces résultats sont totalement différents de ceux des côtes turques [2] où l'allomètrie est majorante (b= 3,186). Toutefois, cette étude a porté sur un faible échantillonnage (207 spécimens) et une marge faible de longueur totale (7,1 <LT <13).

Tab. 1. Les paramètres statistiques de quelques caractères méristiques de *S. diaspros* du golfe de Gabès. ND2: nombre de rayons mous au niveau de la deuxième nageoire dorsale; NA: nombre de rayons mous au niveau de la nageoire anale; NP: nombre de rayons mous au niveau de la nageoire pectorale; NC: nombre de rayons mous au niveau de la nageoire caudale; Branch: nombre de branchiospines.

|        | N   | Min | Max | Moy   | Mode | EC   |
|--------|-----|-----|-----|-------|------|------|
| ND2    | 328 | 28  | 32  | 30.3  | 31   | 0.81 |
| NA     | 328 | 28  | 31  | 29.5  | 30   | 0.77 |
| NP     | 328 | 12  | 13  | 12.82 | 13   | 0.38 |
| NC     | 328 | 12  | 12  | 12    | 12   | 0    |
| Branch | 328 | 17  | 30  | 22    | 24   | 2.79 |

Tab. 2. Croissance relative des différents caractères mètriques chez *S. diaspros* du golfe de Gabès. Lst: longueur standard; T: longueur de la tête; O: diamètre de l'ÅŞil; H1: première hauteur; H2: deuxième hauteur; PD1: distance prédorsale 1; D2: longueur de la deuxième dorsale; ID: intervalle entre les deux dorsales; A: longueur de l'anale; P: longueur de la pectorale.

| Caractères | а      | b      | R <sup>2</sup> | Allométrie  |
|------------|--------|--------|----------------|-------------|
| Lst        | 0.535  | 1.0821 | 0.9611         | Isométrique |
| Т          | 0.2856 | 0.9807 | 0.9599         | Isométrique |
| 0          | 0.5115 | 0.5895 | 0.9353         | Minorante   |
| H1         | 0.7165 | 0.8594 | 0.9522         | Minorante   |
| H2         | 0.772  | 0.854  | 0.9646         | Minorante   |
| PD1        | 0.386  | 0.9393 | 0.9852         | Minorante   |
| D2         | 0.1657 | 1.1316 | 0.9861         | Majorante   |
| ID         | 0.1527 | 1.0571 | 0.9444         | Isométrique |
| A          | 0.1492 | 1.1368 | 0.9312         | Majorante   |
| P          | 0.1876 | 0.8907 | 0.9633         | Minorante   |

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# AGE AND GROWTH OF HAKE IN THE WESTERN MEDITERRANEAN AND THE STRAIT OF GIBRALTAR

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# Abstract

The age and growth of European hake was undertaken for the Moroccan Mediterranean and the Gibraltar Strait regions. The comparison of the von Bertalanffy growth parameters in both regions and between regions, showed significant differences between males and females for all three growth parameters.

Keywords : Demersal, Growth, Strait Of Gibraltar.

## Introduction

The European hake, *Merluccius merluccius*, L.1758, is a species with a high commercial value. The present study focused on the comparison of the precision of age determination and the growth of this species between the Mediterrranean and the Strait of Gibraltar regions by the use of a multivariate analysis.

#### Material and Methods

The area of study covered the hake fisheries off the Mediterranean and the Strait of Gibraltar regions of Morocco. The Mediterranean region extends from Algeria borders to Tangier; while the Gibraltar Strait region, contiguous to the latter, extends from Tangier to Larache.

The samples used in this study were collected by using a stratified random sampling of hake captures carried out in 2004 and 2006 surveys in the Mediterranean region, and in 2004 and 2005, from monthly commercial landings of trawlers in the Gibraltar strait region at the fish auction of Larache.

Samples of 510 individuals, ranging in size between 10 and 60 cm total length, were sexed, measured for total length to the nearest centimeter and weighted with a precision of 0.1 g. For age determination, 10 sagittal otoliths by length class of 1 cm, were removed, washed, viewed whole and sectioned, with a magnification of 50x. Each otolith was read three times. The standard deviation and the Percentage of Agreement between age-readings were calculated for whole and sectioned otoliths [1]. Age readings were analysed with a spreadsheet developed by Guus Eltink [2]. The von Bertalanffy growth parameters using sectioned otoliths were estimated by region, separately for males and females using the length-age keys established by using FISHPARM program [3]. Hotlling's  $T^2$ test [4], was used to compare growth parameters between male and females in each region and between the two regions for each sex separately.

#### Results and discussion

In both regions, high Percentage of Agreement, between the age-readings (over 89% for whole otoliths versus 100% for sectioned ones), was observed for young individuals; but as fish got older for both regions, the distinction of age rings became hard to distinguish, especially for whole otoliths due to their overlappings; thus, for older individuals, the Percent Agreement underwent a sharp decrease (49% and 67% respectively for whole and sectioned otoliths); while the standard deviation increased from 0.33 to 0.72 and 0.57 respectively for whole and sectioned otoliths. These results indicate that age determined by using whole otoliths is underestimated especially for old individuals.

Tab. 1. Von Bertalanffy growth parameters with standard errors (SE) for hake by sex and region; n is the sample size.

| Region           | Sex    | n   | Loo    | SE    | K     | SE   | to     | SE   |
|------------------|--------|-----|--------|-------|-------|------|--------|------|
| Mediterroneon    | male   | 236 | 64.10  | 21.95 | 0.167 | 0.01 | 0.299  | 0.05 |
| weutenanean      | female | 248 | 81.57  | 26.19 | 0.124 | 0.01 | 0.195  | 0.06 |
| Gibraltar Strait | male   | 238 | 78.49  | 40.62 | 0.106 | 0.10 | -0.418 | 1.20 |
|                  | female | 244 | 102.35 | 50.50 | 0.075 | 0.06 | -0.756 | 1.00 |

Von Bertalanffy growth parameters were calculated by region, separately for males and females (Table 1). In both regions, significant differences between males and females were found for all three growth parameters (Hotlling's T<sup>2</sup>tests, P <0.001); females grew faster and on average were larger than males of the same age in both regions. The study showed for the Gibraltar Strait region a slightly higher asymptotic length (L $\infty$ ), for females. Similar comparisons were made between regions for each sex separately. For each sex, all three growth parameters were significantly different between the Mediterranean and the Strait of Gibraltar regions (Hotlling's  $T^2$  test, P<0.001).

The data in our study confirmed that females grow faster than males for both regions, as found in a previous study [5].

Growth rates of fish can be affected by many factors including differences in the seasonality of spawning, environmental factors (temperature), amount of food, and genetics [6].

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# AN ASSESSMENT OF GEARS INTERACTION IN HAKE FISHERIES IN THE WESTERN MEDITERRANEAN AND THE STRAIT OF GIBRALTAR

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# Abstract

A study on gear interaction in hake fisheries was carried out in the Moroccan Mediterranean and the Gibraltar Strait regions. The trawl landings in both regions were composed mainly of immature specimens while longliners were targeting only mature individuals. *Keywords : Demersal, Stock Assessment, Analytical Methods, Western Mediterranean, Strait Of Gibraltar.* 

## Introduction

The European hake, *Merluccius merluccius*, L. 1758 constitutes a species of high commercial value for the Moroccan demersal fishery. This work focused on the study in both regions of gear interactions in hake fisheries using an analytical model.

tion of von Bertalanffy while holding the other parameters constant, the variation of the yield per recruit is particularly important with a reduction of asymptotic length (L $\infty$ ), and K of 20 %. The simultaneous variation of M and F generated an almost negligible variation of the estimate of yield per recruit.

#### Material and Methods

The data used in this study were samples, collected by length category, using a stratified random sampling of hake captures. The sampling was carried out in the 2004 and 2006 surveys in the Mediterranean region, and in 2004 and 2005, from monthly commercial landings of trawlers and longliners in the Gibraltar Strait region.

The samples were weighted and all individuals were measured to the nearest centimeter for total length (TL). A subsample was then chosen, and each fish was measured to the nearest cm and then weighted with a precision of 0.1 g. Otoliths were removed, washed and sectioned for age determination. The von Bertalanffy growth parameters were calculated (sexes combined), using the Fishparm program [1]. The length-weight relationship parameters (a and b), were obtained by linear regression. The natural mortality (M) was estimated based on [2].

The length distributions of the samples were raised to the catches of the vessels and that of the month, and then extrapolated to the species annual catches made in each region.

The annual length distribution by region was then used to estimate the fishing mortality parameters (F) for each region using the linearized catch curve method [3]. The parameters obtained by region are given in Table 1.

Tab. 1. Biological parameters of hake with value (Val.), and standard error (SE):  $L\infty$  (cm), K (per year),  $t_0$  (year), are von Bertalanffy growth parameters. Length-weight relation parameters: a and b (slope); M and F are natural and fishing mortality; n is the sample size.

| Region                | n   |       | (m    | ,    | ĸ    | 4     | 0    | 1      |      | b     | М    | F    |
|-----------------------|-----|-------|-------|------|------|-------|------|--------|------|-------|------|------|
| Medit.                |     | val   | SE    | val  | SE   | val.  | SE   | val    | val. | SE    | val  | val  |
|                       | 484 | \$1.1 | 23.47 | 0.12 | 0.01 | 0.19  | 0.04 | 0.0053 | 3.04 | 0.003 | 0.19 | 0.43 |
| Strait of<br>Gibralta | 482 | 93.1  | 46.11 | 0.09 | 0.09 | -0.37 | 1.10 | 0.0041 | 3.20 | 0.011 | 0.31 | 0.39 |

A yield par recruit analysis by region was then applied to the average pseudocohort 2004-2006, using VIT [4]. An analysis of sensitivities to the errors related individually to all parameters of the model was also performed.

#### Results and Discussion

For both regions, the analysis of annual length-frequency distributions showed that the landings of the trawlers were mainly composed of specimens of sizes ranging between 14 and 36 cm, while the landings of longliners were essentially composed of individuals with length from 25 to 58 cm (Fig.1). The fishing mortality (F) in both regions, was higher for juveniles (14-24 cm), exploited exclusively by trawlers (Fig. 1). Longliners targeted only mature individuals of sizes higher than 40 cm (maximum for the size of 52 cm). Similar studies on hake [5] show that the high level of trawling effort causes growth overfishing.

From a study of sensitivity to the errors related individually to all parameters of the model, it appeared that the estimates of yield per recruit and the biomass are very sensitive to the variation of the slope of the length-weight relationship (b). With a simultaneous variation of parameters of the equa-



Fig. 1. Length frequency distribution (%) and fishing mortality (F) with length for hake fishery in the Mediterranean (a) and Gibraltar Strait region (b).

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# ERADICATION OF INVASIVE ALGA CAULERPA RACEMOSA VAR. CYLINDRACEA IN NATIONAL PARK MLJET (CROATIA)

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#### Abstract

In the summer of 2004 the invasive green alga *Caulerpa racemosa* var. *cylindracea* was found in N.P. Mljet in the area of Great Lake which is a unique marine ecosystem. Eradication was conducted with the aim to slow down the algae spread. Manual eradication methods were used such as covering with plastic foil or collecting by underwater suction pump. In two years period the area covered by alga was significantly reduced.

Keywords : Adriatic Sea, Algae.

#### Introduction

The invasive green alga Caulerpa racemosa var. cylindracea was observed in the Mediterranean Sea for the first time in 1991 in Libya. In a period of 20 years it expanded to almost all regions of the Mediterranean [1]. First record in the Adriatic Sea was in September 2000 in Croatia [2]. Predominantly spreading by current, till the end of 2006 there is more than 50 locations recorded [3, not published data]. In July 2004, the alga was found in Channel Soline in N.P. Mljet between 0.5 and 4 m deep, affecting around 150 m of coastline (Fig 1.). Channel Soline connects open water and two sea lakes which are a unique marine ecosystem. Additional colony of the alga was found just outside of the channel in Gonoturska cove. In September 2004 the alga was found in Grate Lake between 8 and 14 m deep, affecting around 150 m of coastline, just a few meters from the greatest Mediterranean colony of Cladocora caespitosa reef. To protect lakes and the reef of Cladocora caespitosa, eradication of the alga was conducted in channel Soline and in Grate Lake. Colony in Gonoturska cove has affected 600 m of coastline and developed from 1 till 30 m deep. Therefore it was too large for eradication.



Fig. 1. Locations of *Caulerpa racemosa* var. *cylindracea* in National park Mljet. Data of covered area (Cvd), affected area (Aff) and affected coast-line (AffCl) on the first observation.

#### Material and methods

Cartography of location Soline and Grate Lakes was made on 2.5 m wide transects. All detected colonies were eradicated by covering with black plastic foil, by sucking with underwater suction pumps or by manual collecting of small thalli. Plastic foils were left at the bottom for at least 6 months. Applied methods were developed during previous eradication of *Caulerpa taxifolia* [4]. Eradications were made in the beginning and near the end of the vegetative season of the alga (Tab. 1).

#### Results and discussion

Eradication of the *Caulerpa racemosa* var. *cylindracea* colonies was exceptionally difficult. Small fragments are usually invisible until stolon reaches length of 10 - 20 cm. Due to constant eradication efforts number of colonies and covered area was significantly reduced (Tab. 1). *Caulerpa racemosa* var. *cylindracea* is an exceptionally invasive species. Its erad-

ication is difficult due to small fragments, successful reproduction and fast growing thalli. Therefore it was decided by croatian scientists that eradication has to be done in the areas of high biological value but only if the colonies are small, as in the case of Great Lake. Eradication of the alga in Channel Soline and Great Lake can not be done in full due to extensive colony in Gonoturska Cove from where the new fragments or zygotes are carried into Channel Soline and Great Lake. If we allow the alga to spread easily, it would occupy Great Lake, the unique marine ecosystem and destroy the greatest Mediterranean *Cladocora caespitosa* reef. With eradication we can slow down its spreading and protect Great Lake ecosystem. In the mean time, scientist should find global method for algae control, e.g. biological control.

Tab. 1. History of the *Caulerpa racemosa* var. *cylindracea* colonies in eradicated locations Channel Soline and Great Lake.

| Location    | Chann    | el Soline         | Gre      | at Lake           |
|-------------|----------|-------------------|----------|-------------------|
| Date of     | nr. of   | coverage          | nr. of   | coverage          |
| eradication | colonies | (m <sup>2</sup> ) | colonies | (m <sup>2</sup> ) |
| July 2004   | 5        | 132               | -        | -                 |
| Sept 2004   | ~        | -                 | 3        | 10                |
| Dec 2004    | 2        | 2                 | 32       | 34                |
| June 2005   | 17       | 25.5              | 2        | 1                 |
| Sept 2005   | 11       | 14                | 18       | 10.5              |
| Dec 2005    | 9        | 9                 | 24       | 15                |
| July 2006   | 7        | 7                 | 2        | 3                 |

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# Comité 6

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Ecosystèmes côtiers

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NATURAL AND HUMAN-INDUCED ENVIRONMENTAL CHANGES IN THE LAND-SEA INTERFACE OF THE IONIAN SEA - THE LAMINATED SEDIMENTARY RECORD OF LAKE BUTRINTI (ALBANIA)

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Abstract

Lake Butrinti, located in the Ionian Sea shore of southwestern Albania, contains laminated sediments reflecting regional environmental history. A sedimentological and geochemical dataset combined with an excellent chronology indicate that these lacustrine sediments are recording not only changes in Mediterranean climate but also historic anthropogenic and tectonic events affecting the region during the last 260 years.

Keywords : Ionian Sea, Coastal Systems, Global Change, Eutrophication, Geochemistry.

Coastal areas in the Mediterranean realm provide ideal archives of past and present natural and human-induced environmental changes along the land-sea interface. Lake Butrinti, located in southwestern Albania near the Greek border, is a lacustrine archive containing a perfectly laminated sedimentary succession reflecting regional environmental history [1]. On its shore, the antique city of Butrinti, an UNESCO world heritage site, is a unique archaeological example representing a microcosm of Mediterranean history from the archaic Greek until the Venetian cultures providing an unusual source of continuous documentary data. In addition, a meteorological station located in Corfu -relatively close to the lakeprovides instrumental data to calibrate the modern response of the lake system to the most recent changes in climate (e. g., precipitation). Our results indicate furthermore that the lake system is responding not only to changes in Mediterranean climate and historical anthropogenic impact on the catchment but that it is also sensitive to the documented regional seismic activity.

Water column data and a first set of sedimentary cores were recovered in summer 2000 within the framework of an Albanian-Swiss cooperative project. Physical properties (density, sonic velocity and magnetic susceptibility) allowed the correlation of a set of sedimentary cores throughout the basin. The recovered cores with a maximum length of 2 m consist of a continuously laminated sequence covering the last 260 years as confirmed by Cs-137 isotopes. Each annual lamina is composed of three characteristic layers. One layer consists of authigenic carbonates, a classical source of lacustrine chemostratigraphy in hard water lakes and one of the best paleoenvironmental archives. The dominant climate of the region is typically Mediterranean combining dry and hot summers with cold and wet winters. This seasonality provides ideal conditions to promote the precipitation of carbonates in the water column that are in turn preserved in the sediments as fine laminae. The microstratigraphical analyses of the sequence using a wide range of techniques such as SEM, X-ray microfluorescence and X-ray diffraction showed distinctive sediment types and a variable composition and morphology of the authigenic carbonates. Next to the carbonate laminae, the varves are composed of layers with organic-rich biogenic constituents and of dominantly detrital particles, respectively.

These results together with C and O stable isotopes in both authigenic carbonates and organic matter, as well as bulk organic matter pyrolysis, have been used to reconstruct the climatic and anthropic influence on Lake Butrinti sediments. They revealed a hypereutrophication trend increasing towards the end of the 20th century and a decadal cyclicity in the varves thickness that might be partially controlled by the North Atlantic Oscillation (NAO) and/or ENSO-like phenomena. Additionally, a comparison of distinctive and well-dated turbidites with historically recorded seismic events indicate that earthquakes may have triggered their formation. Supplementary field investigations, however, are still needed to confirm the influence of these frequent tectonics events in the Balkanic region on the formation of the mass-wasting deposits.

Further retrieving of long cores in Lake Butrinti will provide a potentially varved section of environmental change punctuated by historic anthropogenic impact, covering the late Holocene period on a decadal and even annual scale. In particular the construction of a few-km long channel, already initiated during the ancient Greeks and maintained during Roman and later periods, connected the antique City of Butrinti and the lake to

the Mediterranean Sea. This sedimentary archive, hence, might also offer new insights into linking coastal lacustrine deposits and the Mediterranean system.

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SUSAK ISLAND (NORTH ADRIATIC SEA): POSSIBLE PROTECTED MARINE AREA

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Abstract

The program encompasses environmental research of the submarine zone of Susak Island (Kvarner bay of the Northern Adriatic Sea), with the aim of proposing the establishment of a protected area. The submarine zone of Susak Island should be proposed as a protected area for the following reasons: the morphogenesis and geological composition of Susak island and the shallow surrounding submarine plateau are unique among the islands of the Northern Adriatic Sea; 3 biocenoses, 4 floral species and 15 invertebrate species found are, according to the Mediterranean Action Plan, of conservation interest; this area is surrounded by sea-grass *Posidonia oceanica* community; the submarine zone of Susak Island complements geographically previously proposed marine protected areas in the Kvarner region. *Keywords : Adriatic Sea, Biodiversity, Geomorphology, Marine Parks*.

Susak Island is situated in the open sea of the Kvarner area, to the west of the Cres-Lošinj archipelago. There are no published data about the benthic communities of Susak Island local waters. Only summarized data about the flora and fauna for the Cres-Lošinj archipelago, which includes Susak Island, were published [1].

Methodology

Biological researches of this area were carried out in the period from 6 -12 October, 2006. The research of benthic biocenoses was carried out by using the method of direct observation and photodocumentation by means of SCUBA-diving equipment. On the basis of field notes and material analyses we determined the benthic communities according to standard classification [2]. The decapod crustaceans were researched by direct underwater visual examination and caught by special baited traps during day and night time. The composition of the fish assemblage was investigated by using the visual census method.

Geology of investigated area

Susak Island has a relatively low-lying irregular shape with NW-SE orientation. The surface of the island is 3.76 km^2 . A relatively flat loess plateau bordered by steep slopes around the greater part of the island is the characteristic feature of Susak. The Quaternary loess and loess-like sediments with maximum thickness of 90 m cover Upper Cretaceous limestones [3]. Limestone bedrock is partially visible on the coast. Shallow and narrow submarine plateau has depth range between 5 and 15 m. Steep submarine slopes are situated along the north-eastern and south-western coast of Susak Island. These submerged relief forms separate the narrow submarine plateau from almost flat sea bottom at the depth of 40 to 50 m. The shallow submarine plateau around the island is mostly covered by sand, and silty sand prevails on deeper sea bottom [4].

Results and discussion

A total of 6 hardbed biocenoses were determined: the biocenosis of upper mediolittoral rock, biocenosis of lower mediolittoral rock, biocenosis of infralittoral algae, precoralligenous aspect of a coralligenous biocenosis, coralligenous biocenosis and biocenosis of semi-dark caves. Furthermore, two biocenoses of movable bottoms were determined: the biocenosis of the Posidonia oceanica meadows and the biocenosis of littoral detritic bottom. The island of Susak is surrounded by sea-grass community of Posidonia oceanica, which appears on sandy seabed at the depths of 1 to 25 m. Communities of infralittoral algae are mostly limited to the narrow zone of rocky bottom up to 2 m deep, where, due to the pronounced sea dynamics, the algae of low taluses predominate. The biocenosis of semi dark caves, precoralligenous aspect of a coraligenous biocenosis and facies with Eunicella cavolinii of the coralligenous biocenosis were mostly observed at the steep rocky bottom of the south-eastern side of Susak Island. In the area of investigation 62 species of macroflora (Cyanophyta 1, Rhodophyta 35, Phaeophyta 13, Chlorophyta 11, Angiospermae 2) and 218 species of macrofauna (Porifera 24, Cnidaria 21, Placophora 2, Gastropoda 12, Bivalvia 23, Cephalopoda 2, Echiura 1, Sipuncula 1, Polychaeta 9, Crustacea 36, Bryozoa 8, Echinodermata 14, Tunicata 6, Pisces 55) were determined. Three biocenoses, 4 floral species, 6 species of Porifera, 1 species of Echinodermata, 4 species of Mollusca and 3 species of Crustacea found are, according to the Mediterranean Action Plan, of conservation interest. The characteristics of the benthic communities of the Susak submarine area differ from benthic communities of other previously investigated submarine areas whose aim is establishing protected areas in the Kvarner region (the Islands Ćutin mali and Ćutin Veli, the Kostrena municipality aquatorium and the Prvić, Grgur and Goli islands) [5, 6, 7]. While the most important feature of benthic communities of the Susak submarine area are well developed meadows of Posidonia oceanica, the most important value of other investigated areas are well developed biocenoses of hard bottom (biocenosis of upper mediolittoral rock, association with Nemalion helminthoides; biocenosis of lower mediolittoral rock, association with Lithophyllum tortuosum; biocenosis of infralitoral algae, associations with Cystoseira spp.; coraligenous biocenosis, facieses with gorgonarians (Eunicella cavolinii, Paramuricea clavata) [5, 6, 7]. The submarine zone of Susak Island should be proposed for a protected area for the following reasons: 1) Due to its morphology and geological fabric, Susak island and the surrounding shallow submarine plateau is unique among the islands of the Northern Adriatic Sea channel zone; 2) The present limited research revealed 3 biocenoses, 4 floral species and 15 invertebrate species that are, according to the Mediterranean Action Plan, of conservation interest. It could be expected that future more extensive researches would increase the known biodiversity and conservation interest of this area: 3) The submarine zone of Susak island is unique among the islands of the Northern Adriatic Sea by the wide spread of Posidonia oceanica meadows, a community of particular conservation interest; 4) This area, with its position in the open Northern Adriatic Sea (west of the Cres-Lošinj archipelago), complements previously researched marine zones in the Kvarner area with the aim of proposing the establishment a protected area. The other previously investigated and possibly protected areas are situated in the channel zone of Kvarner area: Ćutin veli and Ćuti mali islands in Kvarnerić aquatorium, near the eastern coast of Cres Island and Prvić, Grgur and Goli islands are situated in Velebit Channel, and Konstrena area, which is near the northeastern coast of Rijeka Bay.

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CONTRIBUTIONS À L'ÉTUDE DES SUSPENSIONS DANS LES EAUX CÔTIÈRES DU LITTORAL ROUMAIN DE LA MER NOIRE AU PRINTEMPS 2006

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Résumé

L'article présente quelques résultats des analyses de matière organique vivante et non-vivante particulaire de long des côtes roumanines de la mer Noire de Sulina à Copstinesti, en avril 2006. La matière organique particulaire (MOP) du Danube présente des valeurs en δ^{13} C et δ^{15} N plus faibles que la MOP de l'eau de mer de surface. La signature en isotopes stables du fleuve influence d'une manière significative celle de la MOP marine et le zooplancton dont nous avons identifié 24 espèces. Leur densité varie entre 241 ind m⁻³ et 101024 ind m⁻³. Les espèces caractéristiques pour la zone étudiée sont: *Synchaeta littoralis, Asplanchna priodonta* et *Acartia clausi. Mots clès : Black Sea, Coastal Waters, Organic Matter, Zooplankton.*

Les zones côtières à proximité de l'embouchure des grands fleuves se rangent parmi les écosystèmes les plus productifs de la planète.

L'eau des bras Sulina et Sfantu Gheorghe du Danube , ainsi que l'eau de surface (0-10 et 20-30 m de profondeur) de la mer le long des côtes roumaines, a été filtrée sur des filtres GF/F pour l'analyse de la matière organique particulaire (MOP) [1], ainsi que pour les analyses des isotopes stables δ^{15} N et δ^{13} C. L'analyse des signatures de ces isotopes a été effectuée par spectrométrie de masse isotopique en flot continu à combustion assistée par un analyseur élémentaire au Scottish Crop Research Institute (U.K.) selon les techniques usuelles [2].

Nous avons collecté les échantillons quantitatifs de zooplancton dans la colonne 10-0 m avec un filet à traction verticale de maille de 90 μ . Nous avons fait le tri et l'identification taxonomique des organismes, conditionnés avec du formaldéhyde (4%), à l'aide d'un stéréomicroscope Nikon SMZ-2T et d'un microscope Nikon E 200. Les données de densité (D) sont exprimées en nombre d'exemplaires rapportés à un mètre cube d'eau (ex·m⁻³).

Nous avons fait l'échantillonnage en avril (12-17.04.2006) de Sulina à Costinesti. Les paramètres physico-chimiques de l'eau marine (tableau 1) présentent des valeurs normales pour la saison vernale [3].

Tab. 1. Conditions physico-chimiques des eaux côtières de la mer Noire dans la zone d'échantillonnage (12-17.04.2006)

Station	Coord géogra	lonnées phiques	Isobathe (m)	Temp. (°C)	Salinité (psu)	O_2 (mg•l ⁻¹)	Matériel organique (g•m ⁻³)
Sulina Bara	N 45.08	E 29.45	15	12.5	7.7	9.87	85.25 écart type 3.53
Sulina	N 45.08	E 29.47	21	12.7	7.6	9.93	43.80 écart type 1.78
Sf. Gheorghe	N 44.55	E 29.48	20	13.6	6.9	10.13	28.82 écart type 2.54
Zăton	N 44.45	E 29.50	42	14.1	12.9	9.91	3.73 écart type 0.58
Constanta 1	N 44.09	E 28.42	16	11.0	11.5	17.24	2.07 écart type 0.28
Constanta 2	N 44.06	E 28.42	24	9.4	11.3	13.52	-
Agigea 1	N 44.06	E 28.40	17	9.9	9.5	10.06	S.=).
Agigea 2	N 44.05	E 28.42	25.6	8.5	15.2	10.38	
Ef. Nord 1	N 44.04	E 28.43	29	8.4	15.2	10.53	-
Ef. Nord 2	N 44.03	E 28.40	17.5	8.6	15.3	10.32	-
Costinesti	N 43.56	E 28.40	20	7.5	16.7	10.45	-

L'importance des deux facteurs étudiés (site et profondeur) sur la signature en isotopes stables de la matière en suspension a été estimée par des analyses de variance (ANOVA). La MOP du Danube ($\delta^{15}N =$ 4.08+2.20%, $\delta^{13}C = -27.34+1.46\%$ o) présente une signature différente sur les deux bras étudiés (F = 10.10, p = 0.000). Le bras Sf.Gheorghe qui a un débit plus important au printemps présente une signature plus élevée en $\delta^{13}C$ et plus faible en $\delta^{15}N$ que le bras Sulina. La MOP de l'eau marine de surface présente des valeurs en $\delta^{15}N$ (6.64+2.27%o) et $\delta^{13}C$ (-24.36+2.14%o) plus élevées que celles de la MOP du Danube. L'influence du Danube diminue de la côte vers le large et de Nord vers le Sud des côtes roumaines. Elle est plus st plus importante au printemps, en période de crue du fleuve, qu'en automne [2].

Le printemps 2006, dans les eaux côtières roumaines nous avons identifié 24 espèces (12.5% méroplanctoniques et 87.5% holoplanctoniques), les especes d'eaux douces ayant une grande importance (37.5%). Les valeurs de densite sont comprise entre 241 ex·m⁻³à Sf.Gheorghe et 101024 ex·m⁻³ à Eforie Nord 2. Des densités remarquables ont été constatées dans les stations Constanta 2 (22356 ex \cdot m⁻³) et Agigea 2 (58544 ex \cdot m⁻³). Selon les valeurs de l'indice de signifiance écologique, *Synchaeta littoralis* et *Asplanchna priodonta*, suivis par *Acartia clausi*, sont les espèces caractéristiques de la communauté zooplanctonique étudiée [tableau 2].

Tab. 2. Structure qualitative et quantitative du zooplancton des eaux néritiques du littoral roumain de la mer Noire

Espèces	F%	A	D _{MOY}	D _{ECO}	D%	W	R _{kD}
Noctiluca scintilans (Macartney) Kofoid -Swezy	7,69	7	0,54	7,00	0,00	0,14	23
Tintinnopsis beroidea (Stein), Lon.	46,15	24570	1890.02	4095,03	8,69	20.03	6
Tintinnopsis meunieri Kof.et Campb.	53.85	24805	1908.07	3543,56	8,77	21.73	4
Hydractinia carnea (M. Sars)	7.69	3	0.20	2.63	0.00	0.08	24
Brachionus quadridentatus Hermann	7.69	14	1.09	14.15	0.01	0.20	21
Brachionus plicatilis O.F. Müller	38.46	156	11.97	31.13	0.06	1.46	11
Keratella quadrata O.F. Müller	7.69	132	10.12	131 50	0.05	0.60	14
Lepadella patella O.F. Müller	7.69	7	0.54	7.08	0.00	0.14	22
Asplanchna priodonta Gosse	100.00	42237	3249.01	3249.01	14.94	38.65	2
Synchaeta razelmi Rodewald-Rudescu	38.46	27036	2070 72	5407.28	0.56	10.18	7
Synchaeta pontica Rodewald-Rudescu	28.46	24256	2675.06	6951 15	12.11	21.50	5
Synchaeta littoralis Rodewald-Rudescu	60.22	00502	2033,00	10055 01	22.01	47.07	
Mollusca -Larves veligere de Gasteronoda	7.69	90503	2 02	26.30	0.01	47,07	18
Mollusca – Larves veligere de Bivalvia	15.38	263	20.23	131.50	0.09	1.20	12
Larves de Balanus	15,38	44	3.35	21.78	0,02	0,49	15
Chydorus sphaericus O.F. Müller	7,69	85	6,53	84,90	0,03	0,48	16
Eurytemora lacustris Poppe	23,08	1188	91,38	396,00	0,42	3,11	10
Calanus helgolandicus Claus	7,69	42	3,23	42,00	0,01	0,34	17
Paracalanus parvus Claus	76.92	12366	951.25	1236.63	4.37	18.34	8
Pseudocalanus elongatus (Boeck)	76.92	2875	221.13	287.47	1.02	8.84	9
Acartia clausi Giesbrecht	100.00	21936	1687.40	1687.40	7.76	27.85	3
Oithona similis Claus	15.38	184	14.15	92.00	0.07	1.00	13
Cyclops furcifer(Claus)	7.69	17	131	17.00	0.01	0.22	20
Sagitta setosa (O.F. Müller)	23,08	7	0,54	2,33	0,00	0,24	19

En conclusion, la MOP du Danube influence fortement les eaux marines et les communautés planctoniques des côtes roumaines. Le zooplancton vernal, est dominé par les éléments fluviatiles apportés par les eaux danubiennes, par les eaux très eutrophes des enceintes portuaires, ou encore par les effluents de la station touristique Eforie Nord qui sont à l'origine de l'augmentation de la densité du zooplancton.

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RECENT FORAMINIFERA AND OSTRACODA FROM THE SALTPANS AND SALT LAKES OF NORTHEASTERN AND EASTERN AEGEAN SEA (TURKEY)

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Abstract

In the framework of this study, microfauna (foraminifers, ostracods) and microflora (charophytes, diatoms) of some of the salt lakes located on the Aegean coasts of Turkey were investigated. In total, 43 sediment samples were collected from various salt lakes (Büyük Kemikli Cape, Gallipoli Peninsula; Diremin and Dalyan, Biga Peninsula; Gökçeada Island). Physicochemical measurements, such as temperature, pH and salinity were also recorded in order to compare the marine and hypersaline foraminifera and ostracod faunas and the related environmental conditions.

Keywords : Aegean Sea, Foraminifera, Diatoms, Sediments.

Sediment samples from several of the saltpans and salt lakes located on the Turkish Aegean coastline were analysed (Fig. 1). In total, 31 benthic foraminifera and 13 ostracod species were recorded. Five samples also included three species of Charophytes. Four diatom species were observed only in one of the samples. Morphological anomalies were observed in the benthic foraminifera species. In the framework of this study, the foraminiferal composition typical of the marine environment is compared with that of the lagoon environments, characterized by high salinity during summer.



Fig. 1. Map showing the saltpans and salt lakes sampled.

Marine microfauna of the Northeastern Aegean Sea have been investigated in detail [1, 2, 3, 4, 5, 6, 7, 8]. The species composition differed considerably among sampling sites: 163 foraminifera species have been identified in the Gulf of Saros, 104 foraminifera species around Gokceada Island, 58 foraminifera and 24 ostracod species around Bozcaada Island, 44 foraminifera species around Mitillini Island, 160 foraminifera species in the Gokceada-Bozcaada-Canakkale triangle and 101 species of foraminifera in Gulf of Edremit. In a study concerning the 27 samples from Izmir ÇamaltıSaltpan, due to hypersaline environment (45-52 psu), a different but not much diverse foraminifera-ostracod-mollusc fauna have been identified. Besides, several twin and triplet, as well as morphological aberrant forms of *Ammonia tepida* Cushman have been observed.

In the 43 samples analysed, the most abundant species observed comprised *Adelosina carinata-striata* Wiesner, *A. mediterranensis* (Le Calvez, J. and Y.), *Quinqueloculina disparilis* d'Orbigny, *Quinqueloculina seminula* (Linné), *Nonion depressulum* (Walker and Jacob), *Ammonia compacta* Hofker, *A. tepida* Cushman, *Elphidium complanatum* (d'Orbigny), and *E. crispum* (Linné). The two most dominant species were found to be *N*.

depressulum (Walker and Jacob) and *A. tepida* Cushman. The ostracod species most frequently observed were *Cyprideis torosa*, *Eucypris virens*, *Cypridopsis vidua*, and *Loxoconcha elliptica*. *C. torasa* and *L. elliptica* are known to be freshwater species [9].

Brackish and freshwater species of charophytes were also found in the samples. But the presence of the genus *Lamprothamnium* indicates special ecological conditions. The diatom species observed in one sample belong to the Family Cocconeidaceae Kützing.

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IRON, ZN, CU, PB AND CD CONTAMINATION IN THE COASTAL SECTION OF THE EVROS RIVER DELTA (NORTHERN AEGEAN SEA)

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Abstract

The degree of Fe, Zn, Cu, Pb and Cd contamination in the coastal section of the Evros River Delta, Northern Aegean Sea was assessed using water, sediment and the macroalga *Ulva rigida* analysis. Zinc, Cu and Pb levels in the water exceeded the European Environmental Quality Standards (EQSs) of waterborne contamination in estuaries and mainly Cu and Pb sediment contents the baseline levels in estuarine sediments. Metal levels in *U. rigida* indicate that the study area was rich mainly in bioavailable Cu and Fe. *Keywords : Estuaries, Metals, Bio-accumulation, Algae.*

Introduction

One of the most important estuarine areas in Southern Europe, owing to its notable natural history and recreational interest, is that of Evros River, Northern Aegean Sea. Although the Evros Delta is protected as a wetland of international value according to the RAMSAR convention and despite the fact that considerable amounts of metals originated from human polluting activities enter Evros River over almost its entire catchment area, no information on metal contamination in the coastal section of the Evros Delta is essentially available. The use of bioindicators is the most employed method in the assessment of metal contamination in coastal environments; among the organisms most used is the green seaweed *Ulva rigida* C. Agardh ([1],[2] etc.). This study aims to assess the degree of Fe, Zn, Cu, Pb and Cd contamination in the coastal section of the Evros River Delta using *U. rigida*, and supplementary water and sediment, analysis.

Materials and Methods

Metal concentrations in water, surface sediments and *U. rigida* were measured seasonally in the coastal section of the Evros River Delta at four stations located at increasing distance from the estuary of the major branch of Evros River, using flame AAS or graphite furnace AAS with Deuterium background correction.

Results and Discussion

Mean Zn, Cu and Pb levels in the water (63.3, 9.8 and 31.5 μ g l⁻¹, respectively) exceeded, whereas those of Fe and Cd (501 and 0.95 μg 1^{-1} , respectively) did not, the European Environmental Quality Standards (EQSs) of waterborne contamination in estuaries (<40 μ g l⁻¹, <5.0 μ g l^{-1} , <25 µg l^{-1} , <1.0 mg l^{-1} and <5.0 µg l^{-1} , respectively). A comparison of metal concentrations in surface sediments of the coastal section of the Evros Delta (Fe: 19270-31310 $\mu g~g^{-1}$ DW; Zn: 68.7-247.0 μg g⁻¹ DW; Cu: 58.7-710.0 μg g⁻¹ DW; Pb: 66.0-219.4 μg g⁻¹ DW; Cd: 0.2-1.6 μ g g⁻¹ DW) with those of several Greek estuaries ([3], [4], etc.) and baseline levels in estuarine sediments (Zn: <100 μ g g⁻¹ DW; Cu: approx. 10 μ g g⁻¹ DW; Pb: approx. 25 μ g g⁻¹ DW; Cd: approx. 0.2 μ g g⁻¹ DW)([5]) reveals that the coastal area near the mouth of the major branch of Evros River shows some degree of contamination with Zn and Cd and overall the coastal section of the Evros Delta with Cu. Pb and Fe. Mean Fe and Cu levels in U. rigida at the study area (Fe: 2994 μ g g⁻ DW; Cu: 22.4 μ g g⁻¹ DW) are among the highest and mean Zn, Pb and Cd ones (Zn: 61.0 μ g g⁻¹ DW; Pb: 6.1 μ g g⁻¹ DW; Cd: 1.1 μ g g^{-1} DW) in the range of concentrations previously reported for the same species at other coastal areas (Fe: 73.58-4300 μ g g⁻¹ DW; Zn: 6-594 $\mu g g^{-1}$ DW; Cu: 1.1-29 $\mu g g^{-1}$ DW; Pb: 0.51-29.8 $\mu g g^{-1}$ DW; Cd: 0.01-2.5 μ g g⁻¹ DW;), some of which are recipients of domestic and industrial wastes (Thermaikos Gulf, central part of Venice lagoon) ([2], [6], [7], [8], [9], etc.). The above suggest a high bioavailability mainly of Fe and Cu in the coastal section of the Evros Delta.

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LEAD CONCENTRATIONS IN WATER, SEDIMENTS AND BIOTA FROM A MEDITERRANEAN COASTAL LAGOON

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Abstract

Lead concentrations were measured in column, sediments and dominant macrophyte, macroinvertbrate and fish species of a coastal lagoon (Monolimni Lagoon, Northern Aegean). Sediments had the highest Pb contents. *Ruppia maritima* roots, compared to other anatomic plant parts, accumulated higher Pb loads, while this angiosperm leaves contained similar Pb signatures with the green seaweed *Ulva rigida*. Soft tissues of the bivalve *Abra ovata* showed the highest Pb loads among invertebrates. Lead concentrations in whole body of gobies and muscle tissues of mullets were generally lower than those within invertebrates.

Keywords : Metals, Bio-accumulation, Phanerogams, Zoobenthos, Lagoons.

Introduction

Anthropogenic input of heavy metals to coastal lagoons is a potentially serious problem. Nevertheless, scientific knowledge concerning the biological fate and effects of heavy metals in coastal lagoons is limited. This study aims to determine and compare lead concentrations in basic abiotic and biotic components of the ecosystem of a relatively enclosed, macrophyte based Mediterranean lagoon (Monolimni Lagoon, Northern Aegean).

Materials and Methods

Samples of water, surface sediments and biota were collected seasonally from the innermost section of Monolimni Lagoon, where a *Ruppia maritima* meadow occurred. *Ruppia maritima*, the dominant macroalga (*Ulva rigida*), the dominant macroinvertebrates (*Ventrosia maritima*, *Abra ovata*, *Hediste diversicolor*, *Corophium orientale*, *Gammarus aequicauda* and *Crangon crangon*) and the dominant fish species (*Knipowitschia caucasica*, *Mugil cephalus* and *Liza aurata*) were used for analysis; in particular, three anatomic parts of *R. maritima* (roots, rhizomes plus stems, leaves), soft tissues of *A. ovata*, muscle tissues of mullets and whole tissues of the rest species. Lead concentrations were measured using graphite furnace AAS (Perkin-Elmer 4100) with Deuterium background correction.

Results and Discussion

Amounts of Pb obviously reached Monolomni Lagoon; mean dissolved Pb concentrations (25.1 μ g l⁻¹) exceeded the European Environmental Quality Standards of waterborne contamination in estuaries (<25 μ g l⁻¹) and mean Pb contents in sediments (99.1 μ g g⁻¹ dry wt) the baseline Pb levels in estuarine sediments (about 25 μ g g⁻¹ dry wt) ([1]). Lead contents in sediments were significantly higher than those in the biotic components (Mann-Whitney's U-test, p<0.05 or 0.01), reflecting the low bioavailability of this element from sediments. Lead concentrations in *R. maritima* roots (mean 35.7 μ g g⁻¹ dry wt) were markedly higher than those in the other plant parts (p<0.05 or 0.01). This can be explained by the comparatively high sediment metal burden; it may also suggest a high abundance of binding sites in roots and a low or no acropetal Pb translocation ([2], etc.). Leaves and rhizomes plus stems showed similar Pb signatures (10.9-11.5 μ g g⁻¹ dry wt; p>0.05). Lead concentrations in R. maritima leaves did not significantly differ to those in U. rigida (6.9 $\mu g g^{-1}$ dry wt), despite the differences in morphology and physiology. Soft tissues of the deposit-feeding bivalve A.ovata had the highest Pb contents (mean 52.7 $\mu g g^{-1}$ dry wt) among invertebrates, followed by the primarily deposit-feeding polychaete H. diversicolor and the selective deposit-feeding amphipod C. orientale (15.2-10.2 μ g g⁻¹ dry wt), the epifaunal herbivore amphipod G. aequicauda and the selective depositfeeding mudsnail *V. maritima* (5.2-3.4 μ g g⁻¹ dry wt), and finally the epibenthic shrimp *C. crangon* (0.5 μ g g⁻¹ dry wt), that feeds preying on invertebrates (p<0.05). This pattern may mainly reflect interspecific differences in rates of Pb uptake from sediments, since this metal was substantially accumulated in sediments and, being a non-essential one, is taken up by organisms in relation to its environmental levels ([3]). Lead concentrations in fish were generally lower than those within macroinvertebrates. Muscle tissues of both mullets, M. cephalus and L. aurata, showed similar Pb contents (mean 0.8-1.0 μ g g⁻¹ dry wt; p>0.05), probably owing to similar ecological characteristics. Lead contents in mullet

muscles did not significantly differ (p>0.05) to those in the whole body of the goby *K. caucasica* (1.5 μ g g⁻¹ dry wt) despite in fish muscle tissues low metal accumulation generally occurs ([4],etc.).

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GÖLMARMARA LAKE (EASTERN AEGEAN REGION): LATE HOLOCENE ENVIRONMENTAL CHANGES

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Abstract

Gölmarmara Lake's sedimentary record has been investigated by multi-disciplinary approaches, to define environmental and climatic changes during Late Holocene in Eastern Aegean Region. For this purpose two 1.5m long cores were taken from two different depocenters of the Gölmarmara Lake. Along the cores different intervals were distinguished based on lithological, sedimentological properties, type and amount of organic matter and carbon isotopic composition of organic matter. These variations were than used to reconstruct the Late Holocene evolution of the lake system.

Keywords : Organic Matter, Sedimentation, Aegean Sea.

It's known that, even unremarkable changes in climatic, hydrologic, tectonic, volcanic processes are recorded in lake sediments. Although there are a number of recent lake systems in Western Turkey, only a few of them are studied in detail, to investigate this kind of paleo-environmental and paleo-climatic changes during Holocene. One of the less studied lake systems is the Gölmarmara Lake (Manisa). Formation age of the Marmara Lake is reported as Holocene [1], but its exact age is not determined by analytical investigations, yet. It is known that a number of old lake basins, close to the study area (around Salihli-Akhisar-Izmir), existed between Neogene and late Pliocene/late Pleistocene time period. Comparison of the Gölmarmara Lake system with these old lake systems will be one of the most useful approaches not only to understand past (Cenozoic) environmental and climatic conditions, but also to define probable changes of them at recent future in Eastern Aegean Region.

To investigate paleo-climatic and environmental changes during Holocene in Eastern Aegean Region, two different depocenters of the lake were cored by hammer coring techniques. These two cores are approximately 1.5m long and one of them (H3) is taken from the western depocenter of the lake and the other (H5) is from the eastern depocenter. Preliminary analytical result of the H3 core will be presented in detail.

Interpretation of the analytical results indicated that there are two different intervals along the H3 core (Fig. 1).



Fig. 1. The type, amount and carbon isotopic composition variations of organic matter along the H3 core.

First one is 0-115cm interval, which contains relatively high amount of (TOC: 1.4%-3.7%), mixed (HI: 82-315 mg HC/ g TOC) organic matter. The second is 115-150cm interval, which is characterized by less

amount of (TOC: $\leq 0.5\%$), terrestrial (HI: 40-80 mg HC/ g TOC) organic matter. These intervals are also identified by carbon isotopic composition of organic matter and macroscopic investigations such as lithology and sedimentological properties. These variations are interpreted that the sedimentary sequence of 115-150cm is affected by oxidation processes whereas the interval above is deposited in a shallow lake environment. Furthermore variations in mineralogical composition, amount and type of organic matter will be discussed both in terms of environmental changes in the lake system and also of external effects such as climate, tectonics and hydrology.

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THE EROSIONAL RETREAT OF THE ITALIAN COASTLINE AND ITS MEASUREMENT BY GIS TECHNOLOGY

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Abstract

At the beginning of the 21st century one third of Italian beaches is subjected to erosion. The reconstruction of the historical trends of the coastline and the monitoring of actual variations is strongly facilitated by GIS technology. The adopted procedure is based on the overlay of two georeferenced time-sepatated images, the digitization of the two coastlines, the color distinction of areas subjected to shoreline retreat and advancement and the linear and areal measurement of coastal change.

Keywords : Beach, Erosion, Gis, Tyrrhenian Sea, Adriatic Sea.

Coastline erosion

From mid 20th century the stability of the Italian shoreline is increasingly deteriorating. In the literature two important surveys on Italian beaches stand out. The first, known as *De Marchi Report* [1] provides the national picture in the year 1968 with 600 km of eroding beaches. The second known as *CNR Atlas of the Italian Beaches* (1997) depicts the stretches of eroding beaches totalling ca 1000 km [2].

Shoreline erosion is caused by both natural and anthropogenic factors. Among natural factors subsidence may be very important especially in the northeast; the wave climate, affected by increasing storminess, is also important. Anthropogenic factors are frequently overwhelming, converging towards the reduction of river sediment transport to the coast.

Definitions

The measurement of the variation of the physical position of the coastline based on the comparison of dated maps of airphotos is a common practice. The measured change however says nothing of what happened between the considered time-frames; actually the rate of coastal retreat or advancement cannot be measured and may also vary as a consequence of coastal defence interventions.

The coastline is the expression of a dynamic equilibrium; its position in time indicates: *Retreat* (erosion) or *Advancement* in case of migration towards the mainland or the sea, respectively.

Lenght of the coastal stretch (km): Linear development of the coastline measured on the younger image of the couplet; the front of morphologically stable river-mouths is not measured.

Maximum retreat or advancement (m): Straight-line measurement of the distance between the two coastlines made on the transept of maximum migration.

Land surface balance (sqkm): Surface difference between the advancing and retreating portion of the considered coastal stretch. The coastal area increase or decrease is indicated by the positive and negative signs, respectively.

GIS Measurements

This research revealed that the most severe retreat of the Italian coastline is found at the tip of major deltas. This is caused by the wave exposed delta front protrusion and the concomitant reduction of river sediment flux.

The rivers and their respective drainage areas are: Arno (9.116 sqkm), Tevere (17.369), Liri-Garigliano-Volturno (11.326), Po (71.057), Adige (11.981) and Tagliamento (2.871). The analysis of airphotos of the indicated time interval using the ESRI ARC-GIS software provided the following results.

Tyrrhenian Sea - Arno delta, Tevere delta, Garigliano and Volturno delta Duration, time interval (yr) 37, 1959-96 45, 1950-96 39, 1957-96 Lenght of coastal stretch (km) 18.2 33.0 38.5 Retreating shoreline (km) 10.1 (55.5%) 13,8 (41.8%) 17.0 (44.2%) Maximum retreat (m) 273 232 712 Land surface balance (sqkm) -0.76 nc -0.63

Adriatic Sea - Po delta, Adige delta, Tagliamento delta Duration, time interval (yr) 51, 1945-96 33, 1963-96 45, 1951-96 Lenght of coastal stretch (km) 71.6 10.9 16.6 Retreating shoreline (km) 37.6 (52.5%) 5.1 (46.8%) 8.7 (52.4%) Maximum retreat (m) 1466 233 341 Land surface balance (sqkm) -7.19 nc

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LE COMPLEXE LAGUNAIRE DE NADOR (LITTORAL MÉDITERRANÉEN ORIENTAL, MAROC): FONCTIONNEMENT - CONTRÔLE NATUREL ET PROVOQUE - ÉVOLUTION

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Résumé

L'étude de toutes les composantes de l'écosystème lagunaire de Nador (masse d'eau, sédiments, microfaune) ainsi que ses domaines physiographiques et son bassin versant, complétée par les données historiques, a permis de comprendre son mode de genèse et de fonctionnement et de mettre en évidence des évolutions d'ordre spatial et temporel à une échelle saisonnière et à l'échelle du millénaire. Ces évolutions sont liées à des facteurs naturels qui peuvent être interdépendants ou agir de concert et à des facteurs anthropiques. L'analyse de l'impact des facteurs naturels a également permis de prédire sept scenarii d'évolution future de cet écosystème. *Mots clès : Lagoons, Coastal Systems, Western Mediterranean, Time Series.*

Introduction

La lagune de Nador (Fig. 1), présente un intérêt particulier, aussi bien sur le plan écologique, que sur le plan socio-économique, il était donc intéressant de connaître son fonctionnement et sa morphodynamique. Pour ce faire, une nouvelle démarche a été appliquée pour la première fois dans le cadre du projet COLASU. Elle intègre, d'une part, l'étude de toutes les composantes de l'écosystème lagunaire (masse d'eau, sédiments, microfaune) et d'autre part, celle de tous ses domaines physiographiques et de son bassin versant (dans ce volume). De plus, elle fait intervenir des disciplines et des techniques variées: étude morphostructurale, géomorphologie, étude de la qualité de l'eau, sédimentologie, écologie, télédétection et SIG, couplés à un suivi de l'état de l'environnement.



Fig. 1. Situation de la lagune de Nador.

Fonctionnement et organisation la lagune

La corrélation des milieux identifiés: milieux sédimentaire, milieux écologiques et zones hydrologiques et hydrochimiques (dans ce volume), a permis de reconstituer les zones dynamiques de la lagune, de suivre leurs répartitions spatiales pour l'actuel (hiver 2003, été 2004) et pour une période ancienne, estimée à 1000 - 1200 ans BP d'après les datations de Mahjoubi [1] et de préciser le contrôle naturel et anthropique. Cinq zones ont été ainsi reconnues pour l'actuel: la passe et ses alentours proches (zone I), la bordure interne de l'île barrière (zone II), la partie centrale de la lagune (zone III), les extrémités NW et SE (zone IV), la partie nord de la bordure continentale (zone V) et la partie sud de la bordure continentale (zone VI). L'impact saisonnier n'entraîne pas de modification dans l'organisation de la lagune, seule la bordure sud de la zone III subit un changement de son milieu écologique. Cependant, il y a 1000 à 1200 ans BP, le fonctionnement de la lagune était différent du fait de la position de sa limite continentale qui coïncidait avec la limite continentale actuelle du marais salant de Taouima et de celle de la passe qui était au niveau du double tombolo. Les zones dynamiques I, III, V, VI et II, existaient déjà , mais la zone II se limitait à la partie nord de la bordure interne de l'île barrière, la partie sud de cette bordure correspondait à une zone plus confinée (Zone IIa). De plus, à l'emplacement de la zone IV actuelle, se développait une zone où l'influence marine était plus importante (Zone IVa). Enfin, la bordure continentale sud actuelle correspondait à la marge de la partie centrale de la lagune (Zone VIa).

Contrôle naturel et anthropique et scenarii d'évolution futurs La lagune de Nador résulte de la transformation d'une baie comme le montre le MNT et l'analyse morphostructurale. Sa genèse et son évolution ont été contrôlées par la tectonique et le climat. La tectonique contrôle la morphologie du littoral et constitue le moteur : de la subsidence, des mouvements de failles entre les différentes unités de l'île barrière, qui induisent l'ouverture des passes et du tectono eustatisme. Le climat global est à l'origine des mouvements glacioeustatiques durant le Quaternaire, il détermine également le climat local qui contrôle les apports sédimentaires, l'hydrologie côtière, la géomorphologie et la morphodynamique. Il y a 1000 à 1200 ans BP, cet écosystème correspondait déjà à une lagune de type restreinte avec une île barrière étroite et rectiligne de type microtidal. Le changement enregistré dans son mode de fonctionnement depuis cette époque, est lié essentiellement à des évolutions géomorphologiques. Son fonctionnement actuel n'a pas changé depuis quelques années comme le montre les travaux précédents [2, 3 et références citées dans ce volume] et sa profondeur ne varie que durant les périodes d'ensablement de la passe, du fait de la prédominance du taux de subsidence sur celui des apports sédimentaires [1]. Cependant, son équilibre actuel est menacé par les activités anthropiques qui se sont accrues et diversifiées ces dernières décennies. L'impact de la pollution continentale affecte la qualité de l'eau ainsi que la biodiversité et la densité de la microfaune, l'aménagement de la passe engendre des problèmes d'érosion et d'engraissement du littoral et favorise l'ensablement de la lagune, enfin, le comblement artificiel de l'extrémité NW accentue les processus de confinement [4]. L'analyse de l'impact des facteurs naturels identifiés, permet également de prédire sept scenarii d'évolutions futures faisant intervenir : la tectonique (exhaussement ou affaissement de la lagune ou mouvements verticaux et /ou décrochants au niveau de l'île barrière), le volcanisme, les variations eustatiques ou leur interaction.

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INFLUENCE DES APPORTS D'EAU SUR LA VARIATION DE LA SALINITÉ DANS LA LAGUNE DE L'ICHKEUL (TUNISIE SEPTENTRIONALE)

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Résumé

Les salinités des eaux de la lagune de l'Ichkeul sont influencées par l'évaporation et par les apports d'eaux d'origine marine ou continentale. Les fluctuations des salinités ont été très importantes durant la période d'étude (1992-1996) avec des valeurs comprises entre 6,2 psu et 73,5 psu. L'augmentation des salinités peut être expliquée par les variations hydroclimatiques et par les aménagements hydrauliques. *Mots clès : Hydrology, Lagoons, Salinity.*

La lagune de l'Ichkeul était tributaire d'un grand réseau hydrographique qui l'alimentait en eau douce (figure 1). Cependant, les barrages construits sur les principaux oueds qui se déversent dans la lagune ont réduit les apports d'eau douce. Durant la période d'étude (janvier 1992-août 1996), les relevés ont intéressé le sens du courant de l'oued Tinja, noté quotidiennement à la station de Sidi Hassoun et la salinité de l'eau, relevée en moyenne tous les mois dans une station centrale de la lagune.

L'observation du courant de l'oued Tinja nous a permis de distinguer une période de courant entrant continu dans la lagune de l'Ichkeul qui reçoit des apports d'eau marine, une période de courant sortant continu de la lagune de l'Ichkeul qui déverse son surplus en eau douce dans la lagune de Bizerte et une période d'alternance. La date et la durée de ces périodes influencent les migrations des poissons euryhalins comme les muges et les anguilles (juvéniles vers la lagune et adultes vers la mer) qui se font en contre courant. Les salinités des eaux ont considérablement varié entre un minimum de 6,2 psu relevé en février 1993 et un maximum de 73,5 psu enregistré en septembre 1995 (figure 2). Les fluctuations ont été observées à l'échelle saisonnière et annuelle.



Fig. 1. Situation de la lagune de l'Ichkeul.

En effet, durant l'année 1993, les salinités ont été comprises entre 6,2 psu et 38,3 psu avec une moyenne annuelle de 19,5 psu. Pour les deux années 1994 et 1995, relativement sèches, les salinités ont fluctué respectivement entre 24,0 psu et 67,0 psu avec une moyenne annuelle de 41,2 psu pour la première année et entre 40,2 psu et 73,5 psu avec une moyenne annuelle de 54.6 psu pour la seconde. Ces valeurs élevées expliquent la disparition des herbiers à Potamogeton pectinatus, principale source de nourriture pour les oiseaux aquatiques. D'une manière générale, les salinités les plus basses sont observées à la fin de l'hiver et au printemps (février 1993 et 1994 et avril 1995). Elles augmentent ensuite progressivement pour atteindre un maximum en automne (octobre 1993, septembre 1994 et 1995). Les salinités mesurées durant la période d'étude sont nettement supérieures à celles relevées les années précédant notre travail [1, 2, 3]. Cette augmentation peut être expliquée par les variations climatiques mais également par la réduction des apports en eau douce. En effet, la mise en eau des barrages de Joumine (en 1984), de Ghezala (en 1988) et de Sejnane (en 1994) a réduit les apports par les affluents de la lagune et a entraîné par conséquent une élévation des salinités des eaux.

Le suivi régulier du sens du courant et de la salinité des eaux, bons in-

dicateurs des capacités trophiques de la lagune nous a permis d'analyser certaines variabilités surtout avant la mise en service de l'écluse. Celle-ci, construite sur l'oued Tinja, est un aménagement compensatoire destiné à régulariser et à contrôler les échanges entre le plan d'eau de l'Ichkeul et la lagune de Bizerte.



Fig. 2. Evolution saisonnière de la salinité des eaux dans la lagune de l'Ichkeul (janvier 1992-août 1996).

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IMPACT DES APPORTS EN EAU SUR LE NIVEAU DE LA LAGUNE DE L'ICHKEUL (TUNISIE)

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Résumé

La variation saisonnière des apports d'eau dans la lagune de l'Ichkeul préserve sa richesse faunistique et floristique. La pluviosité annuelle moyenne est de 609 mm. Le niveau moyen est de 0,23 m NGT avec un maximum de 0,91 m NGT. L'évolution saisonnière des précipitations et du niveau de l'eau montre une bonne concordance entre les maximums et les minimums enregistrés. Les dates d'établissement des courants continus sont tributaires du niveau de l'eau dans la lagune. Mots clès : Coastal Systems, Lagoons.

La lagune de l'Ichkeul communique indirectement avec la mer Méditerranée par l'intermédiaire de la lagune de Bizerte à laquelle elle est reliée par l'oued Tinja. Elle est alimentée en eau douce par les pluies arrosant directement le plan d'eau et les eaux drainées par son bassin versant. Pendant la saison pluvieuse, les oueds se déversent dans la lagune et entraînent l'élévation de son niveau. En période sèche, en revanche, l'absence d'apports d'eau douce et la forte évaporation engendrent un abaissement du niveau de l'eau. L'alternance saisonnière caractéristique du niveau et de la salinité préserve la diversité et la richesse de l'écosystème et maintient tout autour de la lagune un système de marais recherché par les oiseaux migrateurs. Cependant, trois barrages ont été édifiés sur les principaux affluents de l'Ichkeul et trois autres sont en cours. Ces ouvrages ont réduit les apports d'eau douce alimentant la lagune. L'écluse construite sur l'oued Tinja, est un aménagement compensatoire destiné à contrôler les échanges avec la mer.

La présente étude décrit les fluctuations saisonnières du niveau de l'eau et des précipitations durant cinq années hydrologiques (septembre 1991-août 1996). Le niveau de l'eau de la lagune de l'Ichkeul a été relevé au moins toutes les semaines à l'échelle I de Sidi Hassoun, Tinja. Le sens du courant a été noté quotidiennement sur l'oued Tinja. La quantité de précipitations fournie par l'Institut National de la Météorologie (INM) a été relevée à la station de Sidi Hassoun.

La pluviosité annuelle moyenne calculée pour la période d'étude est de 609 mm. La saison pluvieuse s'étend du mois d'octobre au mois d'avril. Les fluctuations du niveau de l'eau dans la lagune de l'Ichkeul suivent de près les variations de la pluviométrie (Figure 1).



Fig. 1. Relation entre les précipitations (en mm, données INM) et le niveau de l'eau (en m NGT : Nivellement Général du Territoire) dans la lagune de l'Ichkeul ï£; l'échelle I de Sidi Hassoun (septembre 1991-août 1996).

Le niveau moyen de la lagune est de 0,23 m NGT. La variabilité saisonnière du niveau montre que le maximum peut varier de facon importante (0,27 à 0,91 m NGT) alors que minimum est peu fluctuant (-0,04 m et 0,11 m NGT). Il existe une bonne corrélation entre la hauteur maximale et la pluviométrie durant la saison humide. La relation est nettement améliorée en utilisant la pluviométrie moyenne calculée sur l'ensemble des stations du bassin versant de la lagune. Les précipitations de l'automne (septembre, octobre et novembre) et du printemps (mars, avril-mai) donnent une idée sur l'inversion du sens du courant dans l'oued Tinja (Tableau 1). Au cours de la période d'étude, le courant s'est établi définitivement dans le sens Ichkeul-Bizerte pour un niveau compris entre 0,23 m NGT et 0,40 m NGT. Par contre, il s'est maintenu dans le sens Bizerte-Ichkeul pour un niveau variant de 0,01 m NGT à 0,14 m NGT. Ces résultats confirment les

observations antérieures [1].

Les alternances saisonnières caractéristiques risquent d'être perturbées en raison de la restriction des apports en eau douce. Une bonne gestion de l'écluse permet de maintenir le bon fonctionnement écologique de cet écosystème lagunaire.

Tab. 1. Dates d'inversion du courant de l'oued Tinja (1991-1996).

Années	Vers la lag	une de Bizerte	Vers la lagune de l'Ichkeul		
hydrologiques	Pluviométrie de l'automne	Date du début du courant continu	Pluviométrie du printemps	Date du début du courant continu	
1991-1992	195 mm Pluvieux	Début novembre	204 mm très pluvieux	3 août 92	
1992-1993	176 mm Normal	6 décembre 92	103 mm déficitaire	8 juillet 93	
1993-1994	141 mm déficitaire	11 février 94	38 mm très déficitaire	14 avril 94	
1994-1995	206 mm Pluvieux	9 janvier 95	74 mm déficitaire	3 juin 95	
1995-1996	149 mm déficitaire	4 février 96	168 mm pluvieux	Mise en service de l'écluse (avril 96)	

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A DOWNSCALING EXPERIMENT FOR THE LAGOON OF VENICE. TESTING POTENTIAL IMPACTS OF CHANGES IN PRECIPITATION TEMPORAL PATTERN ON BIOGEOCHEMICAL PROPRIETIES

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Abstract

A downscaling approach adopting a transport-biogeochemical model coupled with statistical and regional climate model data has been used to assess potential effects of nutrient loads variations, induced by climate changes, on the water quality of Venice lagoon. Results provide evidence of impact of possible regional effects of global climate change: the strengthening of seasonal dynamics - drier summer and rainier autumn - will produce a decrement of productivity of the ecosystem.

Keywords : Adriatic Sea, Lagoons, Global Change, Coastal Models, Geochemical Cycles.

Introduction - Nutrient loadings are among the most influential forcing in coastal and estuarine ecosystems. Climatic changes can induce variations of precipitation patterns and might substantially modify river runoff and nutrient loading both in terms of amount and timing thus affecting water quality of coastal ecosystems. This is one of the less studied effects of climatic changes because of difficulties in describing these cascading changes [1]. This study aims at assessing the potential impact of changes on seasonal precipitation pattern on biogeochemical proprieties in the lagoon of Venice, where spatial distributions and time variability of biogeochemical proprieties are clearly influenced by river runoff and lagoon-sea exchanges [2]. We implemented a downscaling experiment, represented in Fig. 1, which involves four components: a regional climate model providing inputs for two statistical models that gave boundary conditions for a coupled transport-biogeochemical model of the lagoon. The hierarchy of models was used to hindcast present climate and to explore two possible future scenarios.



Fig. 1. Downscaling approach used in our study. domain of the RegCM (modified from [3], upper panel), statistical models (grey circles), TDM (lower panel). The superimposed box indicates the area of interest.

Models - We use the output of a Regional Climate model, RegCM [3], extracting high-resolved meteo data for the drainage basin of the Venice lagoon (Fig. 1). RegCM provided three multidecadal data sets, relative to a present-day climate (1961-1990, RF), and two future scenarios (2071-2100, A2 and B2) [4]. Output of RF run for the area of interest was validated against several climatologies. A statistical logarithmic regression model between annual nutrient loads and observed precipitation was calibrated using historical data and was used to provided annual loads from RegCM output. A climatological annual evolution of nutrients and phytoplankton concentrations at the lagoon-sea boundaries data was modulated according to seasonal precipitation of RegCM output and a regression model based on historical data. Finally a coupled transportbiogeochemical model (TDM) [5] was used to simulate trophodynamics in the lagoon. The model state variables are inorganic nutrients, phytoplankton and zooplankton concentrations and N, C and P contents in detritus and in sediment. Transport is described in term of pure turbulent diffusion, inhomogeneous and anisotropic diffusion tensors parametrize the tidal mixing. Model boundaries are taken from the two statistical models and directly from RegCM output for meteorological conditions. The TDM model, corroborated using experimental data of 2001-2003 period, showed a good performance when simulating very different conditions of both rainy and dry years.

scenarios, A2 and B2, show both a strengthening of the seasonal dynamics, resulting in more precipitation during the rainy season (autumn) and in less precipitation during the dry season (summer) with respect to the present-day situation (RF). The impact of these variations on biogeochemical proprieties was assessed comparing the present-day TDM run RF-forced, with TDM A2 and B2-forced scenarios. The comparison is summarized in Table 1. Changes of the rain regime implied a seasonal variation of nutrient loads characterized by a mean decrease in spring and summer (more intense in A2 than in B2), and an increase in winter and autumn. As a consequence, the mean level of DIN (sum of NH4 and NOx) during winter and autumn was higher in future scenarios than in the present-day run. Such a surplus of nutrients was not utilised in the system and resulted in an increase of nutrients export to Adriatic Sea in A2 and B2 scenarios. In spring and summer the decrease of nutrient loads implied a decrease of nutrient concentrations in the system. Under A2 scenario such reduction caused a widespread decrease in the productivity of system. The number of years characterized by very dry summer increased of about 20% with respect to the RF run.In B2 scenario, the decrement of nutrient content did affect neither mean seasonal phytoplankton biomass nor primary production, but had a strong impact on secondary production, that decreased by 10% during summer (Table 1).

Tab. 1. Seasonal means of RF run (first 4 rows). The other groups of rows report the comparisons (percentage variation) between A2, B2 and RF.

		Input N	DIN	Phytopl.	Prim. Prod.	Sec. Prod.	Export
		10°kg/y	mg/l	mgC/l 10 ³ kg/y		10 ³ kg/y	10 [°] kg/y
	WIN	1304	0.558	0.290	1352	499	-988
ł	SPR	1629	0.359	0.702	4412	1295	-1119
	SUM	1290	0.172	0.924	4712	1135	-806
	AUT	1710	0.593	0.292	1507	509	-1325
	WIN	+12%	+12%	-2%	-2%	0%	+13%
N	SPR	4%	-2%	-1%	0%	+1%	+1%
٢.	SUM	-9%	-16%	-3%	-6%	-13%	-11%
	AUT	+8%	+7%	+1%	+2%	+3%	+7%
	WIN	+15%	+12%	0%	0%	+2%	+14%
20	SPR	-1%	+4%	0%	+3%	+5%	+7%
	SUM	-6%	-10%	0%	-3%	-10%	-5%
	AUT	.04/	1.20(00/	. 40/	1.01/	01(

Conclusions - Climate predictions showed a strengthening of seasonal dynamics and the decrease of summer precipitation would affect biogeochemical proprieties of the systems: and a productivity reduction of the system would be expected. Such an effect was amplified and more easily recognized in the higher trophic level of the ecosystem.

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Results - The projections of future climate simulated by the two RegCM

PLANNING OF MARINE PROTECTED AREAS: USEFUL ELEMENTS TO IDENTIFY THE MOST RELEVANT SCUBA-DIVING SITES

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Abstract

Recreational scuba diving is a relevant activity for the success of marine protected areas (MPAs). The case-study of the proposed MPA of Rdum Majjiesa and Ras ir-Raheb (NW Malta) illustrates the key-elements that should be considered in the definition of the scuba-diving attractive sites map, which is an important component for the planning of coastal MPAs. *Keywords : Coastal Management, Marine Parks, Mapping.*

Recreational scuba diving is a relevant activity for the success of marine protected areas (MPAs); it allows visitors to appreciate the effects of protection on marine biota, and can financially support MPAs [1] though it needs to guarantee a sustainable use of the marine environment. For these reasons the planning of new coastal MPAs should take into account the collection of data useful for the future management of scuba activities in the framework of the wider MPA management scheme.

The Italian Central Institute for Marine Research elaborated a zoning proposal [2] and a management plan for the marine area of Rdum Majjiesa and Ras ir-Raheb (NW Malta) (fig.1).

Tab. 1. Matrix applied to calculate intensity values

Sectors Variables	a	b	c	d	e (cave)
Benthos (aesthetic value)	3	3	3	2	3
Abundance	2	3	2	2	2
Diversity	2	3	2	2	2
Size	3	1	3	1	1
Uncommon species	2	1	2	1	1
Visibility	2	2	3	3	2
Access	1	2	1	1	2
Geomorphology	3	2	3	2	3
TOTAL	18	17	19	14	16

The activity, conducted in 2002-2004 and coordinated by the Regional Activity Center for Specially Protected Areas, involved the collection and analysis of environmental and socio-economic data, including recreational scuba diving activities. The present paper centers on the relevant aspects that were considered in the identification process of the most important recreational scuba diving sites. The study area was previously known to host some diving activities but no data was available to determine scubadiving site locations. For this reason, information collected from local experts was used in the preliminary identification and description of the interesting diving sites. The identified zones were implemented in a Geographical Information System (GIS) and reselected using bathymetry and geomorphologic spatial data (layers) derived from previous studies. The bathymetry was used to identify stretches of seafloor with scuba-diving depth ranges, while the geomorphology was used to reselect the specific seafloor typologies that are of interest for diving: screes and vertical or terraced rock walls. Each resulting sector was classified through the main environmental features (variables) which influence diving site selection as identified in previous studies [3]. The variables considered were: geomorphology, spectacular seascapes (shallows, caves etc.); benthos, highly aesthetic benthic species (i.e. Paramuricea clavata, Corallum rubrum); abundance, high specimen density (i.e. shoal of fishes); diversity, species number; size, large specimens; uncommon species, rare/relevant species; visibility, water transparency; access, simplicity in reaching the dive site. Each variable was given an intensity value (importance of the variable for each sector) on a 3 level scale: 0, none; 1, low; 2, medium; 3, high. Five sectors (a, b, c, d, e) were identified and classified (tab. 1).

Figure 1 shows the distribution of the relevant sites classified according to the main environmental features that are attractive for scuba diving.



Fig. 1. Map of the relevant sites for recreational scuba diving

The approach considers the key-elements (main environmental aspects) which determine diver preference, through a standardised evaluation of the dive site potentials. Such baseline data are necessary for the development of economic recreational activities to be conducted in compliance with the MPA aims. The rendering of this type of data, in a specific layer and through a GIS, represents a scientific approach that can support an MPA's zoning and planning process, both when scuba diving activities are already existing and need to be managed (through the construction of a layer representing actual site use) or when they are yet to be promoted and developed (through the construction of a layer illustrating the potential attractive sites). The authors are grateful to Prof. P. Schembri and Dr. K. Pirrotta for their support in data collection.

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RADIOECOLOGICAL SENSITIVITY PROJECT ON THE FRENCH MEDITERRANEAN COASTAL ENVIRONMENT

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Abstract

The radioecological sensitivity of Mediterranean French coasts is evaluated in order to propose a forecasting system usable as decision support in case of accidental nuclear release in the marine environment. Radioecological sensitivity is defined as the result of the combination of physical, biological, socio-economical and radioecological parameters (related to radionuclide specificities). A resulting sensitivity index is then attributed for a given zone.

Keywords : Coastal Management, Radionuclides.

Introduction

The impact of an hypothetical marine radioactive pollution on man and his environment depends on the extent and type of pollution, but also on the polluted environment itself. The economical, toxicological or health repercussions will vary according to the characteristics of the polluted environment and its human use. The marine stage of the Radioecological Sensitivity project (SENSIB project), brought by the French Institute for Radioprotection and Nuclear Safety with funding of the French Agency Environment and Energy Management [1], aims to create standardized tools which make it possible to represent and to compare with the same scale the sensitivity of various coastal environments. This concept will be first dedicated to the French Mediterranean coasts.

Method

The marine radioecological sensitivity is defined as the sensitivity of a coastal environment subject to a radioactive contamination. Sensibility refers to the capacity of a given environment to exhibit significant changes concerning various possible indicators: activity concentration, radionuclide stock or flux. This sensitivity is determined by the relationship between the ecosystem intrinsic characteristics (physical or biological), the radioecological parameters (dependant of the concerned radionuclide) and the socio-economical resources.

These three natures of criteria produce several sensitivity factors, which are studied in the project. The ecosystem characteristics concern geomorphic data, sedimentary type, biological resources and eventually the presence of rare species. The radioecological parameters include dilution coefficient, concentration factors expressing the transfer to biological species, partitioning coefficients (Kd), sedimentary migration rate. The socio-economical criteria refer to professional or recreational activities (fisheries, beaches), resource extraction locations (water intake, aquaculture, etc.) and management areas like ecological reserves.

Values are attributed to these factors regarding their efficiency to increase or decrease the final sensibility indicator. The attributed values can be binary (0/1) or entire values comprised between 0 and 10. Their combination results in a sensitivity index, comparable to the ESI (Environmental Sensitivity Index) previously developed in the United States [2]. This indexation requires the attribution of a weight relative to each factor as regards to the others. This weighting depends both on involved radionuclide and on sensitivity chosen indicator. It is evaluated by sensitivity analysis and by expert judgement.

Hence, environmental sensitivity will be calculated by adding the value of each factor weighted by its contribution. The higher is the number, the more sensitive is the environment.

Finally, resulting sensitivity maps are set up using a management subsystem based on geographical information system (GIS). Similar kind of results, i.e. environmental sensitivity mapping, are often used to characterize oil-spill coastal impact [3] and for coastal integrated management [4] [5] [6]. Such maps allow comparisons of environments as regards their sensitivity. The working scale (country, local...) is important as it determines the level of knowledge that is required when assessing ecosystem and human-use data.

Conclusion

In post-accidental situation, the coupling of sensitivity maps with risk maps (based on radionuclides source term knowledge and marine dispersion modelling) might give localisation of vulnerable coastal areas (Figure 1).

A first application of the radioecological marine sensitivity concept will be carried out on Toulon bay area. This area has already been partially studied from ecological, economical and radioecological points of view. Local sediments have been partially characterized [7]. This area is biologically rich with important beds of *Posidonia oceanica*, shellfish fields, spawning grounds, and different protected areas. Human-uses and economic pressure are also important: fishery, aquaculture and tourism especially. These data are still to be completed and updated, and will be used to characterize and evaluate the global radioecological sensitivity of this area.



Fig. 1. The vulnerability assessment process [4]

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AN INTERACTIVE DECISION SUPPORT SYSTEM FOR MANAGEMENT OF THE NILE DELTA SHORELINE OF EGYPT

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Abstract

The Egyptian Mediterranean Coasts in the south of Levantine basin is suffering from coastal erosion and accretion. Inspite of availability of data and information after measurements and models applications, its management still not advanced. This paper presents an effort done for using GIS application as a tool for making information available to decision makers. Data used are taken by field mesurements, Remote sensing and model applications to estimate the variables affecting shore processes, waves and currents. Keywords : Coastal Management, Gis.

Remote sensing and linked database-geographic information system (GIS) have been combined to build an interactive decision support system to better manage the Nile delta coast of Egypt, 140 km long. This computerbased system is designed to support decision makers and planners to deal with beach protection, human infringements, dune, mining, water pollution, over fishing, beach restoration, archeological sites, set-back line, sedimentation in estuarine, lagoon inlet and navigation channels of the delta harbors. Acting in parallel with these issues are possible consequences and proposed adaptation of relative sea-level rise in the non-protected low-lying coastal areas.

The designed DSS is computer-based system for storing, manipulating, analyzing and displaying spatial and non-spatial coastal data at individual coastal stretch. It enables one to compare a large number of maps employing carefully geo-referenced data. Data collected in this system are essentially based on historic data-base comes from the Coastal Research Institute of Egypt and spanned the last two decades in addition to modeling results obtained in the present study [1-6]. This system enables users to automatically update and revise stored data. The designed system is build using visual basic language and consists of four subsystems:

(1) Collection of data and information such as beach profile surveys, grain size distribution of beach and seabed sediment, water circulation, bathymetry, coastal structures, measurements of wave, hydrographic conditions (Salinity, Temperature, Turbidity and pH), wind, current, and tide. Spatial maps obtained from satellite images and topographic charts are incorporated. This subsystem provides the user interface, operation modules, and the view subsystems with data and set of procedures to complete their functions.

(2) The mathematical operations subsystems are a set of procedures (modules), these modules applied on the system of data collection to obtain the results, which can be displayed through the view subsystem. These operations enable a user to calculate sediment volume change trends, sediment budget and rate of shoreline changes for a particular beach. Further, statistical analysis can be manipulated for waves, current, tide and other related parameters such as wave energy, beach slope, breaker heights on beaches, beach face slope, morphodynamic classification of beaches, and swash runup elevations on beaches induced by storm waves, depth of closure and sediment transport rates.

(3) User interface tool manages interactions between the three linked subsystems. The user interface subsystem has the windows manager, which contains all possibilities and operations to help the user to get the information or results.

(4) The system provides an environment, view subsystem, for displaying geographic reference layers such as illustrations, maps as well as tabulated data. A view is simply a user visible representation of the results and information (database).

The system provide the following assistances to decision-makers and planners:

1- Basic facilities for the manipulation, analysis, retrieval, distribution and storage of coastal related information as well as additional remotely sensed or other thematic information;

2- Technical assistance to outline shoreline management plans;

3-Design data to numerical models required to design protective projects;

4- Baseline data for any future EIA studies;

5- Temporal and spatial information on coastal changes, which will meet the immediate needs of authorities and other user groups; and Mapping positions of set-back distance along the delta coastline.

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HOLOCENE SANDY BARRIER EVOLUTION AS INDICATED THROUGH LAGOONAL SEDIMENTARY INFILL. THE EXAMPLE OF THE THAU LAGOON-AND-BARRIER SYSTEM (WESTERN GULF OF LIONS, MEDITERRANEAN SEA, FRANCE)

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Abstract

As soon as a littoral barrier begins to construct, isolating progressively a lagoon, the sedimentary infill of the later can start and be potentially preserved. The different stages of a barrier construction and evolution can be thus analyzed by studying the sedimentary record preserved into the lagoon. Such a study has been performed, using very high resolution seismic data and sediment cores, into the Thau lagoon (SE France) that forms during the Holocene transgression. Two main sedimentary units above the rocky basement have been defined into the infilling. U1 corresponds probably to remnants of pre-Holocene continental facies, U2, which constitutes the main part of the infill, represents the Holocene infill. The detailed analysis of U2 allows to reconstruct the palaeogeographic evolution of the lagoon-barrier system during the last stages of the Holocene transgression. *Keywords : Lagoons, Seismics, Gulf Of Lions.*

The Mediterranean coastline is characterized by numerous lagoons that are separated and protected from the sea by sandy barriers (also called lides) resulting from a process of above regularization by usage [1]. These

lidos) resulting from a process of shore regularization by waves [1]. These lagoon/lido systems have been formed during the Holocene transgression and more precisely during the late Holocene period when sea-level rise slow down. Since they are protected from high energy open marine hydrodynamics, the lagoons are the most favorable areas to preserve into their sedimentary infilling, the different stages of construction of the beach barrier and adjacent shoreface that are usually subject to heavy wave reworking.

The Thau lagoon is one of these Mediterranean lagoons. It is located along the shore of the western Gulf of Lions (Languedoc-Roussillon, France) and belongs to a lagoon system that develops from the Rhone delta to the Spanish border. It is the largest and deepest lagoon. In order to study the sedimentary infill of the Thau lagoon, a very high resolution seismic survey has been performed. In addition, some cores have been collected for lithology analysis and ^{14}C dating.

Three main seismic units have been recognized, U0 representing the rocky substratum, U1 and U2 forming together the sedimentary infill of the lagoon [2] (Figure). U0 is represented by tilted, locally folded, reflectors interpreted as Pliocene to Miocene formations. The upper limit of U0 is an erosional surface corresponding to the bottom of the lagoon basin. The basal unit of the infill, U1, is acoustically transparent, locally chaotic, and rests discordantly on U0. Its thickness is variable, from 0 to about 6 m. It is mainly developed where the substratum is the deepest and tends to shape the erosional top surface of U0. U1 has not been reached by coring and its origin is uncertain. It probably corresponds to the very early stage of the lagoon infill, either of continental or marine origin. U2 constitutes the main unit of the sedimentary infill and reaches locally about 15 m in thickness. It rests discordantly on U0, and concordantly on U1. Its upper surface is the lagoon sediment bottom. U2 displays a general aggrading configuration and consists in an alternation of high amplitude and continuous parallel reflectors, and low amplitude, poorly continuous reflectors. U2 can be divided in two sub-units, SU2-1 and SU2-2. SU2-2 is generally concordant on SU2-1, especially where U2 is the thicker, toward the center of the lagoon. On topographic highs of the basement, SU2-2 rests discordantly on SU2-1. A marked unconformity between the 2 sub-units is also observed on the seaward edge of the lagoon, i.e. on the landward face of the present-day lido (Figure). This unconformity is assumed to indicate a probably important landward shift of the barrier.

Thus, as recorded by the lagoon infill through the seismic data, two main stages of construction of the littoral barrier seem to have occurred, a significant retrogradational event having arised between stage 1 (SU2-1) and stage 2 (SU2-2). During each of the stages, seismic facies evidences alternations of period of respectively low energy (high amplitude continuous reflectors) and high energy (low amplitude discontinuous reflectors) deposition that could be related to more or less protected configuration of the lagoon, and thus to the barrier state of stability. Cores collected in SU2-2 are composed of successive sequences consisting of thick shelly layer passing upward to organic rich clayey layer. The process that could explain this sediment alternation is not fully understood but is probably due to change in biological productivity and thus could be related to climate fluctuation. However the link between such changes in sedimentation,

seismic facies, and barrier dynamic cannot be clearly established at the present state of the study.





In terms of chronology, ¹⁴C AMS analyses are in course. However, we assume that the beginning of the lagoonal infill, coeval with the initiation of barrier construction has occurred when sea-level lowed down, and reached almost its present-day level, i.e. around 6.000 B.P. We assume as well that the barrier retrogradational event recorded into the lagoon infill between SU2-1 and SU2-2 could be dated around 2000 B.P. Indeed, previous studies have demonstrated that the regional coastline has severely retreated since Classical times as a result of a drastic decrease in sediment supply [3]. In that hypothesis, the successive sequences preserved into the lagoon infill could represent the record of millennial to multicentennial time-scale climatic cycles that would have controlled sediment supply and the barrier morphodynamic.

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SUBMARINE GROUNDWATER DISCHARGE IN A MINORCA KARSTIC COVE USING RA ISOTOPES AND ²²²RN

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Abstract

Excesses of radium and ²²²Rn have been found in cove waters of a karstic area in Minorca (Balearic Islands) pointing out the existence of submarine groundwater discharge. Visible springs actually supply enriched groundwater while sediment does not seem to contribute to the Ra balance. The SGD flux has been estimated to be around 5 cm/d by applying a two endmember mixing model. *Keywords : Coastal Waters, Radionuclides, Geochemistry, Western Mediterranean, Coastal Management.*

Minorca (Balearic Islands), as most of the Mediterranean islands, has limited water reserves that are intensively exploited for the demographic pressure. Minorca is divided in two geological settings: an impermeable area in the north and a permeable band constituting the most important aquifer in the south. This area is characterized by an inclined plain towards the sea, crossed by deep precipices that end into small and narrow coves. This aquifer is composed of miocenic materials highly degraded by erosion and karstification processes. The aquifer supplies up to 90% of the extracted water and from the hydrological balance the submarine groundwater discharge (SGD) is estimated to be up to 38 hm³/yr [1]. This may stand for an input of nutrients to the sea that, in certain circumstances, can induce the proliferation of algae. The present study has been carried out in the Alcalfar cove with an extension of 1.74 Ha.

The Ra quartet (223,224,226,228 Ra) has been proposed as a useful tool to estimate SGD in several environments [2; 3; 4]. The strategy for using Ra isotopes in SGD studies is based on the fact that Ra is greatly enriched in groundwater relative to coastal waters (1-2 orders of magnitude) [5]. It is largely particle-bound in fresh water but desorbs from particles in contact with salty water, so adopting a conservative behavior once released in sea water. In order to determine the SGD, a total of 36 samples were collected from seawater, submarine springs, wells and drive points. The short-lived isotopes, 223 Ra and 224 Ra, where measured with alpha delayed coincidence counting [6], while concentrations of 226 Ra and 228 Ra were determined by gamma spectrometry. In order to complete the series of data, 222 Rn was measured in some samples using a commercial RAD 7 detector.

Groundwater discharges from several visible points along the cove and forms a several mm film above surficial seawater. Concentrations of Ra isotopes in spring samples showed an enrichment in comparison with seawater samples (two orders of maginitud for the ²²⁴Ra). The radiumactivities in cove surficial waters versus salinity pointed out a Ra dilution process taking place when mixing with seawater. On the other hand, cove water samples collected at 10 cm above the sediment presented salinities comparable to the open sea stations and ²²²Rn at bottom waters showed lower concentrations, indicating no detectable groundwater is flowing out through the sediment and thus supporting the idea of the submarine karstic springs as the sole groundwater inputs. A two endmember mixing model between spring and open sea waters has been built to estimate the groundwater fraction in cove waters. An average groundwater fraction of about 30% is obtained when using the radium isotopes distribution. This is translated in an approximate SGD flux of 5 cm/d when considering the width of the cove water's fresh layer and the residence time of the water as obtained from the short-lived Ra isotopes distribution.

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SURFACE ACTIVE SUBSTANCES AND NUTRIENTS IN THE NORTHERN ADRIATIC SEA

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Abstract

Spatial distribution and seasonal variability of surface active substances (SAS) and nutrients were studied and correlated for the Northern Adriatic Sea in the period from February 2001 to October 2002.

Keywords : Adriatic Sea, Organic Matter, Po Delta, Surfactants, Eutrophication.

Dissolved organic matter in the sea is an important pool of carbon in the global carbon cycling [1]. Alarge fraction of OM has surface-active properties [2]. The Northern Adriatic Sea is the most productive region in the Mediterranean Sea. The most important source of the nutrients in the region is the Po River and the winter overturn of regenerated nutrients from the bottom layer [3]. As the SAS in the Northern Adriatic are highly dependent on the phytoplankton community production [4]. In this work we aimed to correlate SAS concentration with different nutrients. SAS were determined by phase-sensitive alternating current voltammetry by in-phase measurements using o-nitrophenol as an electrochemical probe [5]. Nutrients (nitrate-NO3, nitrite-NO2, ammonium-NH4, orthophosphate-PO4 and orthosilicate -SiO4) were analyzed by widely used oceanographic methods. Concentration of SAS was correlated separately with the concentrations of different nutrients. The analysis was performed for the two stations 101 and 107 that were representative for the marine system that is under the direct influence of the Po River discharge, and oppositely the system that is rarely influenced by Po River waters, respectively, at water column lavers; 0.5, 5, 10, 20, 30 m and bottom. Temporal distributions of SAS for bottom and surface water for two Stations 107 and 101 are presentedin the Fig. 1.



Fig. 1. The variations of SAS for the eastern Station 107 and western Station 101.

The concentration of SAS of the region varied from 0.042 to 0.145 mg/dm⁻³ equiv. T-X-100. The lower values were observed in February for all water column. The highest SAS values were recorded in surface layer during warm period of the years. In Fig. 2 are presented average concentrations of nutrients for the presented stations and investigated period. Nutrients concentrations were the most variable in low salinity surface water. Bottom layer experienced relatively higher values of all nutrients. Lower values of all nutrients concentrations in the water column were observed at Station 107 as compared to Station 101. Correlation between SAS and certain nutrient concentrations revealed that only statistically relevant correlation was found between SAS and nitrites at Station 107 and depths 0.5 to 20 m (R = -0.51, -0.65, -0.57 and -0.68). Found correlation is negative that might be expected as SAS pool is mainly increasing from nutrients pool. Although statistically irrelevant it is worth mentioning that correlation of SAS with orthophosphate and orthosilicate was mainly found to be negative. Low correlation might be explained with few facts. Northern Adriatic is oligo- to eutrophic region, especially on the westernpart, represented by Station 101. Therefore, phytoplankton was not limited by the nutrients. Also, phytoplankton activity is dynamic and dependant on many factors.



Fig. 2. Average nutrient concentrations for for the eastern Station 107 and western Station 101.

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GEOARCHEOLOGIE DU PORT ANTIQUE DE ROME : PREMIERS RESULTATS PALEOENVIRONNEMENTAUX

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Résumé

Au I^{er} siècle ap. J.C. l'empereur Claude construit un port pour Rome sur le littoral du delta du Tibre. Au II^e siècle ap. J.C. Trajan complète le dispositif en construisant son port hexagonal. Une étude géoarchéologique par carottages a été effectuée sur ce site. Les premiers résultats permettent de progresser dans deux directions : 1. La configuration préportuaire : il apparaît que Claude et par la suite Trajan ont tiré parti de la paléo-embouchure du Tibre pour bâtir leurs bassins. 2. Le fonctionnement du port lui-même : le port de Claude était muni d'une double entrée, générant un courant dans le bassin afin de limiter l'ensablement. *Mots clès : Coastal Engineering, Deltas, Geomorphology, Stratigraphy, Western Mediterranean.*

La ville d'Ostie est fondée au milieu du IV^e siècle av. J.C. à l'embouchure du Tibre afin de servir d'avant port à la ville de Rome. Mais ce port fluvial se révèle rapidement peu fonctionnel en raison des forts courants et de la mobilité des bancs sableux d'embouchure, ne permettant pas d'approvisionner suffisamment Rome en blé [1]. Le port de Pouzzoles, près de Naples, redevient alors le principal port nourricier [2].

Au I^{er} siècle ap. J.C. l'empereur Claude fait construire un véritable port pour Rome sur le littoral du delta du Tibre à 3 km au nord d'Ostie. Au II^e siècle ap. J.C. Trajan complète le dispositif en construisant son port fermé hexagonal.

Quelles raisons ont poussé ces 2 empereurs à construire successivement ces deux ports ? Quels étaient le cours du Tibre et la configuration du rivage dans l'Antiquité ? Par où se faisait l'entrée des navires dans le port de Claude ? Sur quelles bases les moles ont-ils été construits ? Quel était le niveau marin, quelle était la profondeur dans le port et quels types de navires pouvaient y accoster ?

Telles sont les questions auxquelles la communauté scientifique essaye de répondre par l'étude des textes et les fouilles archéologiques ponctuelles depuis la Renaissance.

En raison de l'ampleur du périmètre archéologique, de l'omniprésence de la nappe phréatique, de la rapide progradation du delta qui a entrainé l'enfouissement des structures portuaires sous les sédiments [3] et de la construction de l'aéroport sur le site, la méthode d'analyse stratigraphique par carottages nous a paru particulièrement indiquée.

1) L'étude stratigraphique montre 3 séquences sédimentaires distinctes : fluviale, marine et portuaire. La base de l'unité se compose de sédiments fluviaux du Tibre. La transition fluvio-marine brutale, positionnée à -8 m, est datée de 3100 BP. La présence de sédiments marins si récents (IX^e siècle av. J.C) et si profonds implique une défluviation du Tibre et un envahissement de son embouchure par la mer. L'unité sus-jacente est typique d'un environnement portuaire vaseux.

Autrement dit, sous le port antique se trouve la trace de l'ancienne embouchure du Tibre qui se jetait alors en mer selon une orientation est-ouest, beaucoup plus rectiligne qu'aujourd'hui. Au IX^e siècle av. J.C. le fleuve a connu une défluviation qui lui a fait prendre une direction sud avant de reprendre la direction ouest pour déboucher dans la mer, là où sera fondée 5 siècles plus tard la cité d'Ostie sur la rive gauche du méandre [4]. Ces résultats permettent d'affirmer que Claude et surtout Trajan ont utilisé l'ancienne embouchure du Tibre pour faciliter l'implantation de leurs bassins portuaires.

2) Quant à la position géographique de l'entrée des navires dans le port de Claude, la première hypothèse, émise dès le XVI^e siècle, implique une ouverture plein ouest encadrée par deux moles enveloppants construits en partie en domaine offshore [2]. La seconde hypothèse, proposée au XX^e siècle, se base sur la présence, à l'ouest, d'un long cordon sableux formé par les sédiments du Tibre. Cet obstacle naturel contraint une configuration portuaire avec une ouverture au nord [5].

Les principaux carottages ont été réalisés le long du mole nord de Claude. Dans son secteur ouest, la stratigraphie indique non pas un cordon dunaire sur lequel serait venu s'appuyer le mole, mais au contraire, des sédiments marins sur 9 mètres d'épaisseur. Le mole a donc été construit en domaine offshore. Une carotte réalisée dans le mole montre que ses fondations, composées d'éléments grossiers et de pouzzolane, descendent jusqu'a -7 m de profondeur et reposent sur les sédiments marins. Une telle assise amène à reconsidérer la façon dont les ingénieurs ont conçu le port de Claude et de façon plus générale les ports à cette époque.

A l'opposé, les carottages réalisés dans le secteur est du mole montrent

une accumulation de 1.5 m de sédiments marins. La base de ces sédiments a été datée du II^e siècle ap. J.C. Il y avait bien une communication avec le domaine marin mais de faible profondeur. Il s'agissait probablement d'une entrée secondaire, plus tardive, destinée aux navires de faible tirant d'eau. Le port de Claude était donc muni d'une double entrée et les deux hypothèses de départ n'étaient donc pas antinomiques. Cette double entrée devait générer un courant dans le bassin afin de limiter l'ensablement.

Ces premiers résultats géoarchéologiques permettent de faire progresser nos connaissances sur l'histoire des ports et indirectement celle de la navigation antique.



Fig. 1. Configuration du Portus d'après les nouvelles analyses sédimentaires.

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CONTRÔLE ET ÉVOLUTION DES MILIEUX DE SÉDIMENTATION DE LA LAGUNE DE NADOR (LITTORAL MÉDITERRANÉEN ORIENTAL, MAROC)

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Résumé

L'étude sédimentologique des dépôts intra lagunaires et extra lagunaires (embouchures des oueds) prélevés dans la lagune de Nador (littoral méditerranéen oriental, Maroc) au cours de trois campagnes d'échantillonnage (hiver 2003, été 2004 et hiver 2005), a permis d'identifier les milieux de sédimentation et de suivre leur évolution spatiale pour la période actuelle (Hiver 2003, été 2004 et hiver 2005) et pour une période ancienne estimée à 1000 à 1200 ans BP. Elle a également permis de préciser les sources d'apport, les processus de transport et les facteurs (climat, contexte géologique de l'arrière pays, morphologie et taille de lagune, position de la passe et activités anthropiques), qui contrôlent les faciès ainsi que la répartition et l'évolution des milieux de sédimentation. *Mots clès : Lagoons, Coastal Systems, Western Mediterranean, Sedimentation.*

Introduction

La lagune de Nador (Fig. 1) a fait l'objet d'un certain nombre d'études sédimentologiques [1-5], cependant, dans le cadre du projet COLASU, il était nécessaire disposer de données sédimentologiques récentes et contemporaines de celles de la masse d'eau et de la microfaune (dans ce volume). Ce travail a porté sur l'analyse stratonomique, l'étude granulométrique, la calcimétrie et l'étude minéralogique aux RX (roche totale et minéraux argileux) de 146 carottes (20 à 50 cm) et 146 échantillons de sédiments superficiels prélevés dans les dépôts intra lagunaires et extra lagunaires (embouchures des oueds) lors de trois campagnes d'échantillonnage (hiver 2003, été 2004, hiver 2005).



Fig. 1. Situation de la lagune de Nador.

Les milieux de sédimentation: caractérisation, évolution et contrôle La reconstitution des faciès sédimentaires a permis d'identifier les milieux de sédimentation et de suivre leur évolution spatiale pour la période

actuelle (sommet des carottes de l'hiver 2003, l'été 2004 et l'hiver 2005) et pour une période ancienne 1000 à 1200 ans BP (base des carottes de l'Hiver 2003), estimée d'après les datations effectuées par Mahjoubi [4]. Cinq milieux de sédimentation ont été ainsi reconnus pour la période actuelle.

- La bordure interne de l'île barrière (milieu sédimentaire SI), caractérisée par des sables moyens bien classés et une fraction importante de rudites (galets et fragments de bioclastes), des teneurs élevées en carbonates (26.,5 à 53 %) et l'abondance de feldspaths, de quartz et de minéraux argileux où domine l'illite.

- La partie centrale de la lagune (milieu sédimentaire SII) caractérisée par des sables moyens moyennement à bien classés, des teneurs moyennes en carbonates (26%) et la dominance des feldspaths, de l'illite et de l'aragonite (parmi les minéraux accessoires).

- La bordure continentale (milieu sédimentaire SIII) caractérisée par une prédominance des lutites et des sables mal classés, ainsi que par de faibles teneurs en carbonates (5.3 à 26.5 %) et une prédominance du quartz, de l'illite et de la kaolinite.

- Les extrémités NW et SE de la lagune (milieu sédimentaire SIV), caractérisées par : la prédominance des lutites mais également par l'abondance des rudites au niveau de l'Attalayun, des sables mal à moyennement classés, de faibles teneurs en carbonates (sauf dans la bordure marine), l'abondance de quartz et de minéraux argileux et la présence de minéraux accessoires: gypse, halite, aragonite, hématite et pyrite.

- Les embouchures des oueds (milieu sédimentaire SV) caractérisées par des graviers et des sables mal classés, de faibles teneurs en carbonates (5 à 15 %), la prédominance du quartz et des feldspaths, ainsi que la présence de dolomite, d'hématite, d'illite et de kaolinite.

La comparaison saisonnière a montré que en dehors d'une élévation importante de la quantité des lutites au niveau de la bordure continentale (SIII) pendant l'été, les autres milieux ne montrent aucune évolution significative entre la saison d'hiver et la saison d'été. Cependant, la comparaison des milieux sédimentaires actuels avec ceux de la période ancienne, a mis en évidence l'existence d'une influence marine dans l'extrémité NW (SIV à Ben Ensar) et le Nord de la partie centrale (SII) ainsi que des conditions de confinement au niveau de l'extrémité SE (SIV à Kariat Arekmane), il y a 1000 à 1200 ans BP. Cette évolution confirme les résultats de l'étude écologique (dans ce volume) qui ont montré que la passe était située à cette époque à l'emplacement du double tombolo.

La composition des sédiments reflète une alimentation par des processus de transport variés (écoulements à travers la passe, vagues de tempêtes, émissaires à écoulements torrentiels, ruissellements, vents et écoulements gravitaires) et à partir de sources intra bassin (faune lagunaire, minerais d'épigenèse) et de sources extra bassin (sédiments marins et produits de l'érosion des formations géologiques et des sols du bassin versant, de la bordure continentale et de l'île barrière). Par ailleurs, les faciès ainsi que la répartition et l'évolution des milieux sédimentaires, traduisent un contrôle par le climat, le contexte géologique de l'arrière pays, la morphologie et la taille de lagune, la position de la passe et enfin les activités anthropiques qui accentuent le confinement des extrémités NE et SW.

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CIRCULATION SAISONNIÈRE DE LA LAGUNE DE NADOR (MAROC)

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Résumé

La circulation saisonnière de la lagune de Nador, située en mer Méditerranée marocaine, a été appréhendée à l'aide du modèle hydrodynamique MIKE3-HD. La lagune est classifiée comme étant une lagune de type étouffé et sa circulation est principalement régie par les vents dominants qui sont, sur la période 1991-2001, de secteurs W, NE et ENE. La circulation moyenne de surface de la lagune est présentée ainsi à partir de ces différents champs de vents.

Mots clès : Alboran Sea, Coastal Processes, Lagoons, Coastal Models.

Introduction

La lagune de Nador, située sur la façade méditerranéenne marocaine entre le Cap des Trois Fourches et le Cap de l'Eau, présente un grand intérêt socio-économique pour la région où s'exercent différents types d'activités, notamment celles liées à la pêche artisanale. Cette lagune a fait l'objet de diverses études visant la compréhension du fonctionnement de son écosystème [1-3] mais celles relatives à son hydrodynamisme sont très peu nombreuses [4-6]. L'objectif de cette étude est de présenter la circulation saisonnière de la lagune élaborée par modèle numérique.

Matériel et méthodes

La circulation tridimensionnelle des eaux de la lagune de Nador a été étudiée à l'aide du modèle hydrodynamique MIKE3-HD, calibré et validé sur la période d'automne 2001 [4, 6]. Les vents utilisés dans cette étude pour le forçage du modèle, sont des vents moyens journaliers observés sur la période 1991-2001 [7]; la circulation saisonnière de la lagune est ainsi appréhendée à partir de ces différents champs de vent.

Résultats

La lagune est classifiée comme étant une lagune de type étouffé [4, 6] et sa circulation est principalement régie par les vents [4-6]. Les vents moyens observés sur la période 1991-2001 sont dominants de secteur W durant les mois de novembre, décembre et janvier, et leurs intensités moyennes varient entre 3.8 à 4.4 m.s⁻¹. Ils sont de secteur NE durant les mois de mars, septembre et octobre, avec des intensités moyennes variant entre 4.6 à 5.3 m.s⁻¹. Les vents les plus intenses sont de secteur ENE d'intensités moyennes variant entre 4.6 à 6.2 m.s⁻¹ et dominent pratiquement en février et entre avril à août [6]. Compte tenu de ces différentes configurations des champs de vent, la circulation moyenne de surface de la lagune de Nador va présenter quelques similarités durant les saisons étudiées.

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ÉVOLUTION DE LA QUALITÉ DES EAUX DE LA LAGUNE DE NADOR (LITTORAL MÉDITERRANÉEN **ORIENTAL, MAROC) DURANT LA PÉRIODE 2003-2005**

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Résumé

L'étude de la qualité des eaux de la lagune de Nador (littoral méditerranéen oriental, Maroc) a porté sur l'évaluation et le suivi des paramètres physico chimiques, des éléments nutritifs et de la matière en suspension des eaux lagunaires (de surface et du fond) et extra lagunaires (émissaires de la bordure continentale), pour les périodes : hiver 2003, été 2003, été 2004 et hiver 2005. Elle a permis de distinguer quatre zones hydrologiques et hydrochimiques dans la lagune, de connaître l'évolution spatio-temporelle des paramètres étudiés et enfin de mettre en évidence une importante dégradation de la qualité de l'eau dans les extrémités NE et SW et la bordure continentale de la lagune qui est engendrée par les activités anthropiques.

Mots clès : Lagoons, Hydrology, Western Mediterranean, Coastal Systems.

Introduction

La lagune de Nador (Fig. 1) a fait l'objet de plusieurs suivis concernant l'hydrologie et l'hydrochimie [1-5], du fait de son intérêt pour l'aquaculture et la pêche. Cependant, il était nécessaire de disposer de données récentes sur la qualité des eaux dans le cadre du projet COLASU. Pour ce faire, un suivi des paramètres physico chimiques, des éléments nutritifs et de la matière en suspension des eaux lagunaires (de surface et du fond) et extra lagunaires (émissaires de la bordure continentale), a été réalisé durant les périodes : hiver 2003, été 2003, été 2004 et hiver 2005, en collaboration avec l'Institut National de Recherches Halieutiques. Les résultats obtenus ont permis de distinguer quatre zones hydrologiques et hydrochimiques dans la lagune et de connaître l'évolution de la qualité de l'eau.



Fig. 1. Les zones hydrologiques et hydrochimiques de la lagune de Nador.

Les zones hydrologiques et hydrochimiques de la lagune

- La zone 1 correspond aux extrémités Nord Ouest (Beni Enzar) et Sud Est (Kariat Arekmane) de la lagune, elle se caractérise par des valeurs de pH élevées et de fortes concentrations en éléments nutritifs qui sont en relation avec un confinement important et la pression anthropique.

- La zone 2 correspond ï£; la passe, elle se caractérise par des paramètres physico chimiques proches de ceux de la mer Méditerranée, des concentrations faibles en éléments nutritifs et un hydrodynamisme énergétique. Elle est contrôlée essentiellement par les facteurs naturels.

- La zone 3 correspond ï£; la partie centrale de la lagune, elle se caractérise par les valeurs les plus faibles de pH (6,8 ï£; 7,92), des concentrations faibles en éléments nutritifs et une faible circulation. Elle est contrôlée par les facteurs naturels.

- - La zone 4 correspond ï£; la bordure continentale entre Nador et oued El Bachir, elle se caractérise par un pH généralement très basique, des teneurs élevées en éléments nutritifs et une turbulence liée aux décharges fluviatiles. Elle est sous l'influence continentale et la pression anthropique.

Evolution de la qualité de l'eau

Les résultats indiquent une importante dégradation de la qualité de l'eau, en particulier dans les extrémités NE et SW ainsi que la bordure continentale durant la période d'étude et par rapport aux données des études antérieures réalisées durant une période où la passe dont la largeur ne dépassait pas 100m, était le siège d'un ensablement. Cette évolution est d'autant plus inquiétante que actuellement, la largeur de la passe (300m), permet une alimentation en eaux marines plus importante.

- Les valeurs du pH varient de (6 - 8) en hiver ï£; (7 - 10) en été et au niveau de Kariat Arekmane, les mesures indiquent une augmentation considérable entre 2003 et 2005, avec un maximum de 9,21 durant l'été 2004 et une alcalinisation importante par rapport aux données des études antérieures, en particulier dans les zones soumises ï£; un stress anthropique très important.

- Les mesures de l'oxygène dissous varient de 6.3 ï£; 8.73 mg/l avec des valeurs maximum au niveau de la passe et du canal d'irrigation. Elles indiquent une diminution par rapport aux données antérieures qui traduit un confinement général.

- Les concentrations en éléments nutritifs montrent une diminution durant la période d'étude de : 0.004 ï£; 0.1 µmol/l pour l'ammoniac, 37 μ mol/ pour les nitrites, 0.1 ï£; 12.3 μ mol pour les nitrates et 0.2 ï£; 8.44 μ mol pour le phosphore qui pourrait être expliquée par une consommation excessive par le phytoplancton. Mais, elles ont augmenté de manière significative par rapport aux données antérieures du fait de l'impact de l'aquaculture.

Les résultats ont également mis en évidence :

- une augmentation de la matière en suspension, en particulier durant l'été 2004 où elle atteint des valeurs de 0,38 ï£; 0,52 mg/l, en relation avec l'augmentation des rejets urbains, le sapement de la bordure continentale et le développement excessif du phytoplancton,

- une augmentation de la température de 11° durant la période d'étude et de 6° ï£; 7° par rapport aux données antérieures,

- des valeurs de la salinité qui varient en moyenne entre 35 et 38 g/l en hiver, et 38 ï£; 40 g/l en été, mais qui restent proches des données antérieures.

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ASSESSING FRESWATER AND NUTRIENT FLUXES IN NESTOS RIVER AND ITS PLUME

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Abstract

Three oceanographic cruises were conducted to determine the seasonal and spatial variability of the water column characteristics along the coastal zone of western Thracian Sea, under the variable influence of Nestos River discharge rates. *Keywords : Estuaries, Coastal Waters, River Input.*

Introduction

Nestos River flows for 230 km through Bulgarian and Greek territory before emptying in Thracian Sea. The mean annual discharge for the period 1966-1990 was measured to 37 m³/s, ranging below 10 m³/s (August) and 150 m³/s (February). The coastal area of River Nestos outflow is influenced by the cooler and fresher Black Sea Water (BSW), which moves cyclonically along the Thracian Sea [1]. The present study aims at describing the level of riverine influence in the distribution of nutrients, chlorophyll and suspended matter along the coastal zone near the Nestos River mouth.

Materials and Methods

Three hydrographic cruises were conducted during March, May and August 2006 for the collection of water quality data from 24 stations, commencing 20 km upstream of the river's outflow, following its route and covering the broader river plume area. Sampling cruises took place during high (84.8 m³/s in March 2006), intermediate (59.0 m³/s in May 2006) and reduced (21.0 m³/s in August 2006) river flows. Temperature, salinity, conductivity and density were recorded using a Seabird SBE-19plus CTD. Water samples were collected from the surface and the bottom layer of the water column for the determination of nutrients according to [2] and chlorophyll-a according to [3] method. Finally, meteorological data were obtained from Chryssoupolis Airport located 10 km from the river mouth.



Fig. 1. Surface salinity spatial distribution during (a) high and (b) intermediate river flow.

Results and Discussion

Explicit T-S diagrams were used to define the level of background salinity corresponding to the limit between BSW and river plume water, and thus estimate the freshwater volume of the river plume area [1], which was calculated at 176×10^6 , 172×10^6 and 13×10^6 m³ for March, May and August, respectively. Nestos River dissolved inorganic nitrogen (DIN) loads were calculated at 116.1, 70.9 and 29.4 tones per month for the increased, intermediate and reduced flow conditions, respectively. Similarly,

dissolved inorganic phosphorus (DIP) loads were assessed at 16.7, 21.0 and 3.2 tones per month, for the increased, intermediate and reduced flow conditions, respectively. River plume nutrient concentrations, integrated over the entire freshwater layer, showed that the total DIN content reached 29.6 tones in March 2006, reduced to 5.6 tones in May 2006 and dropped further to 0.4 tones in August 2006. Similarly, the total DIP pool within the propagating river plume water was estimated at 4.5 tones, 4.4 tones and 0.03 tones, respectively. Plume dynamics were mostly governed by the strong geostrophic and tidal currents, enhanced in the Nestos River mouth area due to the presence of Thassos Passage, a narrow canal connecting Kavala Gulf with North Aegean Sea [4]. Atmospheric forcing seems to play a secondary role in plume expansion. Maximum plume surface expansion was observed in May, due to limited vertical mixing (Figure. 1).

Nutrient stoichiometric ratios within the plume depicted nitrogen limitation during March and May, and phosphorus limitation at the distant stations of the coastal zone, under low flow conditions. Nutrients spatial distribution presented an inverse linear relation to salinity, indicating the conservative mixing behavior under high (DIN: R^2 = 0.96, DIP: R^2 = 0.87 and Si: R^2 =0.94) and intermediate (DIN: R^2 = 0.92, DIP: R^2 = 0.89 and Si: R^2 =0.92) flow rates, while weaker correlations prevailed in August (DIN: R^2 = 0.04, DIP: R^2 = 0.13 and Si: R^2 =0.30) due to the limited nutrient fluxes.

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NUTRIENT DISTRIBUTION IN THE MEDITERRANEAN COAST OF TURKEY

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Abstract

In this study, seawater samples were collected during September 2005 at 50 points in the eastern and western part of Mediterranean coast of Turkey and analyzed for nutrients, temperature and salinity. The concentrations of nutrient changed between nd-1.60 μ g/L for NO₂-N; nd-7.95 μ g/L for NO₃-N; nd- 25.93 μ g/L for NH₄-N; nd-4.68 μ g/L for PO₄-P; and 0.42-91.09 μ g/L for Reactive Si. The results are compared with data obtained from previous studies.

Keywords : Eastern Mediterranean, Pollution.

Introduction

The coastal zone of the Mediterranean Sea is of considerable socioeconomic importance for Turkey, since it supports large scale tourism, fishing and port activities. Discharge of industrial, agricultural and domestic activities, which are the main sources of nutrients, flow to the Mediterranean Sea. Terrestrial phosphate input into the Mediterranean Sea has been increasing considerably since 1960 [1]. The eastern Mediterranean including Turkish coasts has oligotrophic conditions due to the lack of freshwater input and physical characteristics of water masses [2]. The objective of this study is to determine the nutrient distributions in the Mediterranean coast of Turkey. The results are also compared with the previous studies.

Material and Methods

The study (within the framework of the Project 104Y065 supported by TÜBITAK) was carried out at 50 stations during one month period between 12 September - 7 October 2005. Map of sampling locations are given in Figure 1.



Fig. 1. Map of sampling stations

Surface water temperature and salinity were measured during the sampling cruise with a SCT meter (YSI model). Water samples for nutrient determinations were collected at surface waters in 1000ml polyethylene bottles and then immediately frozen. Samples were kept continuously in deep freeze (-20 °C) until analysis. Sample analyses were generally carried out within one week of the completion of the cruise. Nutrients were measured spectrophotometrically [3].

Results and Discussion

Nutrient distribution is associated with physico-chemical dynamics (temperature, salinity, etc.) of the sea. In this study, the sea surface temperature ranged from 21.4° C to 31.4° C in September. The salinity changed between 13.3-39.4 ppt; low salinities are observed near freshwater input (Station 39). Table 1 summarizes the nitrate, nitrite, ammonium nitrogen, phosphate phosphorus, reac. silicate, salinity and temperature data for the 50 stations all of which the water depth is approximately between 1 and 2 meters. Mean values with the standard error and previous studies are given.

Nutrients (especially nitrite, ammonium, phosphate) concentrations are extremely high at station 15 in the Mersin Bay where the fertilizer, chemistry textile industrial wastes are discharged. Maximum peak in silicate and nitrate concentration took place at station 39 located in Beymelek Lagoon in Antalya owing to the freshwater input. Dissolved inorganic nutrients were generally low in Northeastern Mediterranean Sea [4, 5, 6]. Especially phosphate phosphorus, found below or near detection limit, is considered to be the limiting nutrient in Mediterranean Sea [7].

Tab. 1. Minimum, maximum and mean values together standard	error	of
physico-chemical characteristics and nutrients in Mediterranean	coast	of
Turkey and previous study (range values)		

Variables	Min.	Max.	Mean±SE	Northeastern Mediterranean [4]	Iskenderun Bay [5]	Cilician Basin [6]
Temperature (°C)	21.4	31.0	27.09±0.28	14	15.9-29.0	-
Salinity (ppt)	13.3	39.4	37.34±0.68		38.0-39.2	-
NO2-N (µgat/L)	nd	1.60	0.16±0.03		20	123
NO ₃ -N (µgat/L)	nd	7.95	0.86±0.22	0.05-6.0	0.31-1.63	0.16-0.31
NH4-N(µgat/L)	nd	25.93	1.33±0.52			-
PO ₄ -P (µgat/L)	nd	4.68	0.42±0.15	0.01-0.24	0.08-0.60	0.02-0.03
Reac.Si (µgat/L)	0.42	91.09	10.97±2.16	1.0-11.0	0.5-2.7	0.95-1.2

In conclusion, although the land-based activities (agriculture, industry, tourism) on the Mediterranean region of Turkey has brought increased phosphate and nitrate inputs to the Mediterranean Sea, this coast is not eutrophicated due to the physical characteristics related to the different water masses.

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STABLE ISOTOPIC TRACERS (DELTA13C AND DELTA15N) OF RIVERINE INPUTS INTO THE GULF OF LIONS: RESULTS FROM A ONE-YEAR SURVEY

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Abstract

Continental margins are regions that receive and store high amounts of organic carbon and nitrogen introduced by a variety of terrestrial and marine sources. This sedimentary material represents a complex mixture of biogenic substances with variable biological reactivity. Therefore, a good understanding of the biogeochemical processes requires an accurate estimation on the origin of this detrital material. Stable C and N isotopes are used in this study to define the signature of the terrestrial source and the accuracy consists of the integration of spatial (six different rivers) and temporal (season and flash-flood event) variations. Keywords : Gulf Of Lions, Organic Matter.

Continental margins are dynamic sedimentary environments that receive and store high amounts of organic carbon (OC) and nitrogen (N) introduced by a variety of terrestrial and marine sources. Rivers, termed as "arteries of continents", provide the major pathways for the input of terrestrial organic matter to marine sediments. In addition, riverine inputs are unidirectional fluxes affected by numerous natural factors such as precipitations, mean temperatures and morphology of the draining basin, as well as by anthropogenic factors such as agricultural, industrial and urban uses.

Freshwater inputs from rivers play a major role in the Mediterranean Sea since they enhance significantly the primary productivity and play a major role in the balance of water inputs through the Strait of Gibraltar. However, the actual water discharge of rivers into the entire Mediterranean Sea is estimated to be about 330 km³ yr⁻¹ [1], which is only 55% of the value at the beginning of the 20th century. The sediment fluxes into the Mediterranean have also markedly dropped of an estimated 70% to less than 200 Mt yr^{-1} , because of the massive construction of water reservoirs.

The Gulf of Lions is a key area of the Mediterranean Sea since it receives the Rhone river discharge, the largest river input into the Mediterranean Sea in terms of liquid and solid fluxes. Also, the Rhone river is an exception to the general temporal trend of Mediterranean rivers as its average runoff seems to remain at constant levels. The Gulf of Lions receives also numerous small Mediterranean coastal rivers such as the Tet, Agly, Aude, Orb and Herault rivers (Figure 1). Due to the strong seasonal contrast of climate, the hydrological regime of these small Mediterranean rivers is quite particular compared to other regions. The difference between low and high water discharge in drainage basins of 1.000 to 10.000 km², which is quite typical for Mediterranean rivers, is frequently about one order of magnitude greater than for rivers in non-Mediterranean basins, as the Rhone river [2]. Therefore, the impact of storms on river discharge is largely enhanced in the Mediterranean terrestrial basins where the mountains are adjacent to the shore and where storm frequency is high.



Fig. 1. Location of the sampling sites (circles) on six rivers (Tet, Agly, Aude, Orb, Herault, Rhone) flowing into the Gulf of Lions (NW Mediterranean Sea).

The aim of this study is to perform for the first time a one-year survey on the quality of the riverine particulate organic material discharging into the

Gulf of Lions. Carbon and nitrogen stable isotopes (δ 13C and δ 15N) are used to trace this terrestrial source. Variations of the carbon isotopic ratio in organic matter result mainly from the type of autotrophic species and from the intensity of degradation processes. Regarding nitrogen, isotopic changes in an aquatic ecosystem are mainly explained by the dynamics of inorganic nitrogen compounds and more particularly in rivers, by the intensity of the denitrification process related to waste water treatments in urban areas.

The use of stable isotopes on suspended material will allow us to determine the spatial variations of the terrestrial inputs into the Gulf of Lions and to check if there is a difference in the nature of the organic material discharged by coastal Mediterranean rivers (Tet, Agly, Aude, Orb, Herault) and the Rhone river. We will also determine the temporal variations of these terrestrial inputs into the Gulf of Lions, in order to know if there are seasonal organic material changes in all rivers and how organic matter change during flash flood events.

This survey benefits from the network of sampling stations framed in the ORME (Observatoire de Recherche Méditerranéen sur l'Environnement) programme. Riverine suspended material is monthly and simultaneously collected in the six selected rivers to determine the particulate load and analyze the OC and N contents and the isotopic ratio δ 13C and δ 15N. The study of short-term variations during a flash flood event is carried out on the Tet river, which is equipped with an automatic sampling station.

This integration of spatial and temporal variations of the riverine sources in the Gulf of Lions will improve our knowledge on the functioning of this terrestrial sources and will, therefore, allow us to trace accurately this source into the marine coastal system.

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REGULATION ON SHIPS NAVIGATION TO REDUCE RISK OF MARINE ACCIDENTS IN FAVOUR OF MARINE AND COASTAL ECOSYSTEMS ON THE AEGEAN COASTS IN TURKEY

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Abstract

A regulation on ships navigation was put into force in order to reduce risk of marine accidents after a ship grounding on Çavuş Island, SW Turkey. Following the regulation established in February 2001, certain type and size ships are obliged to navigate out of ecologically sensitive marine and coastal areas in Ayvalik, Foça and Bodrum Peninsula on the Aegean coasts of Turkey. *Keywords : Coastal Management, Conservation, Pollution, Aegean Sea, Water Transport.*

Introduction

Oil pollution by ship accidents require clean-up when spilled oil comprises persistent oils such as crude oil, fuel oil, heavy diesel oil and lubricating oil [1]. SAD-AFAG completed a field study on endangered Mediterranean monk seals Monachus monachus and habitats on the Bodrum Peninsula in 1996 [2] while, interestingly, a heavy but local oil spill was identified on rocky cliffs of Çavuş Island by the first author during the implementation of this project. A sample from the pollution was analyzed by the Ministry of Environment (MoE) who confirmed the pollution was origin of both aliphatic and aromatic hydrocarbons [3]. According to witnesses, a coaster grounded on NW coasts of Çavuş Island in the summer of 1996 and pollution occured by an oil spill from the ship, possibly bilge comprising high density and aged lubricating oils in a few hundred tons quantity, which seriously affected coasts of Çavuş Island and Gümüşlük, a tourist attraction village at 2nm. distance. The fact that Çavuş Island holds important monk seal caves in whole Bodrum Peninsula with surrounding 21 islands & islets [2] forced SAD-AFAG to take action for an oil spill clean-up operation to save marine and coastal ecosystem with special emphasis to endangered monk seals in the area.

Methods

SAD-AFAG, the Friends of Bodrum Society and the MoE have completely cleaned both the oil sludge floating on the sea surface & inside a cave and cliffs & cobble beach on Çavuş Island. 137 tons of oil sludge was collected via labor intensive cleaning methods and dumped into a suitable terrestrial dumping site in 1997 [4]. After clean-up was completed, SAD-AFAG deemed necessary to bring a permanent solution to reduce the risk of further marine accidents. First an analysis was made among SAD-AFAG members and a gap was identified on environmental safety; there was no regulation to let ships avoid to navigate in the narrow waterways near coasts where also biological diversity is rich and/or endangered species inhabit. Therefore, SAD-AFAG proposed Undersecretariat for Maritime Affairs (UMA), the competent maritime authority, to regulate the navigation of ships prohibiting routing through coastal waters between mainland and adjacent islands on Ayvalik, Foça and Bodrum Peninsula in 08.02.1999.

Results

The proposal of SAD-AFAG was thoroughly examined by UMA comparing similar and successful examples in the world. After having the opinions from the relevant organizations, it was finally evaluated affirmatively and the Navigation, Hydrography and Oceanography Dept. (NHOD) announced the new regulation on "areas to be avoided by ships". According to this regulation, *navigation is prohibited within the indicated bounded areas for cargo vessels greater than 300 GRT and all vessels carrying dangerous goods in order to avoid risk of pollution and damage to environment. This interprets that navigation between the mainland and adjacent islands in Ayvalik, Foça and Bodrum Peninsula marine areas is restricted for the purpose of protecting marine life with special emphasis to endangered monk seals and their habitats. It was published in the NHOD's journal Denizcilere Ilanlar (Announcements to Mariners) in 10.02.2001 [5] and the marine areas to be avoided by ships were plotted onto the relevant navigation charts.*

Discussion

Maritime traffic increased %169 in 2004 compared to 1970 worldwide and trend is increasing [6]. In spite of all measures taken, marine incidents shall continue to happen, however, precautionary actions such as understanding the risks and designing the navigational regulations in certain ecologically sensitive marine zones shall reduce the risk of marine incidents. Basic navigational regulations, Traffic Separation Schemes (TSS), Vessel Traffic Management and Information Systems (VTMIS) and Automatic Identification System (AIS) are effective tools. In the maritime areas given in this article, the application of "areas to be avoided by ships", as a basic navigational regulation, is unique in its category in Turkey and no ship accidents resulting in oil pollution happened in these marine areas since the regulation was in effect in 2001.



Fig. 1. The marine areas where regulation is applied on Aegean Sea coasts of Turkey (inset) and the marine area to be avoided by ships indicated with the dotted line at Bodrum Peninsula.

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A METHODOLOGY FOR ASSESSING THE CURRENT STATE AND FUTURE TRENDS IN COASTAL AREAS: THE CASE OF KALLONI BAY, LESVOS, GREECE

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Abstract

In this paper, a methodology is presented for assessing the current state and future trends in coastal areas which are important prerequisites for the implementation of appropriate management schemes. The methodology is based on the integration of Geographical Information Systems and multiple criteria choice methods. A case study is carried out in the coastal area of Kalloni Bay on the island of Lesvos (Greece) where multiple activities take place causing an urgent need for the application of proper management policies. *Keywords : Coastal Management, Coastal Systems, Gis, Eastern Mediterranean.*

Introduction

Under the legislation of the European Union, the sustainable development of coastal zones is a main priority. To achieve this priority, long-term economic, environmental and social information data has to be analyzed for gaining a better understanding of coastal areas and designing appropriate management plans [1]. Therefore, decision-making in coastal areas involves collaboration among various disciplines related to environmental and socio-economic issues. Geographical Information Systems play a significant role in that field, since they provide a powerful framework where detailed spatial databases can be developed and integrated with appropriate methodologies and models [2]. In this paper, multi-dimensional evaluation and ranking of coastal areas using a set of selected criteria and based on the combination of multiple criteria choice methods and Geographical Information Systems (GIS) was carried out.

Description of the study area

The Bay of Kalloni is a deep coastal embayment at the south-western part of the island of Lesvos with a surface of 110 km^2 . The watershed is limited by steep mountainous formations. Several small settlements and villages are located around the Bay. The area has remained rural and the total population accounts approximately 12.808 inhabitants [3]. During the last 15 years the development of a confined area in Kalloni settlement as a tourist site has been the key factor controlling the economic development of the region. Until now, activities in the area are based on occasional schemes ignoring any sustainable development.

Methodology and analysis results

In this study, a methodology was developed for assessing the current state of the coastal ecosystem of Kalloni Bay and evaluating its future trends towards different aspects of development. The catchment area was divided into five management zones (Z1 to Z5) with a high degree of homogeneity regarding their socio-economic and environmental characteristics. Assessment of the state of each zone was carried out based on selected criteria. The methodology involved combination of GIS with multiple criteria choice methods. The principle of multiple criteria evaluation choice methods is the classification / ranking of alternative choice possibilities on the basis of various criteria. In this study, the regime multiple criteria choice method was applied [4]. In Fig. 1, the division of the study area into five management zones is illustrated.



Fig. 1. Division of the study area into five management zones.

The criteria used for the evaluation of the current state of each zone and the comparison among zones, are the following: C1: Natural and cultural resources, C2: Exploitation of resources, C3: Protection of ecosystems, C4: State of pollution, C5: Population, C6: Quality of life, C7: Human

potential, C8: Primary sector, C9: Secondary sector, C10: Tertiary sector. The analysis was carried out by considering three objectives regarding development: Agricultural, Tourism and Sustainable Tourism. Subsequently, the regime multiple criteria choice method was applied twice for each objective: (a) No weights were assigned to the criteria as they were considered of equal importance. (b) Priorities were assigned to the criteria for representing their degree of importance. It should be noted here that some criteria were given negative values; those represent cost criteria, since the lower their value, the better for the considered objective. The rankings of the zones for each objective are shown in Table 1. Zones Z4 and Z1 are ranked at high levels for all the objectives, since well developed infrastructures are available in these zones. Z3 is always ranked in low levels which can be attributed mainly to the lack of infrastructures. Z2 is more orientated to agricultural development and less to tourism development. Furthermore, the potential for touristic development is better when considering sustainable approaches. Z5 is ranked in better place concerning Tourism and Sustainable Tourism compared to Agriculture, since natural land overwhelms agricultural land. Finally, an important feature is that the zones ranked in lower levels are characterized by a serious shrink of the local population.

Tab. 1. Ranking of the five zones for all the objectives under examination.

		2	Ranking						
Objective	1	2	3	4	5				
Agriculture	No weights	Z1	Z4	Z2	Z3	Z5			
	Weights	Z1	Z4	Z2	Z3	Z5			
Tourism	No weights	Z4	Z1	Z5	Z2	Z3			
	Weights	Z4	Z1	Z5	Z2	Z3			
Sustainable	No weights	Z4	Z1	Z5	Z3	Z2			
Tourism	Weights	Z4	Z1	Z5	Z2	Z3			

Conclusions

The ranking of coastal zones could be useful to coastal decision-makers for assessing their current state, indicating the ones where specific initiatives should be undertaken and evaluating their potential for development in accordance with specific objectives. Finally, the possibility of assigning priorities to the criteria is important, since it allows the reflectance of different viewpoints to be examined.

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THREE-DIMENSIONAL MODEL FOR THE SIMULATION OF SUSPENDED MATTER PELAGIC-BENTHIC EXCHANGES IN COASTAL WATERS

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Abstract

A three-dimensional model has been formulated for the description of fine matter exchanges between sea-column and benthos in the coastal environment. The physical processes affecting the properties and the propagation of a sedimentary plume, embodied in the model, include coagulation-deflocculation, the effects of stratification and ambient density to the vertical propagation and the density of the sedimentary plume, settling and deposition on the seabed, self-weight consolidation of deposited particles and erosion of the bed. The usability of benthic ascidia as biological filters was investigated by the exploitation of *in situ* and laboratory experiments. *Keywords : Aegean Sea, Coastal Models, Coastal Processes.*

Introduction

The mathematical model [1] is based on the tracer method and thus describes the sediments entering the marine environment as particles each representing particular mass of matter. Every particle bears personal information in the form of indicators that express the total of the mass that composes the particle, which may however differ between the various particles included in the simulation, enabling the tracing of changes in the characteristic properties of the sediments with time. The physical processes affecting the properties and the propagation of the sedimentary plume embodied in the model include flocculation, settling, deposition, consolidation, resuspension and erosion of the bed.

Description of the mathematical model

The movement of each particle under the influence of coastal currents is analyzed into a deterministic part that expresses advection, controlled by the local fluid velocity and the settling rate of the particles and a stochastic that accounts for the random Brownian motion of the particles. Changes of the characteristic diameter of the cohesive aggregates due to coagulation and deflocculation processes are defined applying the simplified flocculation model. The effect of ambient density to the density of the particle is calculated in relation to the porosity of the cohesive aggregate and the density of the primary particle. These properties are used for the determination of the settling velocity of each particle applying Stoke's law for cohesive sediments. When a particle reaches the bed the shear stress conditions determine the possibility of the particle to deposit and the beginning of self-weight consolidation during which the critical stress for resuspension of the material increases with time the particle remains in deposition. After the completion of the process the particle is considered to be part of the seabed.

The sources of sedimentary particles that can be included are various, among which rivers, aeolian transported matter and erosion of the seabed. Input parameters of the model are hydrodynamic and physical parameters data that include values of seawater velocities, salinity and temperature.

Application of the model for the simulation of the efficacy of benthic ascidia as biological filters

The model has been applied for the investigation of the applicability of benthic ascidia as biological filters. Specifically the model described has been properly adapted so as to mathematically express the filtration of marine water by the ascidia and the removal of suspended material from the water column.

For this purpose the findings of a research program carried out in the gulf of Thermaikos (NW Aegean) for the potential of the ascidia *Styela Plicata* [2] were put to use. Dense ascidia populations were found in the SW gulf, which is the area of application for both the *in situ* [2] and the mathematical experiments. The average filtration efficacy of the ascidia e_{filt} was determined experimentally to be 40%, whereas the length of the ascidia from *in situ* measurements was of an average of 6cm. These parameters were put to use as loss-terms of particle mass in conditions a particle approaches the ascidia populations in their detection distance (d_{det}) [3]. Namely the possibility of absorption P_{ab} of a particle in suspension at a distance z_b from the bed is considered to be zero if $z_b < d_{det}$ and 1 otherwise. The time considered for the assimilation of the particulate matter by the ascidia (t_{ass}) was found to be 2hrs, period during which the absorbed particle is excluded from the calculations. Following full assimilation (t >t_{ass}) the particle reenters the flow with reduced mass (m_p):

$m_p = (1 - e_{filt}) m_{in}$

where m_{in} is the initial particle mass.

The results from the mathematical experiments conducted in the area fully support the findings of the laboratory experiments performed regarding the applicability of benthic ascidia as biological filters, since the efficacy in removing suspended matter from the water-column has reached satisfying percentages.

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PRINCIPAL COMPONENT ANALYSIS PHYSICO-CHEMICAL AND BIOLOGICAL PARAMETERS IN THE INNER PART OF BOKA KOTORSKA BAY

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Abstract

In the period from September 2003 to August 2004, physico-chemical and biological parameters (phytoplankton abundance and chlorophylla) were analysed at five sampling locations in the inner part of the Boka Kotorska Bay. Principal component analysis showed the greatest interaction between chlorophyll *a* and silicates then follows its interaction with nitrites and phosphates in the first group of data. In the second group of data a great interaction between temperature and nitrites was present as well as between transparency and salinity. *Keywords : Adriatic Sea, Eutrophication.*

Introduction

The Boka Kotorska Bay is located in the south eastern part of the Adriatic Sea, comprising a part of the Montenegrin coast. The ecological studies of seawater at the Montenegrin coast, conducted in different seasons between 1995 and 2005 [1], showed that the problem of anthropogenic eutrophication increased. The results of Principal Component Analysis (PCA) carried out using physical, chemical and biological parameters in the inner part of the Boka Kotorska Bay (Adriatic Sea) are presented in this paper.

Materials and Methods

Seawater samples were taken on a monthly basis from September 2003 to August 2004 from five sites in the inner part of the Boka Kotorska Bay. Temperature, salinity and oxygen concentration were measured *in situ* by the use of an oxygen meter. Turbidity was determined with a Secchi disk. Nutrients were estimated by standard methods [2]. Chlorophyll *a* concentration was calculated according to Jeffrey et al. [3]. Abundance of phytoplankton was calculated according to Utermöhl [4]. Statistics 7 was used for statistical analyses of data. Biplot for the studied elements was obtained by using S-Plus statistical programme.

Results and discussion

Principal Component Analysis (PCA) was carried out by the use of physical, chemical and biological data from the inner part of the Boka Kotorska Bay (Fig. 1).



Fig. 1. Biplot of studied physico-chemical and biological parameters at explored sites in the inner part of the Boka Kotorska Bay.

In daily date results of Perez-Ruzafa et al. [5], the relationship between chlorophyll a with nutrients is negative, disagree with traditional models, and suggest that phytoplankton controls nutrient concentration. In the researches of Weckström et al. [6], a great negative correlation between silicates and salinity was expected because the rivers are the main external

sources of silicate in the coastal waters of Finland and that can be accepted as explanation for the data obtained for the Boka Kotorska Bay. Also, great interaction and correlation between chlorophyll a and silicates point out to the statements of Kristianses & Hoell [7], that silicon is an important element in still insufficiently known mechanism of harmful algal bloom. It is possible that the input of nutrients by rain in spring and autumn was the main cause of increased abundance of phytoplankton and chlorophyll a during these researches, while temperature was not a limiting factor that is in concord with the model of Dugdale & Goering [8].While in the investigations of Dorgham et al. [9] the salinity was determined as an important factor in relation to the concentration of chlorophyll a, in this study the relationship between them is negative. A permanent monitoring has to be organized for a better understanding of the interaction between physico-chemical and biological parameters that influence the process of eutrophication in the Boka Kotorska Bay.

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THE DISTRIBUTION AND MOBILITY OF IRON IN COASTAL SEDIMENTS COVERED WITH CYANOBACTERIA MATS

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Abstract

In coastal marine environments with shallow, warm and calm waters, it is sometimes possible to observe the presence of organosedimentary structures (algal mats). The aim of this work was the study of the distribution and mobility of Fe among the main layers of coastal algal mats in a closed bay at Anavissos, on the coast of the Saronikos Gulf. Small sediment cores were collected and separated to three discrete layers. The trace metals of each layer were extracted according to the BCR sequential extraction method. The main results of the study are: a) The labile forms of Fe are mostly associated with organic compounds and sulfides and b) Fe tends to accumulate in the anoxic layer of the sediment.

Keywords : Algae, Anoxia, Metals, Sediments.

In coastal marine environments with shallow, warm and calm waters, it is sometimes possible to observe the presence of organosedimentary structures, which are produced by sediment trapping, binding and /or precipitation as a result of the growth and metabolic activity of microorganisms, principally cyanobacteria [1].

The aim of this work was the study of the distribution and mobility of various forms of Fe, in the main layers of coastal cyanobacteria mats that have been observed in some Greek coastal areas.

The area under research is a closed bay at Anavissos on the coast of the Saronikos Gulf, 50 Km away from Athens, with an area of about 20,000 square meters. This area has ideal conditions for the development of such formations [2]: A line of beachrocks shuts the bay's entrance, obstructing the water's renewal. At the shallow bottom of the cove (max. depth of about 0.6 meters) a layer of green algae with a thickness of 0.2 - 2 mm is observed, which extends throughout the bottom of the bay [3].

Sediment cores about 10 cm long, were collected seasonally from one point inside the bay that is partly covered with seawater for a course of one year. The cores were separated in three layers that were freezedried and sieved through 0.25 mm sieves: a) the upper one, 0.2 - 2 mm thick, which includes the cyanobacterial mat; b) the middle one, up to 5 cm thick, of dark colour, which is anoxic and has the characteristic odour of hydrogen sulfide; c) the third one, about 5 cm thick, of brown colour, which represents the background sediment. According to the BCR sequential extraction procedure the trace metals were separated in four fractions: Fraction A: metals connected to small inorganic particles and carbonates; fraction B: metals connected to oxides/hydroxides of Mn and Fe; fraction C: metals connected to organic compounds and sulfides; fraction D: metals strongly bound in the alumino-silicate lattice. A Flame Atomic Absorption apparatus equipped with Sample Introduction Pump System and D₂ lamp for the background signal correction was used for the determination of Fe. The contents of all layers of the sediment in the various fractions of Fe are presented in table 1.

Tab. 1. The content of the sediment in Fe (in mg/Kg)

Fraction	Summer 2000	Autumn 2000	Winter 2001	Spring 2001
	Sur	face layer		
A	0.091	0.049	0.050	0.114
в	0.788	0.721	0.230	0.260
С	0.693	1.54	0.526	0.826
D	13.1	11.9	17.5	18.2
	An	oxic layer		
A	0.152	0.185	0.072	0.075
в	0.532 0.577 0.356		0.356	0.253
С	1.43	1.55	1.74	0.981
D	12.7	14.3	17.6	11.5
294	Back	ground layer	1945-20.03	
A	0.040		0.055	
в	0.139		0.190	
С	0.353		0.637	
D	12.6		16.4	

According to that table, 90% of Fe in the surface layer, 88% of Fe in the anoxic layer and 95% of Fe in the background layer is strongly bound in the sediment's crystalline grid. The second most abundant form of Fe in all sediment's layers is the one associated with organic compounds and

sulfides and represents 61%, 72% and 70% of all labile forms in the surface, anoxic and background layers respectively. On the other hand, the less abundant form of Fe is the one connected to small inorganic particles and carbonates as it represents 5 -7 % of its labile forms. About half of the labile forms of Fe accumulate in the anoxic layer of the sediment. In order to explain the distribution of Fe among the sediment's layers we tried to extract the ratio $[Fe^{+3}]/[Fe^{+2}]$ in the porewater as the mobility of Fe is dependent on its oxidizing level. After theoretical calculations we found out that this ratio is a function of the oxygen concentration (PO₂), pH, temperature (T), E_o (of the reaction Fe⁺³ + e⁻ à Fe⁺²; here is 0.770) and the number of electrons moved (n; here is 1). Thus, $\log([Fe^{+3}]/[Fe^{+2}]) =$ f(PO₂, pH, T, Eo, n). When applying the physicochemical measurements that we carried out in the anoxic sediment's porewater (pH = 6.8, T = 293 °K, PO₂ = 0.01 (anoxia), n = 1 and $E_o = 0.770$) we found out that $\log([Fe^{+3}]/[Fe^{+2}] = 0.2$, meaning that considerable amounts of Fe⁺² are present in the porewater. Cyanobacteria that extend through the surface of the sediment uptake inorganic Fe and convert it into organic Fe. After their death, organic Fe is gradually buried in the anoxic layer and converted again into inorganic Fe. A part of the Fe^{+3} is reduced to Fe^{+2} due to the anoxic conditions and partly converted into FeS. As Fe^{+2} is more labile than Fe^{+3} , a part of it can reach the surface via porewater, be oxidized into Fe⁺³ and then be recycled. Figure 1 presents the cycle of Fe in this particular ecosystem.



Fig. 1. The behaviour of Fe in the cyanobacteria mat

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DÉTERMINATION DES ZONES POTENTIELLEMENT AQUACOLES EN OFFSHORE PAR TÉLÉDÉTECTION ET SYSTÈMES D' INFORMATION GÉOGRAPHIQUES (SIG) : CAS DE LA BAIE DE M' DIQ AU NORD OUEST MÉDITERRANÉEN MAROCAIN.

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Résumé

La télédétection et les SIG ont été conjugués dans ce travail pour déterminer les sites aquacoles dans la baie de M'diq. Une image multi bande du capteur TM de Landsat datant du 28 mars 1998 a servi de base: la circulation des eaux, la répartition de la chlorophylle et l'état de la pollution du littoral ont été cartographiés. Les données physicochimiques in situ issues d'une campagne de prospection (juillet 1997) ainsi que celles extraites de l'image ont été intégrées dans un SIG en mode vectoriel. Les fonctionnalités du SIG ont permis la détermination des zones potentiellement aquacoles du loup et de la daurade en cages flottantes et des huîtres, moules et coquilles Saint Jacques en filières.

Mots clès : Aquaculture, Remote Sensing, Swath Mapping, Western Mediterranean.

Le développement de l'aquaculture se heurte de plus en plus à des contraintes environnementales : sites non propices, indisponibilité et non renouvellement des eaux, concurrences avec d'autres utilisations, etc. Le choix des sites en offshore permet de contourner ces problèmes. Pour se faire, les méthodes traditionnelles ne permettent pas une vue synoptique ; de plus, certains paramètres connaissent des changements liés aux fluctuations de la marée, du vent et des décharges d'eau douce.

L'utilisation conjuguée de la télédétection et des SIG permet d'explorer les nouveaux sites aquacoles potentiels [1]. En effet, les données satellitaires sont adaptées à l'échelle marine et fournissent des scènes synoptiques des étendues marines ; de plus, elles sont dotées d'une richesse en informations inhérentes à l'eau puisque le passage des valeurs radiométriques aux grandeurs thématiques se fait aisément à l'aide d'algorithmes et de modèles mathématiques pré-établis [2, 3].

La baie de M'diq, située au Nord ouest méditerranéen marocain, et seule région du Maroc présentant un intérêt pour l'investissement en aquaculture offshore, a été sélectionnée. Le processus d'intégration des données dans un SIG a permis de construire une base de données qui renseigne sur les conditions environnementales de la baie. L'information intégrée en mode vectoriel comprend d'une part des données satellitaires extraites de l'image Landsat TM [4] datant du 28 mars 1998 (fournie par le Centre Royal de Télédétection Spatiale) et couvrant la circulation des eaux, la répartition de la chlorophylle et l'état de la pollution des eaux, et d'autre part, des données physicochimiques mesurées in situ issues lors d'une campagne de prospection du 6 au 21 juillet 1997 dont la température, la salinité, les nitrates, les phosphates, l'ammonium et les matières en suspension [5]. La bathymétrie et la nature des fonds ont été tirées d'un précédent travail dans la région [6].

L'analyse spatiale a permis de réaliser deux fonctions principales : croisements et requêtes. Le processus de croisement des couches thématiques initiales consiste d'abord à établir les croisements primaires suivants : profondeur + types de fonds, salinité + température, MES + oxygène dissous, nitrates + nitrites, ammonium + phosphates et pollutions + chlorophylle. Les croisements secondaires combinent les primaires deux à deux et ainsi de suite jusqu'à la couche finale. On obtient ainsi une couverture dont la taille des attributs englobe tous les paramètres de la base des données.

L'application des requêtes relevant des exigences de la daurade, du loup, des huîtres, des moules et de la coquille Saint Jacques [7] donne directement les résultats escomptés. La figure 1 représente les zones potentielles aquacoles résultantes de l'analyse spatiale des couches thématiques initiales concernant les poissons en cages flottantes et les coquillages en filières.

Considérant les faibles différences des limites de tolérance des espèces vis-à-vis des conditions environnementales [6], il s'est avéré judicieux de procéder à trois regroupements des espèces : daurade et loup, moules et huîtres, et enfin coquille Saint Jacques ; cette dernière a été écartée des autres coquillages, car elle ne supporte pas les hautes teneurs en turbidité. Les zones révélées comme potentielles pour l'aquaculture en offshore montrent bien que la baie de M'diq est apte à l'élevage des espèces étudiées. Les plages de variation des paramètres physicochimiques ne présente aucun obstacle pour la survie des espèces en période estivale. Pour la profondeur, contrainte plutôt technique, l'emplacement des zones sélectionnées comme favorables sont comprises entre les isobathes 10 et 50 m, cette dernière a été choisie comme profondeur maximale vue que la stabilité des structures requiert une installation coûteuset au-delà de cette

profondeur. La turbidité est le seul facteur déterminant dans le choix des sites vu le déversement de deux oueds dans la baie.

La force du courant dans la baie varie de 10 à 70 cm/s au Nord et de 2 à 5 cm/s au Sud [5]. En comparant avec les valeurs limites prescrites, la partie sud de la baie pourrait être favorabsle à la conchyliculture [8]. Alors que la pisciculture en cages ne souffre pas de l'hydrodynamisme de la baie. Les résultats obtenus ne sont qu'une analyse concrète des potentialités aquacoles de la baie en période estivale, la fiabilité définitive des résultats ne peut être acquise qu'après avoir fait la même analyse en période hivernale.



Fig. 1. Zones potentielles pour l élevage de la daurade et du loup en cage (A), de la coquille Saint-Jacques en filières (B), et des moules et des huîtres en filières (C) au niveau de la baie de Mdiq (Maroc).

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MONITORING AND MODELING EFFORTS FOR NUTRIENT CYCLING AND FLUSHING DETERMINATION IN A COASTAL LAGOON

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Abstract

Physicochemical parameters and nutrient concentrations were measured during 13 monthly samplings in the water and 4 seasonal samplings in the sediment at Eratino Lagoon, northern Greece. Salinity data were utilized for freshwater content and discharge determination. Lagoon-open sea interactions were assessed through direct monitoring and budget calculations. An integrated lagoon biogeochemical model was developed to describe nutrient cycling and transformation.

Keywords : Lagoons, Sediments, Phosphorus.

Introduction

Eratino is a shallow (mean depth: 0.5 m) coastal lagoon located in northern Greece with a surface area of about 3.5 km^2 . It is part of a coastal lagoon system, with a total area of 1,700 ha, located at the western part of Nestos River Delta. The lagoon is supplied with freshwater by a small stream (2 km long), draining agricultural land, and communicates with the nearby Kavala Gulf by a tidal channel. Tidal elevation at the lagoon's mouth ranges between 0.14 and 0.39 m [1, 2]. The present study provides a preliminary approach aiming towards the estimation of nutrients influx, the determination of flushing and exchange with the adjacent sea, and the understanding of nutrients cycling inside the lagoon.

Materials and methods

Overall 13 sampling cruises were conducted between August 2005 and August 2006. Water temperature, salinity, pH and dissolved oxygen content were measured in situ at 10 stations inside the lagoon, using portable instrumentation. Nutrients (N-NO₂, N-NO₃, N-NH₄, P-PO₄, Si-SiO₂), chlorophyll-a and total suspended solids were determined at each site [3, 4]. Sediment samples were collected seasonally using a box-corer sampler at 5 stations, to determine nitrates, total Kjeldahl nitrogen (TKN) and total phosphorus content (TP) [3]. Salinity data were used for the freshwater content and discharge estimation [5], while flushing and exchange dynamics were considered from previous monitoring efforts [1]. A lagoon biogeochemical box model was developed [6], and the present dataset were imported for preliminary runs. The model simulates the temporal variability of nutrients (nitrates, ammonium, phosphates, silicates), phytoplankton, zooplankton, detritus (nitrogen, phosphorus and silica), dissolved oxygen and benthic nutrients (nitrogen, phosphorus and silica).

Tab. 1. Mean values of water and sediment quality parameters with temporal standard deviation in parentheses.

Paramotoro		Station group)
Falameters	tidal	lagoon	fresh
T (°C)	18.2 (8.2)	18.6 (8.6)	19.3 (8.0)
S	22.5 (6.7)	18.3 (5.6)	15.5 (6.9)
DO	7.7 (1.4)	8.6 (2.4)	8.9 (2.0)
рН	8.38 (0.25)	8.41 (0.23)	8.19 (0.23)
NO2 (µg-at l ⁻¹)	0.43 (0.49)	0.61 (0.78)	1.43 (1.28)
NO3 (µg-at l ⁻¹)	5.9 (10.1)	7.0 (9.3)	23.6 (25.6)
NH4 (µg-at l ⁻¹)	4.2 (2.8)	3.6 (2.9)	10.5 (11.4)
PO4 (µg-at l ⁻¹)	4.7 (2.3)	5.3 (2.6)	8.4 (3.0)
Si-SiO2 (µg-at I-1)	62.9 (25.2)	84.0 (35.9)	112.8 (30.4)
Chl-a (µg l ⁻¹)	15.7 (14.3)	20.8 (16.0)	43.3 (57.5)
TSS (mg l ⁻¹)	24.9 (16.1)	24.6 (18.1)	21.5 (14.0)
NO3 (µg g ⁻¹ d.w.)	14.8 (1.9)	16.0 (2.9)	15.6 (1.5)
TKN (mg g ⁻¹ d.w.)	0.64 (0.15)	1.07 (0.33)	1.23 (0.70)
TP (µg g ⁻¹ d.w.)	91.8 (52.3)	39.9 (10.1)	73.6 (11.6)
	$\begin{array}{c} \mbox{Parameters} \\ \hline \mbox{T (°C)} \\ \mbox{S} \\ \mbox{DO} \\ \mbox{pH} \\ \mbox{NO2 (}\mbox{\mu}\mbox{g-at }\mbox{l}^1\mbox{)} \\ \mbox{NO3 (}\mbox{\mu}\mbox{g-at }\mbox{l}^1\mbox{)} \\ \mbox{NO4 (}\mbox{\mu}\mbox{g-at }\mbox{l}^1\mbox{)} \\ \mbox{NO4 (}\mbox{\mu}\mbox{g-at }\mbox{l}^1\mbox{)} \\ \mbox{Si-SiO2 (}\mbox{\mu}\mbox{g-at }\mbox{l}^1\mbox{)} \\ \mbox{Si-SiO2 (}\mbox{\mu}\mbox{g-at }\mbox{l}^1\mbox{)} \\ \mbox{Si-SiO2 (}\mbox{\mu}\mbox{g-at }\mbox{l}^1\mbox{)} \\ \mbox{Si-SiO2 (}\mbox{\mu}\mbox{g-at }\mbox{l}^1\mbox{)} \\ \mbox{Ch-a (}\mbox{\mu}\mbox{g-1}\mbox{l}^1\mbox{)} \\ \mbox{NO3 (}\mbox{\mu}\mbox{g-g}^{-1}\mbox{d}\mbox{.w.)} \\ \mbox{TKN (mg g^{-1}\mbox{d}\mbox{.w.)} \\ \mbox{TP (}\mbox{\mu}\mbox{g-g}^{-1}\mbox{d}\mbox{.w.)} \end{array}$	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	$\begin{array}{c c c c c c c c c c c c c c c c c c c $

Results and discussion

Sampling sites were classified in three groups (tidal, lagoon, freshwater) according to the factors driving their water quality. The temporal variability of the in situ measurements in the water column, as well as the results from the chemical analyses of the water and sediment samples is presented in Table 1. Salinity depicts inversely proportional relations with nutrient concentrations along the main lagoon axis, although the spatial and temporal variability of sediment nutrient concentrations do not follow a similar pattern. Preliminary model runs evaluate the rates of phytoplankton grazing and mortality, heterotrophs excretion, detritus mineralization and nutrients uptake, along with benthic mineralization, absorption and denitrification.

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IMPACTS OF CLIMATE CHANGE ON THE FRESH WATER FLUXES TO THE MEDITERRANEAN SEA: CASE STUDY OF COASTAL RIVERS IN LANGUEDOC-ROUSSILLON AREA (SOUTH-EAST OF FRANCE)

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Abstract

Languedoc-Roussillon area experimented a high temperature increase during the spring and summer seasons for the period 1965-2004, but no clear evolution for the precipitation. Increase of the associated water loss by evaporation explains partly the general decrease of discharge in the rivers limited to this area and therefore their contribution less important to the fresh water fluxes to the Mediterranean Sea. *Keywords : Gulf Of Lions, Hydrology, Time Series.*

This study was initiated by the recent analyses reported by IPCC (Intergovernmental Panel on Climate Change) about the past, actual and future evolution of bioclimatic conditions on Earth and the observed/excepted consequences on the water cycle. Among recent studies relating to the ongoing climate change context, those pertaining to the Mediterranean area have revealed evidence of a reinforcement of dryness conditions over the recent period [1-3]. This evolution is the result of a couple effect of a high annual temperature increase in the whole basin and a decrease of precipitation observed mainly during the winter months in some countries (Italy, Greece and Maghreb states). These studies also suggest that western Mediterranean basin is presumably more affected by the ongoing Global Change than the others land-sea areas.

As a consequence of these preliminary results, a comprehensive dataset related to the hydroclimatic conditions and atmospheric dynamic patterns has been collected for the Languedoc-Roussillon area for the period 1965-2004. Climatic data were collected from a network of 44 and 117 stations measuring temperature and precipitation respectively (fig. 1). These climatic parameters were spatially interpolated and averaged for 15 subcatchments whose hydrologic data were equally acquired. Main objective of this work was to study possible recent changes of evolution of climatic conditions presumably related to the ongoing Global Change and its consequences on the hydrology of rivers limited to the studied area. These latter are considered typical to Mediterranean basins, that are characterized by a great interannual variability of discharge and occurrence of severe flash-floods. Statistical analysis performed on time series of hydroclimatic data allowed us to study trends and links between surface hydrologic conditions and climatic variability. An attempt to explain origin of the climatic variability and its recent evolution was investigated from correlation analysis between the observed climatic parameters and related to the atmospheric circulation NCEP data.

This study revealed an annual temperature increase of about 1.5° for the entire studied area during the considered period. Temperature increase was the most important for the spring and summer seasons and negligible during the others seasons indicating that annual thermal amplitude has recently significantly increased in this area. Annual precipitation didn't show clear evolution but some catchments (Orb and Herault) experimented a slight shift in the intra-annual precipitation distribution. Increase of pressure conditions over the Mediterranean area for the period 1965-2004 seems to explain mainly the important temperature increase during most months. Furthermore, high positive phases of NAO index during the wintry months explain partly the observed precipitation decrease during this season for the Orb and Herault catchments.

As a consequence of this recent climatic evolution probably added with human activities influence, most of discharge series showed a general trend to a decreasing of available water resource in Languedoc-Roussillon area, especially during the spring and summer seasons. Correlation analyses showed statistically significant link between temperature and discharge series for the summer season, which underlines role of the increasing water loss due to the temperature increase during this season.

Accounting future climate conditions predicted by most of Global Circulation Models, this study also revealed consistent evolution of the observed past and predicted future conditions for temperature. This is not clearly the case for precipitation, which can be partly explained by the great interannual variability of this parameter in the studied area.



Fig. 1. Location of hydroclimatic stations used in this study.

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HYDROLOGICAL AND SEDIMENTOLOGICAL BEHAVIOR OF THE CATALAN RIVERS. COMPARISON WITH A MEDITERRANEAN NATURAL SEDIMENT FLUX MODEL

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Abstract

The Inner Catalan river basins (NW Mediterranean) have been analysed from two different perspectives. The first analysis deals with the long-term hydrological evolution of the studied watersheds and its relation with global and regional climatic factors. The second analysis integrates the available sediment load data with lithologic, climatic, land-use, and geomorphic parameters in order to develop a reliable model of river influx under natural and human impacted conditions. This second analysis is reinforced by a similar study involving other 79 Mediterranean river basins.

Keywords : Gis, Hydrology, River Input.

Introduction

The pressure over fluvial systems is especially intense in the Mediterranean region mainly due to the rising human population and the agricultural needs. Mediterranean rivers are not only important as fresh-water sources, but also as nutrient and sediment suppliers to the marine environment. A significant scientific effort is underway to understand the hydrological and sedimentary behavior of Mediterranean rivers in order to ensure their sustainability and that of the Mediterranean Sea and its shorelines.

Catalonia is in the western part of the NW Mediterranean Basin. As in many other Mediterranean regions, fluvial solid discharge has not been regularly and historically monitored. The challenge is, therefore, to achieve a reliable model of river input under natural and human impacted conditions.

Analysis of long-term hydrological and climatic time series

Long-term water discharge (Q) data series have been gathered from the Catalan watersheds, 10 fluvial systems ranging between 70 and $5,000 \text{ km}^2$. Various global datasets compiled into a GIS allowed extracting lithologic, climatic, land-use, and geomorphic parameters for each watershed.

Q was essentially homogeneous in the Catalan rivers along the 20^{th} century, with slightly increasing or decreasing long-term trends. Mean values for all rivers ranged from 0.3 to 11 m³/s. Precipitation (P) decreased in all the watersheds at a rate of about 0.33 mm/yr, while temperature (T) increased nearly 0.02° C/yr. This is in agreement with the mean P and T trends on the NW Mediterranean Basin, although in Catalonia these climatic changes are larger in land than above the sea. However, these P drop and T rise do not directly translate into river flow reduction.

Hydrological periodicity has been also analysed. A negative relationship between the Q data series and the NAO index has been observed, i.e. maximum discharge events often fit with the most negative NAO values, and vice versa. The frequency and magnitude of droughts (flow below the 15^{th} percentile) and floods (flow exceeding more than 10 times the average Q) were very irregular during the last decades, a period during which most of the Catalan watersheds showed a slight increase in the magnitude of these extreme events.

Sediment load analysis: From the Catalan to the Mediterranean case Total suspended sediment (TSS) field data from the Catalan basins are limited to 6 years of punctual uneven measurements. The recorded values (average 9-209 mg/l equivalent to 0.4-15 t/km²yr) show that sediment flux is relatively low in Catalan rivers compared with other Mediterranean rivers [1].

River regulation in the form of dam construction and water extraction concentrates in 2 of the 10 studied basins. Residence times on reservoirs range from one day to more than one year, causing variable impacts on sediment transport. 10 over the existing 16 dams retain more than 90% of the suspended material. The overflow rate indicates that only 4 dams allow bypassing medium silt sized sediment.

All the parameters collected from the Catalan basins were used to develop a TSS multiple regression model (R^2 =0.87) that involved Q, slope, the Fournier index, the percentage of agricultural land, and the percentage of outcropping hard rocks. We also compiled all the available Mediterranean natural (before human regulation) water and solid discharge values and the same lithologic, climatic, land-use, and geomorphic parameters used

for the Catalan case in order to analyse a larger number of Mediterranean rivers on the same basis and compare the resulting models. 79 Mediterranean river basins ranging from 300 to 90,000 km² were considered. The highest correlation indexes (r>0.6) are found between Q, P and 1/T, while TSS is best correlated with the inverse of the basin area and with the percentage of outcropping sedimentary rocks. The best multiple regression models between TSS and the available parameters come to light after classifying river basins by their temperature-precipitation relationship, obtaining 4 sets of rivers with significative regression models (R²=0.42-0.99) based on slope, basin area, P, T, lithology and land-use. Our first results show that most of the Catalan rivers are part of the driest Mediterranean groups whose sediment flux depends largely on terrain characteristics such as lithology, land-use and slope.

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MORPHODYNAMIQUE ET EVOLUTION GEOMORPHOLOGIQUE DU COMPLEXE LAGUNAIRE DE NADOR (LITTORAL MÉDITERRANÉEN ORIENTAL, MAROC)

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Résumé

L'étude géomorphologique détaillée du complexe lagunaire de Nador et de son arrière pays (littoral méditerranéen oriental Maroc) a été réalisée en intégrant pour la première fois : l'analyse des images satellites, l'analyse morphostructurale, l'étude de terrain, les données historiques et l'outil informatique. Elle a permis de réaliser une carte morphostructurale, une carte géomorphologique et un MNT continent/ lagune/plate-forme et de préciser le cadre géomorphologique et géodynamique régional, en particulier, l'extension du bassin versant et les facteurs qui ont contrôlé la genèse et le mode d'évolution du complexe lagunaire. Elle a également permis de préciser la morphodynamique et l'évolution morphologique du complexe lagunaire de Nador.

Mots clès : Lagoons, Coastal Systems, Geomorphology, Western Mediterranean.

Introduction

L'étude géomorphologique détaillée du complexe lagunaire de Nador (littoral méditerranéen oriental Maroc) et de son arrière pays (Fig. 1) a été réalisée dans le cadre du projet COLASU en intégrant pour la première fois : l'analyse des images satellites (Landsat MSS., 1975 ; Landsat TM ,1986, 1988, 1993 et Landsat +ETM, 2000, 2005), l'analyse morphostructurale, l'étude de terrain, les résultats de l'interprétation des photos aériennes au 1/20000 [1, 2], les données historiques et l'outil informatique. En plus, de l'établissement d'une carte morphostructurale et d'une carte géomorphologique, ce travail a permis de préciser le cadre géomorphologique et géodynamique régional ainsi que la morphodynamique et l'évolution géomorphologique du complexe lagunaire.



Fig. 1. Situation de la lagune de Nador.

Cadre géomorphologique et géodynamique régional

Les résultats obtenus ont permis d'identifier les failles (N-S, E-W, NE-SW et NW-SE) ayant servi de moteur à la tectonique et à la subsidence qui sont à l'origine de la genèse et du contrôle de l'évolution de la lagune de Nador. Par ailleurs, la réalisation d'un modèle numérique de terrain (MNT) continent/ lagune/plate-forme a permis d'aboutir à des conclusions essentielles pour la compréhension du contexte géomorphologique et géodynamique de la zone d'étude.

- Les chaînons montagneux encadrant la lagune s'organisent selon des alignements qui dessinent un V ouvert vers la mer. Cette disposition explique à la fois l'origine multi sources des apports qui alimentent la plaine de Bou Areg et son caractère subsident.

- La lagune montre une intégration morphologique logique dans la géométrique continentale générale de la région. Elle correspond au point de convergence topographique principal de ce secteur.

- L'île barrière correspond à une discontinuité géomorphologique entre le compartiment continent-lagune et la plate forme continentale. Cette discontinuité prolonge la faille de direction WNW-ESE, qui est à l'origine de l'exhaussement des barres de calcarénites ayant servi d'île barrière lors de la genèse de la lagune.

- La limite du bassin versant de la lagune correspond au ressaut topographique qui sépare la plaine du Gareb et la plaine de Bou Areg. L'île barrière est constituée par quatre unités morpho- sédimentaires limitées par des accidents : N-S, N 70 et N 45 (dont le jeu peut être vertical ou décrochant). L'extension des deux unités centrales est différente de celle proposée antérieurement [2, 3]. La position de la passe a changé plusieurs fois au cours de l'histoire de la lagune. En 1975, la passe était située au niveau du delta relique de Oulad Zahra. La passe qui a fonctionné il y a 1000 à 1200 ans a évolué en tombolo simple entre 1975 et 1993 puis en double tombolo. La passe située entre l'extrémité SE de l'île barrière et la Tour Restinga dont l'ouverture est liée à un mouvement de failles a été comblée par des flèches azoviennes dont la progradation se poursuit actuellement comme cela est attesté par les images satellites de 1975 à 2005. La superficie des extrémités de la lagune a enregistré une diminution depuis 1975 du fait du comblement artificiel de l'extrémité NW pour les besoins de la construction du port de Beni Ensar et de la progradation d'une flèche sédimentaire dans l'extrémité SE. Cependant, la profondeur de la lagune n'a pas changé comme cela est démontré par les mesures bathymétriques effectuées au cours de la campagne d'hiver 2003, qui indiquent pour la zone centrale, la même profondeur (7.5 m) que la carte bathymétrique de l'Institut hydrographique de Cadix, réalisée en 1951. Dans la bordure continentale, les deltas des émissaires enregistrent un engraissement progressif depuis 1975, alors que les trottoirs subissent des sapements fréquents.

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Morphodynamique et évolution géomorphologique du complexe lagunaire

A METHODOLOGICAL APPROACH TO STUDY THE ENVIRONMENTAL IMPACT OF OIL AND GAS OFFSHORE PLATFORMS

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Abstract

The Central Institute for Marine Research (ICRAM) deals with a monitoring of the eventual environmental impact of the offshore platform activities. Specific monitoring programmes concern the discharge of the Produced Formation Water (PFW) into the sea, the installation operations of platforms and the existence of the offshore structures themselves. In this work we describe the methodological approach for the offshore monitoring used by ICRAM since more than five years.

Keywords : Adriatic Sea, Monitoring.

The oil and gas industry is truly global, with operations conducted in every corner of the world. In Italy there are about 1200 productive wells and 124 offshore platforms, whose 112 in the Adriatic Sea. Oil and gas exploration and production operations have the potential for a variety of impact on the environment. This potential impact may be avoided, minimized and mitigated, through proper tools of environmental monitoring. In particular, with regards to the aquatic environment, the principal problems are linked to the installation of the offshore structure and then to waste streams of drilling fluids, cuttings, well treatment chemicals and produced formation water (PFW). Since 2000 the Central Institute for Marine Research has been carrying on national monitoring plans concerning the environmental impact both of the PFW discharge into the sea and of the installation operations and existence of platforms in the Adriatic Sea, according to national and international protection policies and legislation [1-4].

Our methodological approach matches information on physical, chemical and biotic variables in order to give the best description of the environmental quality status by means of an integrated approach [5]. Through an appropriate sampling strategy we monitor selected chemical and physical variables of water column and sediment, studying the effects on biota and spatial-temporal trend of the eventual alteration that could occur [6-7].

The perforation activities, by the discharge of the water-based drilling fluids and cuttings, and the positioning of a permanent structure may cause effective changes of the chemical quality and physical characteristics of sediment; moreover perturbations on the sea-bottom geomorphology and on the marine living communities could occur. During the offshore production phase water is produced along with oil and gas. This water is called Produced Formation Water (PFW). The PFW discharge impact on marine ecosystem is highly dependent on its quantity, its quality, the characteristics of the receiving environment and dispersion processes.

The extent of the impact can only be judged through specific monitoring activities. The following parameters have been selected for the environmental investigations.

Parameters to investigate Matrix

PFW

Parameter: BTEX, total mineral oil, aliphatic hydrocarbons, PAHs, phenols, metals, total nitrogen, sulphurs, sulphorate compounds, suspended matter, total organic carbon, nutrients, ecotoxicological assays *Water column*

Parameter: current, temperature, pH, salinity, trasmittance, dissolved oxygen, chlorophyll *a*, nutrients, total nitrogen, total sulphurs, particulate matter, BTEX, total mineral oil, metals, aliphatic hydrocarbons, phenols, ecotoxicological assays

Sediment

Parameter: grain size, % water, metals, PAHs, PCBs, organotin compounds, total nitrogen, sulphorate compounds, total mineral oil, total organic carbon, aliphatic hydrocarbons, phenols, BTEX, ecotoxicological assays, macrozoobenthic soft-bottom community analysis *Biota*

Parameter: fish assemblages analysis, bioaccumulation analysis on *M. galloprovincialis*

Sea bottom

Parameter: bathymetry and morphology

The investigations on water column, sediment and biota matrices allow to study, thus highlighting, the natural features of the marine environment

and then the changes due to the PFW discharge into the sea and to the presence of the offshore structure.

Chemical analysis is known to permit to identify and quantify different single compounds responsible for the environmental contamination, so to give a measure of pollution. Nevertheless, since the chemical approach alone can not provide information about the possible toxicity of bio-available pollutants, it should always be associated to biotic investigations [8]. The monitoring of chemical-physical characteristics of water and sed-iment, together with ecotoxicological assays, bioaccumulation analyses, macrozoobenthic soft-bottom community structure and fish assemblages study, let to provide the necessary information for assessing the actual spatial and temporal perturbations occurring in the marine ecosystem. Moreover, the acoustic investigations can also allow to map the alterations and to supply the background information necessary for a correct planning of sampling activities and represent the basis for a long-term monitoring study.

The methodological approach presented in this paper is the result of more than five years of experience, gained by ICRAM in the drawing up of the monitoring projects, the performance of the analytical methodologies and the carrying on the monitoring activities. This kind of studies allow us to collect integrated data in order to provide environmental information particularly useful for the public administration and decision makers for the protection of the marine ecosystem.

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EVALUATING THE IMPACT OF CIVIL WORKS ON WATER FLOW IN THE INLETS OF THE VENETIAN LAGOON

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Abstract

Local fishermen in the Venetian lagoon reported an increase in the currents velocities at Chioggia inlet. A deeper insight into ADCP records revealed an increase in the flow energy even though the average remains statistically unchanged. Also a significant change in the relationship between vertically averaged current time-series and water flux rate has been detected directly connected with the reduction of cross-sectional area due to civil works carried out inside Chioggia inlet.

Keywords : Currents, Lagoons, Time Series.

Long-term monitoring has been going on in the inlets of the Venetian lagoon within the framework of CORILA project to study variability of water exchange at different time scales between the lagoon and the open sea. Current measurements have been carried out with bottom mounted ADCP (Acoustic Doppler Current Profiler) since June 2001 in Lido and Malamocco inlets and since February 2002 in Chioggia inlet.

Since the Italian government approved major works in order to prevent the flooding of the city (locally called "Acqua Alta") this record has become essential in order to study possible changes in the dynamics due to civil works carried out. Previous analysis have revealed a highly tidal driven flow with 95% of the energy due to astronomical signal [1], [2]; an other property is the high polarisation along the channels with more than 99% of energy in the principal axe at each channel.

Commenting of local fishermen about changes in the velocity of currents in Chioggia became evident by the end of 2005. Also minor precision in the tidal predictions based on the bottom-mounted ADCP was noticed. Once failures at instrumental level were discarded, Principal Component Analysis (PCA) and Harmonic Analysis (HA) were applied to currents time series on a monthly basis to obtain series of estimates of main HA parameters as well as energies, maxima and minima currents.



Fig. 1. Standard deviation of vertically averaged time-series of currents in the inlets of the Venetian lagoon with the major civil interventions indicated: 1.- Begining of works. 2.- Barrier under the sea surface. 3.- Barrier start emerging. 4.- Ending of works. 5.- Construction of navigation lock. 6.- Finishing of navigation lock.

Statistic tests yielded no detectable change in the mean currents values, but a gradual increase of velocity maxima and minima has been found in Chioggia since late 2004. This indicates an increase in the variability as apparent in the Figure 1. Also estimates of magnitudes of K1, M2 and S2 tidal constituents denoted an increase in Chioggia, which is connected also with the velocities reported by the fishermen. However, the average remains statistically unchanged so an increase in the energy follows as a consequence.

Chronology of major civil interventions is also shown in the Figure 1

including wave-breaking barriers and navigation lock. In Malamocco constructions are outside of the inlet while they are inner in Chioggia. Moreover, the cross-sectional area has decreased in Chioggia by about 18% causing the increasing of currents magnitudes even though they are the same in average. Thinning of channel changed also the linear relationship between water transport (Q_T) and the vertically averaged velocity (V), which was used as a predictor in the estimation of water flux rates. While this relationship was $Q_T = 4969.2V - 159.61$ with $R^2 = 0.9808$, now it is $Q_T = 4023V - 18.07$ with R²=0.9940. So, higher velocity is required in order to produce the same water transport. The transport, which is mainly astronomically driven, tends to be steady. Additional studies are necessary to complete the picture of impact of civil interventions in the water exchange rate.

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PHYSICAL PROPERTIES AND NUTRIENT DYNAMICS IN COASTAL WATERS OF SOUTH TYRRHENIAN SEA (CAMPANIA REGION)

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Abstract

Seven coastal sites along the Campania Region (Southern Tyrrhenian Sea) were sampled biweekly from June 2001 till May 2005 for physical and chemical properties. As expected due to very different riverine and anthropic influences, notable differences in hydrographical and chemical properties occurred but still common patterns in temperature, salinity and nutrients were observed. *Keywords : Coastal Systems, Tyrrhenian Sea, Monitoring.*

Introduction

The coastal zone is one of the most valuable areas of Earth from a human perspective. More than half population resides within 100km from the coast and this proportion is expected to increase in the future. Large perturbations related to human activities on land have contributed to severe degradation of water quality and alterations of marine food webs and community structure. Trying to evaluate the response of coastal waters to human perturbations and climate changes is the challenge of the worldwide monitoring coastal water programs. This study is conducted in the framework of the Italian monitoring coastal ecosystems project. The physical properties and the nutrient dynamics of seven sampling sites, distributed along the coasts of the Campania Region (South Tyrrhenian Sea), were analysed. The stations differ for their environmental conditions from strongly eutrophic (influence of large urbanized areas, proximity of river outlets) to oligotrophic (in a Marine Protected Area).

Materials and Methods

The sampling was carried out biweekly from June 2001 till May 2005. Temperature and salinity profiles were acquired by a SBE 19 Plus of Sea - Bird Electronics. Nutrient analyses of surface samples were performed with a TECHNICON II autoanalyser.

Results

Temperature profiles showed a clear seasonal pattern (thermal stratification during summer and winter mixing) and a strong interannual variability. In winter, a progressive temperature decrease was observed in all the sampling stations. The minimum temperature, integrated over the water column, was 1.4° C lower in 2005 as compared to the 2002 value. Highest temperatures were recorded in the surface layers in summer 2003 (28.4 \pm 0.5 °C). Due to freshwater inputs, local hydrodynamic conditions and water column depth, salinity showed a pronounced spatial variability. The lowest salinities were recorded in the proximity of rivers and the highest occurred in the Marine Protected Area. Despite the very different properties observed, a decrease in salt content was noticed in all the sampling sites during the spring - summer period from 2001 till 2004.

Nutrient concentrations showed a very wide range of variability. The average concentrations of dissolved inorganic nitrogen (TIN) were two orders of magnitude greater in polluted areas (e.g. 18.3 μ M off the Volturno River as compared to the Marine Protected Area 0.5μ M). Each sampling site presented a specific N:P ratio. This ratio was higher than the Redfield value [1] near the river mouths (>40), close to the typical western Mediterranean ratio [2, 3] near the city of Naples (18), and lower for the Marine Protected Area (10). However, the N:P ratio always presented a bimodal distribution strongly linked to seasonality. The minimum values were recorded in the period from May to September, mainly due to a relevant decrease in TIN. Phosphates, total phosphorous and total nitrogen did not show a clear seasonal signal.

Discussion

The sampling sites presented different hydrographical and chemical properties related to their environmental conditions. In particular, the northern part of the Campania coastal area resulted more influenced by human activities. Despite these strong differences, common patterns in temperature, salinity and nutrients were observed. The different N:P ratios in summer and in winter was opposite to that observed in the western Mediterranean open waters (Dyfamed time-series station) [4]. However, a preliminary analysis suggests that the different phytoplankton communities (prymnesiophytes in Dyfamed, diatoms in Campania coastal waters) might explain these differences in nutrient dynamics.

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DEFINITION AND OPERATING VERIFICATION OF INSTRUMENTS AND PROCEDURES FOR THE MANAGEMENT AND THE SUSTAINABLE DEVELOPMENT OF THE MEDITERRANEAN BEACHES

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Abstract

BEACHMED-e RFO "Strategic management of beach protection measures for the sustainable development of the Mediterranean coastal areas", financed by INTERREGIIIC-Sud European Program, faces several themes related to coastal management, overall related to coastal erosion defence. An entire Component of the Operation is dedicated to the feasibility study of a European "Observatory System" for the Defence of Mediterranean Coast, presented as a useful tool foretold by several administrations involved and with competences on coastal management. They expressed a diffused awareness of the need to monitor erosion in all its aspects, as a territorially based phenomenon on a continental scale and having a structural nature.

Keywords : Erosion, Beach, Coastal Management, Monitoring, Shoreline Evolution.

One of the main lines of activities of the Beachmed-e Operation responds to the need to create a European Observatory for the Defence of the Mediterranean Coast in order to survey the morphological changes (erosion, shoreline evolution, etc.). The study for this proposal includes the census of the infrastructures involved in the monitoring and defence of the Mediterranean beaches, the description of methods and control systems for each region and the assessment of these systems. The motivation comes from the interpretation of a diffuse awareness, within scientific and administration bodies, about the need of a systematic survey and monitoring of coastal erosion phenomena at a continental Mediterranean basin scale [1, 2]. The idea is to create a network with already existing structures, to promote the creation of new structures were needed and to provide services to them. In order to maintain its indispensable flexibility and overall applicability, then, the feasibility study must not just concern "an observatory" but "an Observatory System" which must find its basic foundations in current, potential or existing organisational assets.

The Observatory should be an opportunity both for administration bodies, already having or not having dedicated structures, and for scientific community all around the Mediterranean basin, in order to optimise data acquisition/purchase, elaboration processes, techniques and outputs, exchange of best practises. The system should allow registering and observing the phenomenon of coastal erosion, analysing the morphological changes in a quantitative way, predicting crisis in wide areas in medium or long term, informing about work, initiatives and opportunities in the field of coastal defence, offering advices in environmental, technical and juridical matter concerning dredging and nourishment work in the Mediterranean sea. Additionally, a structured IT system would be carried on for the management and collection of data, modelling and simulation of dynamic processes in large Coastal Zone, helped by a geographic information system (GIS) that would be able to distribute statistical and cartographical data of the Coastal Zone.

To build up a first nucleus of organisations which already hold some experience in coastal defence represents a primary importance goal, especially if these structures are already integrated within existing administrative structures or have anyway some authority in terms of defending coastlines.

In fact, the strategy of giving preference to or highlighting those administrative situations which are directly connected to the management of coastal defences, is to be encouraged. In this way the link between the "Observatory System" and planning activities can be favoured if not guaranteed (for obvious structural reasons).

The work method proposed for the development of the sub-project therefore focuses - thanks to the required technical/scientific contributions on existing structures and those that may potentially be developed within Public Administrations, specialised in local planning and managing initiatives for coastal defence. These are the main planned activities:

1. CURRENT STATUS: census and analysis of the structures which carry out coastal monitoring activities, especially in terms of erosion or climatic phenomena, through direct contacts and questionnaires.

2. NEEDS: Exploratory analysis of information needs for structures to

defend coastlines.

3. METHODOLOGY: proposal of an observatory system for an organisational and operative point of view (type of organisation, activities to be carried out, costs, etc.).

4. RESOURCES: Exploratory cost analysis (in monetary and organisational terms) currently incurred to monitor coasts, potential costs incurred for operations - not necessarily public - interested in supporting monitoring activities

The study of feasibility is already started in the 2005 and will be ended within June 2008. The first issues are already published on the web site www.beachmed.it in the OBJECTIVES REPORT (measure 4.1) and the future developments will be dealt in the pages of OBSEMEDI sub-project [3].

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INVESTIGATION OF BLACK SEA COASTAL CURRENT CIRCULATION BY REMOTE SENSING AND OCEANOGRAPHIC DATA

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Abstract

Increasing resolution of satellite data and recent coastal oceanographic researches has contributed significances to our present information of the Black Sea coastal current circulation. Coastal eddies observed in the Black Sea are normally elongated, anticyclonic gyres jammed between the cyclonic Rim Current over the coast and the shelfbreak. In this study, near-shore current system of the Turkish Black Sea coasts is investigated in the light of the data collected in six main cruises handled between the years 2003 and 2005 and the satellite images of the region.

Keywords : Black Sea, Remote Sensing, Surface Waters.

Introduction

The Black Sea is a nearly enclosed basin connected to the Marmara Sea and the Azov Sea by the narrow Turkish Strait system (Bosporus, Marmara Sea and Dardanelles) and Kerch Straits, respectively. Its catchment area covers large parts of Europe and Asia, providing a total freshwater supply of 3 x 102 km³ per year. However evaporation exceeds precipitation, the freshwater flux remains large in comparison to basin volume (approximately 5.4 x 105 km³), making the Black Sea having brackish water. Because of the large freshwater flux and the narrow opening in the strait of Bosporus, the exchange between the Black and Marmara Sea is asymmetric: the volume of water transported by the out flowing surface current is two times larger than the inflowing deep counter-current, thus the Black Sea's surface salinity is about half that of the Mediterranean's salinity. Unlike other large estuarine basins (e.g., the Baltic Sea), the Black Sea is a deep basin (maximum depth of 2200m) with a large shelf. A distinct vertical avering is created between the surface waters in the upper 100 m and the deep waters, limiting the vertical exchange and creating a unique chemical and biological environment.

The Black Sea circulation involves a complex, eddy dominated system with different types of structural organization in which eddies and gyres of the interior cyclonic cell interact continuously among themselves and with meanders and filaments of Rim current system [1].



Fig. 1. Coastal surface circulation of the Black Sea observed by satellite images.

Results and Discussion

As bottom topography is known to be the main controlling agent of the Black Sea surface circulations, we can talk about wind curl effects to be the secondary in triggering relative vorticity for the Black Sea basin. In addition to these, along the Turkish shores, the shoreward side of jet is a regional of strong anticyclonic shear typically 40 cm/sn per each 10 km. An other derived result is the strong seasonal stratification cycle that probably has an important effect on coastal anticyclogenesis through nonlinear dynamics.

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EVALUATION DES RISQUES D'INONDATION DUS A UNE ÉLÉVATION DU NIVEAU MARIN: ANALYSE PRÉVISIONNELLE DE LA ZONE COTIÈRE DE TÉTOUAN, MAROC

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Résumé

En raison du réchauffement climatique, le niveau moyen global des océans est en hausse et les risques d'inondation des terres basses et peuplées sont à craindre. Une étude prospective de telles menaces a été réalisée sur le littoral de Tétouan situé au Nord du Maroc, pour les horizons 2050 et 2100. L'analyse montre que quelque soit le scénario d'élévation du niveau marin, les submersions y seraient préjudiciables, particulièrement sur la côte sud plus basse et où la population y serait plus menacée. Les pertes en terre par inondation sont estimées entre 36 et 50% de la superficie totale de la zone d'étude; ce qui aura des impacts considérables sur les écosystèmes et les valeurs socio-économiques. Une stratégie d'adaptation est par conséquent nécessaire pour protéger cette côte de plus en plus convoitée par le tourisme, contre un phénomène incontournable.

Mots clès : Sea Level, Shoreline Evolution, Coastal Systems, Mapping, Western Mediterranean.

Les conséquences potentielles du réchauffement climatique en termes de hausse du niveau de la mer, sont inquiétantes pour les infrastructures et les populations des zones cotières. Mais le plus menaçant serait la probabilité d'une intensification et d'une fréquence plus grande des événements extrêmes qui entraîneraient des inondations exceptionnelles. Le Maroc, qui possède 3500 km de côtes dont certaines très basses, n'est pas épargné par ces risques, d'autant plus que plusieurs secteurs côtiers ont été modifiés et aménagés de façon intensive au cours des dernières décennies; ce qui les a fragilisés et rendus plus vulnérables à une remontée du niveau marin. Cette étude consiste en une évaluation prévisionnelle des risques d'inondation dus à une accélération de l'élévation du niveau de la mer sur le littoral de Tétouan. Il s'agit d'une cote qui s'étend sur 44 km entre Fnidek au Nord et Azla au Sud et qui présente deux zones sableuses basses séparées par un cap rocheux. Ce littoral, l'un des plus urbanisés de la Méditerranée occidentale marocaine, comprend trois centres urbains totalisant une population de 500,000 habitants [1]. Sur le plan naturel, ce littoral recèle en outre des écosystèmes variés potentiellement très vulnérables: plages, plaines alluviales et zones humides cotières. L'économie du secteur est basée principalement sur le tourisme balnéaire. La méthodologie adoptée est basée sur le choix d'un certain nombre de scénarios : (i) L'élévation relative actuelle du niveau moyen de la mer utilisée est celle mesurée par Topex /Poseidon depuis 1993 en Méditerranée occidentale, et qui est en moyenne de 2.5 mm/an. Cette valeur ne tient cependant compte que de l'effet du forçage anthropique du climat. (ii) Les scénarios d'élévation eustatique future du niveau marin utilisés sont ceux du troisième rapport du GIEC [2], qui suggère une augmentation du niveau global de la mer entre 0.09 et 0.88 m d'ici 2100, avec une valeur médiane de 0.48 m. Trois scénarios d'élévation future du niveau marin ont été considérés pour les deux horizons temporels 2050 et 2100 : des prévisions sans accélération de l'élévation du niveau marin, une hypothèse moyenne et une estimation haute de l'élévation du niveau de la mer. (iii) Deux scénarios d'inondations avec un niveau minimum et un niveau maximum ont été déterminés à partir de la formule de Hoozemans et al. [3]. Afin d'évaluer les zones à risque d'inondation, ces niveaux ont été ensuite digitalisés en tenant compte de la topographie et de l'occupation des sols. Les résultats montrent que pour un niveau d'inondation minimum de 5 m, 36% de la totalité du littoral étudié seraient submergés. Ils atteindraient 50% de la superficie totale pour un niveau d'inondation maximum de 10 m. Ce dernier correspondrait à la conjonction exceptionnelle de tempêtes extrêmes et de l'hypothèse haute de l'élévation du niveau de la mer. L'invasion marine se ferait particulièrement par les plaines littorales (Restinga, Smir et Martil) avec une extension plus importante de zones submergées dans la côte sud à topographie basse (Fig.1). Les bouleversements environnementaux affecteraient la population cotière, particulièrement celle de la ville de Martil qui serait la plus menacée, ainsi que tous les écosystèmes côtiers. En outre les impacts seraient catastrophiques pour les infrastructures (ports, routes, unités industrielles, complexes touristiques et centre urbain de Martil) et par conséquent tous les secteurs socio-économiques seraient affectés. L'élévation accélérée du niveau de la mer conjuguée aux événements climatiques extrêmes, pourrait avoir de lourdes conséquences sur l'avenir du littoral de Tétouan. Une stratégie d'adaptation est impérative pour faire face aux impacts d'un tel phénomène et à ceux des changements climatiques en général.



Fig. 1. Superficies inondables avec des niveaux de submersion de 5 m et 10 m du littoral de Tétouan en réponse à l'élévation du niveau de la mer

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CU AND PB INPUTS FROM A SMALL RIVER TO THE MEDITERRANEAN SEA

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Abstract

The particulate and dissolved Cu and Pb inputs to the Mediterranean Sea from a small, anthropized Mediterranean coastal river located in the South of France were quantified along a whole hydrological year. More than 90% of the annual metal inputs were due to short, intense floods, occuring after a long dry period. Extrapolation to the whole Mediterranean basin indicates that the Cu and Pb inputs from such small rivers are of the same order of magnitude than the inputs from large rivers, and they should not be neglected in their pollution contribution to the sea.

Keywords : Coastal Waters, Metals.

Most studies concerning continental inputs to the sea focused on large rivers. However, small coastal rivers, can have a high ecological impact because they rapidly bring to the sea the contamination produced in the coastal area, especially when it is located in dense human population area. Among the studies of small coastal rivers, only a few deal with the Mediterranean area, despite its fast anthropization and its climate specificities: long dry periods corresponding to low water levels (base-flow) are interrupted by short, severe floods.

We chose to study the Eygoutier river, whose watershed is representative of modern anthropization, mixing urban, semi-urban, small industrial and agricultural areas. The base-flow of the river is typically around 10 $m^{3}h^{-1}$, while the river flow rapidly (commonly within 15 minutes) increases up to $40,000 \text{ m}^3\text{h}^{-1}$ during floods. After the end of a rainfall, the river returns to its base-flow level within less than 24 h. We characterized the base-flow along one hydrological year and we studied into details 5 representative flood events occurring within one year. We quantified the fluxes of suspended particulate matter (SPM, fraction >0.22 μ m), dissolved organic carbon (DOC), particulate organic carbon (POC), as well as dissolved and particulate Cu and Pb and nutritive ions brought to the sea. The base flow was studied by a bimestrial sampling and the floods by the mean of an automatic sampler providing 25 samples per flood, the sampling interval being smaller at the beginning of the flood because of higher concentrations. The water flow was measured every 30 minutes all along the year 2004. The base-flow fluxes were calculated by multiplying the mean concentration values by the mean base flow. Flood fluxes were calculated considering that any flow higher than $200\,\mathrm{m^3}\,\mathrm{h^{-1}corresponded}$ to a flood event. Consequently, 1432 hours of flood (16% of theyear) were registered during the year 2004 with a mean flow around 5100 m³.h-1. The Table 1 presents the fluxes calculated over the whole year.

Tab. 1. Species annual fluxes at the outcome of the river.

	Base flow	Flood	Total
Flow (m ³ .yr)	0.39 10 ⁶	7.34 10 ⁶	7.73 10 ⁶
MES (t.yr ⁻¹)	5.1	2638.4	2643.5
DOC (t.yr ⁻¹)	4.7	125.7	130.4
$POC(t.yr^{-1})$	1.2	384.7	386.0
Dissolved Pb (kg.yr ⁻¹)	0.1	8.2	8.3
Dissolved Cu (kg.yr ⁻¹)	1.9	26.0	27.9
Particulate Pb (kg.yr ⁻¹)	1.2	452.4	453.6
Particulate Cu (kg.yr ⁻¹)	1.4	466.3	467.7

The total Pb concentration transferred to the sea was estimated around 462 kg.year⁻¹ (98% in the particulate phase) and the total Cu concentration around 496 kg.year⁻¹ (94% in the particulate phase). More than 99% of the total Pb and Cu were transferred during floods, exceeding the values acceptable for a good quality water. This indicates that brief periods of high metal concentrations occurred at the outcome of the river, and could have a negative impact on biological life in the sea. Considering the whole Mediterranean basin, the annual input of riverine water is 620 km³.year⁻¹, with 81% brought by the northern half of the basin [1]. Six large rivers (Nile, Rhône, Pô, Drin, Ebro and Neretva) contribute for 43.4% of the annual input, and the 56.6% remaining are due to small rivers. Extrapolating our small river data to the corresponding water vol-

ume, small rivers input to the Mediterranean Sea would be around 25 and 420 t.year⁻¹for dissolved and particulate Cu, respectively, and around 7 and 408 t.year⁻¹for dissolved and particulate Pb, respectively. This extrapolation is somehow excessive, but gives an order of magnitude of what would be small rivers input by a fully anthropized Mediterranean coastal area. For comparison, realizing a similar extrapolation to larger river inputs to the Mediterranean scale using the Rhône annual transfers values [2], 517 t.year⁻¹ of total Cu and 26 t.year⁻¹ of total Pb were obtained. Such values do not go beyond rough estimate, but, being of the same order of magnitude than the input from small rivers, indicate that the latter cannot be neglected in contaminant balance at the Mediterranean scale.

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DUMPING OF HARBOUR-DREDGED MATERIAL: A MULTIDISCIPLINARY MONITORING STUDY OF TWO DISPOSAL SITES IN CENTRAL ADRIATIC SEA (ITALY)

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Abstract

About 600.000 mc of sediment from Port of Pescara (Central Adiatic sea, Italy) were dredged and dumped in two sites located 3-4 Nm from the coast, during the period 1994-2004. In order to assess the potential environmental impacts due to the dumping of harbour-dredged material, the Central Institute for Marine Research (ICRAM) performed a multidisciplinary monitoring plan that carried out during three cruises (1999, 2001, 2004).

Keywords : Adriatic Sea, Chemical Analysis, Coastal Systems.

Accessibility of ports, harbours and navigable waterways is very important for the economic growth of coastal regions. Navigable depths must be maintained by repeated dredging and the disposal of dredged materials is one of the most important problems of coastal zone management. Depending on their chemical and sedimentological characteristics, dredged sediments may be disposed of in different ways. Sometimes good quality dredged materials are dumped in appropriate off-shore disposal sites.

In this context ICRAM (Central Institute for Marine Research) in 1999, 2001 and 2004 performed monitoring activities in two dumping sites of material dredged in the harbour of Pescara (Central Adriatic Sea). In these zones (defined as site A and site B), partially overlapping, about 600.000mc of materials were dumped between 1994 and 2003. These sites are located 3-4 Nm offshore, between 21 and 60m of depth.



Fig. 1. Location of sampling stations and dumping sites.

During the monitoring activities acoustic investigation and sampling of sediment for physical (grain size), chemical (heavy metals, PCBs, Pesticides, PAHs, TBT, DBT, TOC and organic substances) and biological (benthic fauna) analyses were carried out.

The acoustic investigation performed by side scan sonar highlights a non homogenous distribution of harbour-dredged materials in the dumping sites. In particular the most amount of materials is concentrated in the landward part of site A, with some deposits out of the authorized area. In the overlapping sector between sites A and B sporadic deposits were also observed.

The grain size analysis shows the preponderance of clayey silt and silty clay, with the fine fraction increasing with depth. In the sampling station S1, located in the landward part of site A, a dysfunctional content of coarser sediments (gravel: 7.12%, sand: 29.45%), with respect to the previous monitoring activities is observed. In the same station, an anomalous concentration of lead (604.5 mg/kg d.w.) is found. This value can be associated with the presence of dumping material. Lower values of TOC

and organic substance are found in the sampling station S1 and S3, both located in the site A and characterized by low percentage of mud.

PCBs levels detected in the dumping sites could be considered low (range 3.98-9.61ng/g). Lindane and Aldrin are absent in both sites investigated. DDT and its metabolites concentrations are lower middle (max value 5,55 ng/g d.w.).

PAHs concentrations result very low in all sampling stations (range 53 - 194 ng/g). Levels of contamination by TBT ranging from low (30 - 50 ng TBT/g) to moderate (65-85 ng TBT/g). Instead DBT concentrations are lower than the detectable limit.

Finally, the macrozoobenthic communities do not show any effects related at dumping of harbours sediments.

In conclusion, we point out that in site B, located at a gretaer distance of the coast, only sporadic deposits of harbour-dredged materials were observed. Moreover, these deposits were located in the landward part of site B, which is overlapping with site A. Evidence of recent and more consistent harbour-sediments deposition was found in site A; in addition some cumulus were found outside the authorized area on the landward side.

We underline the necessity to limit the dumping of harbour sediments derived from dredging activities in off-shore disposal sites and to prefer other, less impacting solutions.

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TOURIST INDUSTRY GROWTH PRESSURE ALONG THE BULGARIAN BLACK SEA COAST

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Abstract

Coastal zone representing the boundary between sea and land is a highly dynamical and sensitive area that comprises a large variety of natural resources. Population growth in the littoral causes rapid urbanization of the coast, development of infrastructures, transport system and so on. Therefore, coastal ecosystems experience pressure and become vulnerable to pollution, habitat degradation and loss, overfishing, and increased coastal hazards. Accelerated tourism development during the recent years is an extra risk factor for the Bulgarian Black Sea coastal zone. Considering that the coastal zone is a limited and very vulnerable land area, the high population increase due to tourism is one of the most hazardous factors for coastal zone sustainability. Although tourism growth and coastal development give rise to a number of economic benefits, they also could lead to loss of habitat, green space, and biodiversity. *Keywords : Black Sea, Coastal Management.*

Introduction

Coastal zone is a highly dynamical and sensitive area that comprises a large variety of natural resources. This predetermines the attractiveness of the littoral for settlement and other human activities, like tourism, recreation etc. Population growth causes rapid urbanization of the littoral, development of infrastructures, transport system etc. Therefore, coastal ecosystems experience pressure and become vulnerable to pollution, habitat degradation and loss, overfishing and increased coastal hazards [1]. Vast sand beaches along the Bulgarian Black Sea coast, in combination with favorable climate and clean seawater, are valued preconditions for tourist industry development. The speeded tourism development during recent years is an extra risk factor for coastal zone. Both local residents and tourists cause pressure to the ecosystem, therefore population in the coastal regions is used as pressure indicator for ICZM [2].

Analysis

The Bulgarian Black Sea coast, situated in the Western part of the Black Sea, has a 378 km long coastal line, 140 km of which occupied by 78 beaches. 14 of 262 state municipalities [3] are located in the coastal zone. The Bulgarian Black Sea coastal zone is 5.21% of the country territory and hosts 8.85% of the national population.

Official census results [4] show that during 1934-2001 the total coastal population growth is almost six times higher than in the entire country. Thus, the Bulgarian Black Sea coastal zone is one of the most rapidly growing and developing areas at national scale.

Tourism and in particular coastal tourism is one of the fastest developing world industry sectors [5], and Bulgaria follows this tendency. Data for tourist international arrivals in Bulgaria during the period 2000 - 2004 show that the number of tourists has been continuously increasing: from 2 354 052 in 2000 to 4 010 326 in 2004, so the gain is more than 70 %. Rapid development of coastal tourism is analyzed on the basis of official data [6] and the results are presented in Fig. 1.



Fig. 1. Tourist industry growth along the Bulgarian Black Sea coast.

It is found out that from 1999 to 2004 the number of hotels in coastal municipalities increased from 322 to 640, almost 100 %, beds number increased in 82.8 %, and the spending in 112 %. The biggest growing is registered in the most famous Bulgarian Black sea resorts - Golden

sands, Sunny beach and Albena, which now represent 76.25 % from the hotels, 84.18 % from beds, and counted 88.33 % from all spending in the Bulgarian Black coast. There is also a big disproportion between these 3 municipalities and the remaining 11, which indicates that some costal areas are critically overcrowded.

The number of tourists preferring to spend their vacation at the seacoast continuously increases as well. For the investigated period the growth is 118 % and the total number reached 1 450 188 that is more than twice the local coastal population. Most of the tourists (85.58 %) stay in the big resorts. Every tourist spends 7 days in average, but the busiest months are July and August. In these months, total coastal population increases with approximately 20%, but in some resorts more than 200%. The trend shows that at least a 10% yearly tourists' growth can be expected for the next few years.

In the analysis of human population pressure on the coastal ecosystem, it is assumed a total population of local residents plus tourists. In the last twenty years there is no significant local population growth. The continuously improved infrastructure has the capability to meet and reduce anthropogenic impact on the ecosystem caused by local population growth.

Conclusions

Tourist spate towards Bulgarian Black Sea coast dramatically increased during last fifth years and will continue to growth at least for few more years. The existing facilities in some municipalities are not able to meet this additional pressure and to reduce adequately anthropogenic impact to the marine ecosystems. Considering that the coastal zone is a limited and very vulnerable land area, the population increase due to tourism is one of the most hazardous factors for coastal zone sustainability. Although tourism growth and coastal development give rise to a number of economic benefits, they also could lead to loss of habitat, green space, and biodiversity, especially in case of new constructed tourist sites, some of which are in very low populated coastal regions or neighboring protected territories. Public policymakers and coastal managers are now facing the challenging task of finding a balance between benefits of touristm growth and mitigation of its effects on the coastal environment.

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DISSOLVED OXYGEN AND NUTRIENT CONCENTRATIONS IN KORINTHIAKOS GULF DURING 2004-2005

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Abstract

In this paper dissolved oxygen (DO) and nutrient data in the Korinthiakos Gulf are presented. Four sampling cruises were conducted by the Hellenic Centre for Marine Research, during 2004 - 2005, within the framework of the monitoring program "MED/POL". High DO concentrations were measured at all the stations of Korinthiakos Gulf. High values of nitrate and silicate were also measured in the deep basin of the Gulf. According to the DO and nutrient concentrations, it seems that the water column of the deep basin of Korinthiakos Gulf was fully homogenized.

Keywords : Eutrophication, Oxygen, Pollution.

Korinthiakos Gulf with a maximum depth of 900m, is connected to the west with the Ionian Sea through Patraikos Gulf and with the Saronikos Gulf to the east, through Korinthos channel. It is noteworthy, that very few scientific data for Korinthiakos Gulf are available and that makes the study of the area very interesting [1, 2]. The study area is affected by agricultural activities in the coastal zone as well as pollutants from domestic and industrial effluents (e.g. PECHINEY Power Plant Station in the north coast). Water samples for DO and nutrient (nitrate, nitrite, silicate, ammonium and phosphate) determination were collected during four sampling cruises in May and September 2004 and in February and December 2005, over a grid of six oceanographic stations [3]. The samples for the determination of nutrients were collected in 100 ml polyethylene bottles and kept continuously under deep freeze (-20 °C) until their analysis in the laboratory [4-7], whereas the DO analysis was performed on board, immediately after sampling using the modified Winkler method [8]. DO concentrations were high at all the stations of the Gulf showing temporal as well as spatial variation. The minimum DO concentration (4.73 ml/l) was observed in September 2004 at the relatively shallow station (depth 80m) in Itea bay. It is noteworthy, that at the deep basin of Korinthiakos Gulf the water column was well oxygenised. The comparison with existing data (2000) [2] confirmed that the deep waters of Korinthiakos Gulf are quite often renewed. During the period 2004 - 2005, nutrient concentrations in Korinthiakos Gulf ranged as follows: Phosphate: 0.097 - 0.264 μmol/l; Silicate: 0.98 - 7.23 μmol/l; Nitrite: 0.040 - 0.608 μmol/l; Nitrate: 0.07 - 5.87 µmol/l; Ammonium: 0.010 - 1.429 µmol/l. Spatial and temporal variation of nutrient concentrations was observed. Relatively high ammonium concentrations at the surface waters were measured probably related with anthropogenic pollution. High values of nitrate and silicate were observed in the deep basin of Korinthiakos Gulf (bellow 100-150m). It is interesting to notice that nitrate concentrations at the deep stations of Korinthiakos Gulf were lower than those recorded in the deep basin of the Western Saronikos Gulf (depth 420m). According to the nutrient data, the deep waters of Korinthiakos Gulf are enriched in nutrients showing the high rate of productivity in the area. The comparison with the previous data of 2000 showed a decrease in nitrate concentrations in the deeper layer (near the sea floor) as well as an increase in phosphate concentrations [2, 3].

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SUBMARINE GROUNDWATER DISCHARGE ESTIMATES ON COASTAL WATERS BASED ON ²²²RN MEASUREMENTS

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Abstract

Submarine groundwater discharges were estimated on two coastal area of the Mediterranean Sea from 222 Rn analyses in the water column. In the large Vaccares Pond (Rhone deltaic plain), the 222 Rn budget reveals a submarine input of about 1 10⁵ m³/d. In the small cove of Es Canutells (Minorca Island), this input is very low and probably below 2 m³/d. Both examples highlight the use of radionuclides in the estimation of SGD which could be an important information for coastal zone management

Keywords : Coastal Waters, Radionuclides, Geochemistry, Western Mediterranean, Coastal Management.

Submarine groundwater discharges occurs in various coastlines around the world [1, 2]. They are relatively well known and easily identifiable in karstic areas, but they are more difficult to evidence when groundwater and seawater are exchanged across sand sediment. However, this exchange could bring excess nutrients or dissolved pollutants to the coastal sea being the issue of growing concern [3]. Our understanding of submarine groundwater discharges (SGD) has improved during the last decade with the use of natural radionuclides to estimate the input of fresh or brackish water into the coastal zone (e.g. [4, 5]). Radon and radium are suitable nuclides for this purpose due to their short half-lives and their conservative behavior in salty water. They are highly enriched in groundwater compared to coastal water (factor up to 1000) due to in situ production in the aquifer, and thus, even a small input in the coastal zone may be evidenced. Here we present preliminary results of SGD estimations based on the noble radioactive gas 222 Rn ($T_{1/2}$ = 3.8 days) for two different coastal areas of the Mediterranean Sea : the Vaccares lagoon (France) and the Es Canutells cove (Minorca). These examples highlight the use of radionuclides in the estimation of SGD which could be an important information for coastal zone management.

The Vaccares lagoon system in the center of the Rhone deltaic plain is a good example of strong inter-relationships between human activities and ecosystem evolution. This hydrosystem is representative of human influences upon water and salinity regimes: for the last fifty years, the water resource management has led to complex situations with numerous conflicting objectives. The national GIZCAM project is dedicated to propose an integrated coastal zone management plan for this area. One of its objectives is to define the hydrological and salt budgets of the system, with a particular attention to the potential groundwater inputs. A RAD7 system was used to measure 222 Rn activities from water sam-

A RAD7 system was used to measure 222 Rn activities from water samples collected in June 2006 within the lagoon (surface 65 km²; maximum water depth = 2m) and from adjacent aquifers. Activities ranged from 25 to 150 Bq/m³ showing relatively constant values over the entire lagoon. Inputs of 222 Rn to the lagoon are due to diffusion from the sediment, in situ production from 226 Ra, irrigation canals and SGD inputs. The outputs correspond to the exchange with the atmosphere and in situ decay. By assuming a steady state balance, SGD can be estimated based on the measurements of the other terms. Doing so, the flux of 222 Rn from SGD required to sustain the water column inventories range from 8.5 to 11.3 Bq/m²/d. Assuming a 222 Rn activity of 6000 Bq/m³ for the SGD endmember, it corresponds to a groundwater input of 9.2 10⁴ to 1.2 10⁵ m³/d. This value is in good agreement with the one estimated from hydrological budget using long term measurements of water levels, precipitations and canal inputs (around 1 10⁵ m³/d).

The same approach was conducted in February 2006 in a small cove of Minorca Island (surface : 6000 m^2), where SGD inputs occurred through both the surrouding calcareous cliffs and the sand beach (program PICS). The radon budget based on calculations similar to those for the Vaccares Pond indicates a relatively low SGD with values lower than 2 m³/d. Important errors can be associated to some parameters with such a low SGD value (especially for the exchnage with the atmosphere) and they will be presented and discussed. Additional sampling is also required to reduce

these uncertainties. It will be done in winter 2007 and the first results will be presented.

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CONNAISSANCE ET PROTECTION DES ESPACES NATURELS MARINS ET CÔTIERS DE LA CÔTE ALGÉRIENNE

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Résumé

Devant le développement urbain et industriel en Algérie, la connaissance et la protection des sites naturels est le souci actuel. La diversité floristique, faunistique et paysagère est sans égal dans le bassin occidental de la Méditerranée. Plusieurs sites naturels ont été classés prioritaires et un réseau d'aires protégées (parcs nationaux et réserves naturelles) ont été mis en place. Une présentation d'une partie de ces espaces côtiers et marins sera exposée mettant en évidence l'importance et l'intérêt de la conservation de ces sites écologiques. *Mots clès : Biodiversity, Conservation, Coastal Management, Coastal Engineering.*

Le littoral algérien est l'un des pays les plus originaux d'un point de vue géographique, climatique et écologique et par voie de conséquence, parmi les plus intéressants sur le plan biologique et biogéographique. Plusieurs facteurs se sont conjugués pour offrir à l'heure actuelle une diversité floristique, faunistique et paysagère sans égal dans le bassin occidental de la Méditerranée. Le souci de protéger et de conserver ce patrimoine naturel [1, 2, 3, 4] est croissant devant le développement urbain et industriel. Plusieurs sites naturels ont été classés prioritaires et un réseau d'aires protégées (parcs nationaux et réserves naturelles) ont été mis en place. La connaissance, la protection et la conservation des sites naturels et plus particulièrement côtiers et marins sont présentées d'Est en Ouest :

Le Parc National d'El Kala, d'une superficie de 80 000 ha, est situé au Nord Est et fait partie de la Wilaya d'El Kala. Ce parc couvre 40 km de littoral de Cap Rosa au Cap Roux. Ce parc englobe une zone humide unique en son genre et classée réserve de la biosphère en 1990 par le programme M.A.B. de l'UNESCO. Ce parc est classé comme zone d'importance internationale (Convention de RAMSAR). Il est caractérisé par une grande variété d'écosystèmes :

 - L'écosystème marin et littoral: composé essentiellement de formations à corail rouge, d'herbiers à Posidonies. Les dunes littorales sont occupées par les formations naturelles à pins,

- L'écosystème lacustre : au niveau des lacs (Tonga, Oubeira, Bleu, ...), une flore très diversifiée est observée avec la présence de plusieurs espèces endémiques,

- L'écosystème forestier : composé principalement de forêts de chênes.

Le Parc National de Taza (Wilaya de Jijel) est situé dans la région Est de la côte algérienne, il comprend le massif forestier de Guerrouche tout en présentant une façade maritime puisqu'il offre 9 km de plages et de corniches. Il s'étend sur 3 807 ha. Ce parc a pour objectif de protéger la flore et la faune à intérêt écologique, floristique et faunistique, ainsi que les sites géomorphologiques (grottes et falaises).

Le Parc National de Gouraya : il s'étend sur une superficie de 2 080 ha et est situé au Nord Ouest de Béjaia (Wilaya de Béjaia). Il est caractérisé par un massif montagneux qui se brise dans la mer, il comporte 10,6 km de côte de rochers et de falaises. Il a pour objectif de protéger les sites aux paysages exceptionnels, de conserver et de sauvegarder l'écodéveloppement de la nature.

La Réserve Naturelle de la Macta : s'étalant sur une superficie de 19 750 ha, les marais de la Macta sont situés au Nord Ouest de l'Algérie à une vingtaine de km à l'Ouest de Mostaganem. L'intérêt de la création de cette réserve vise à la protection et au maintien de l'équilibre écologique des espèces faunistiques et floristiques menacées d'extinction.

La Réserve Naturelle Marine des Iles Habibas : elle s'étend sur une superficie de 2 684 ha, et se situe à l'Ouest de la côte algérienne (baie d'Oran). Cette réserve vise à protéger les espèces endémiques de faune et de flore. Plusieurs autres sites naturels méritent un intérêt écologique important, notamment le Mont Chenoua qui appartient à la baie de Tipaza-Bou Ismail à 70 km à l'Ouest d'Alger ; il présente une superficie de 8 000 ha sur sa partie terrestre et 2 000 ha en zone marine. Ce site est exceptionnel sur tous les plans: paysager, historique, culturel et naturel. La connaissance et le suivi scientifique sont indispensables à la protection et à la conservation des aires protégées. Il est important d'intégrer les phénomènes nouveaux ou potentiels qui interfèrent avec l'équilibre de ces écosystèmes, et d'appréhender le suivi des activités anthropiques directement ou indirectement liées aux intérêts patrimoniaux des sites, ou tout simplement pouvant interagir avec le fonctionnement écologique des écosystèmes protégés.

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FAST COASTAL PROCESSES ON VOLCANIC SHORELINES: EXAMPLES FROM STROMBOLI, ITALY

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Abstract

Very fast coastal processes occur on volcanic coastlines, particularly in response to alternating constructive (eruptive activity) and destructive (erosion or collapse) stages. Rapid morphologic readjustment has been documented at Stromboli after the 30/12/2002 landslide and tsunami. Studies of historical coastal evolution of the island, reconstructed from maps and aerial photographs dating back to the past century, clearly indicated that coastal processes develop at high rates. Alternating coastal accretion and erosion stages have been recognized, in fact, for the main beaches of the island, where accretion is related to main stages of eruptive activity and to littoral drift processes redistributing sediment along the coasts.

Keywords : Aeolian Arc, Coastal Processes, Tyrrhenian Sea.

Stromboli is located at the NE end of the Aeolian Archipelago in the Southern Tyrrhenian Sea. It is known worldwide for its persistent, mainly mildly explosive, central volcanic activity spanning at least the last 2000 years. In historical times, volcanic activity has been mostly concentrated on one flank of the island (western), which supplies sediments for most of the northern beaches. Sciara del Fuoco, a horseshoe-shaped feature located in the western flank of the island, is in fact where most of the volcanic products/lavas of recent activity have been accumulated. It is a partially filled scar, formed in the last of a series of major flank collapses; its steep lateral walls extend well below sea level and act as a channelway to the sea for most of the eruptive products. Loose volcaniclastic materials (breccia, gravel and sand) are reworked gravitationally down the steep Sciara scree slope (>38°) to the sea shore. Small lava deltas, built when lava flows reached the sea during the last main historical eruptions (such as in 1930, 1954-55, 1967, 1975, 1985-86, 2002-2003), have invariably been almost completely eroded away by wave action within a few days or months after formation. As directly observed during the 2002-2003 eruption, the entrance of lava flows into the sea at the foot of Sciara del Fuoco, and the interaction with seawater there, directly produces large quantities of volcaniclastic deposits by quenching and fragmentation due to phreatic explosions. This caused, for instance, the initial filling of the slide scar created by the 30/12/2002 landslide event, at present almost completely obliterated.

The foot of the Sciara del Fuoco slope is exposed to westerly winds; from data on the marine climate, it is expected that nearshore waves and windgenerated currents induce a prevalent clockwise drift along the N half of the island. From Sciara del Fuoco, in fact, sands and gravel drift alongshore, due to this prevalent and most energetic wave climate approach, and reach beaches on the north and northeastern side of the island, where the sediment residence in the nearshore is promoted by the physiographic setting.

Evolution of the N and NE coastlines of Stromboli in the last 50 years has been traced in detail using historical maps and series of vertical aerial photographs, taken on average at decadal intervals [1]. There are evidences that the historical evolution of beaches at Stromboli can be related to the occurrence of volcanic activity. While cliffed tracts were relatively stable, in fact, beaches on the N and NE side of the island experienced alternating accretion and erosional stages linked, respectively, with the contemporary eruptions and with sediment redistribution and/or the washing out and loss of sediment to deeper waters.

In particular, in the northern and northeastern sector of the island, from a condition of prevailing coastal erosion at the end of the 1800s, beaches accreted until 1938 and during the period of 1967-1987 and were slowly but consistently eroded during the intervals 1938-1955 and 1987-2001. Periods of coastal accretion follow episodes of relatively intense volcanic activity, as recently observed after the 2002-2003 eruptive crisis. On the other hand, during stages of lowered eruptive activity (as, for instance, in the interval 1938-55 or 1987-2001), a diffused reduction in beach volume has been documented, possibly induced by washing out and loss of sediment to deeper waters under storm conditions, particularly where active canyons and gullies dissect the coastal sectors.

Complementary information from field studies and beach sediment analyses (granulometric data and rounding observation) also support the clockwise longshore drift model along the western, northern and north-eastern coasts of the island.

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RIVERBORNE HEAVY METALS AS INDICATORS OF PARTICLE DYNAMICS AND ANTHROPOGENIC PRESSURE IN THE GULF OF LIONS (NW MEDITERRANEAN)

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Abstract

Particle dynamics has been traced in the Gulf of Lions (NW Mediterranean) through the use of particulate heavy metals introduced by rivers. It allowed first to reconstruct the main trends of the hydro-sedimentary functioning of this non tidal environment and second to draw a global portrait of the distribution of the metallic contamination. Results evidenced the determinant role of the prodeltas - i.e. shallow sedimentary units off the river mouths - in the control of land-derived sediment and associated contaminant fluxes. *Keywords : Metals, Sediment Transport, Pollution, River Input, Gulf Of Lions.*

The Gulf of Lions is one of the largest continental shelves of the Mediterranean Sea, receiving various sources of particulate materials delivered by far from rivers. Around 80 - 90 % of this terrestrial input originates from the Rhône River [1], the most important river of the western Mediterranean basin. In contrast, the other rivers (e.g. Têt, Aude, Orb and Hérault) are characterized by smaller watersheds and show a highly variable discharge regime governed by episodic flood events. The Gulf of Lions is, in this respect, a heterogeneous system, and hence represents an interesting worksite for the exploration of land-to-sea transfer of sediments. Another factor of interest is that this zone is bordered by numerous cultivated/industrialized watersheds, which release a large panel of contaminants such as trace metals that preferentially incorporate the particulate phase. These elements can therefore be used as tracers of the particle dynamics in an attempt to determine the ultimate fate of contaminated sediments, and hence their subsequent impact in the marine system. On this basis, the main trends of the hydro-sedimentary functioning of the Gulf of Lions have been pointed out: (i) the nearshore sedimentary units off the river mouths (i.e. the so-called prodeltas) are the first repository areas for riverborne particles owing to early sedimentation at the saline front. They act as sink but also as source of fine particles [2], depending on meteorological conditions, (ii) finest-grained sediments are advectively exported from direct continental sources and/or prodeltas towards the middle-shelf mudbank, and (iii) a homogeneous material is exported outside the continental shelf under the influence of the western general circulation, which is intensified during storms. Tightly bound to these sedimentary mechanisms, the distribution of the metallic contamination reveals that the most impacted areas concern the prodeltas. When going seaward, the persistence of the contamination likely depends on elemental behaviours, which makes that only conservative metals (i.e. fixed on particles) still depict anthropogenic enrichments [3] [4].

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MARINE TOURISM DEVELOPMENT AND SUSTAINABILITY. CASE STUDY OF THE SARONICOS GULF MARINAS, GREECE

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Abstract

The coastal region development should be accomplished under the umbrella of sustainability, bearing in mind the specific ferrying capacity of the area. The concept of a holistic approach should be applied, in an effort to establish and conserve a healthy business in a well being environment. In the present study, the Saronicos gulf marinas (in Greece) are studied and compared, according to their effectiveness to correspond to high quality standards, respond to consumer needs and preserve the environment. *Keywords : Pollution, Aegean Sea, Coastal Management.*

The coastal region is a fragile and complex ecosystem with a variety of land uses. Sustainability emphasises the interdependence of social and economic development as well as environmental protection. Marine tourism is one of the extremely growing today's industries and it is incorporated in the recent EU Marine Policy [1]. Improper marina operations and maintenance activities have the potential for environmental degradation. The marina ecosystem receives a variety of pollutants [2, 3] from activities such as re-fuelling operations, boat maintenance and boat cleaning, while domestic wastes and other discharges produced on board, as well as water runoffs from the parking, maintenance and repair areas have a strong potential to enter the water basin with its limited water circulation. On the other hand, marine tourists, as typical consumers, ask for high quality standards, such as a healthy coastal and marine environment. Trying to sustain long-term profit, improved competitiveness, continuous growth and enhanced employment rates, the marina industry has begun to embrace the need to promote clean boating, clean facilities and clean operations. For a sustainable marina's development, adverse impacts on water quality and disturbances to wetland should be minimized, animal and plant habitat conservation should be promoted and land use policies aiming to a healthy environment should be established.

Studying the Saronicos gulf marinas, based on information provided by the facility owner/manager and a representative number of users, it is obvious that most of them do not offer high quality standards services. A boat supplies shop, that could promote environmental friendly goods, a boat maintenance and repair facility, a technical support of electronic devices facility and a repairs supply shop are absent, apart from one case. Public education for pollution prevention, and relevant publicity are rare. There is a need to establish a list of economically achievable measures to control the addition of pollutants to coastal waters. In all of them, apart probably from one case, the best management practices should be applied in order to eliminate, control and reduce environmental pollution, bearing in mind that for a marina's appropriate management scheme, the business availability is strongly related to the environmental health. Research is continued trying to identify a marina that, through best management practices adoption, has already resulted in positive economic benefits. That will be of great help in an effort to persuade marina's decision makers to make the required environmental changes. In other words, findings will act like economic tools, helping marinas to meet their environmental responsibilities.

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INTERACTIONS BETWEEN KAMCHIA RIVER AND COASTAL WATERS (BULGARIAN BLACK SEA)

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Abstract

Understanding the connection between Water Quality (WQ) in the coastal zone (CZ) and river catchment is important in order to better assess the CZ processes. One of the main sources of pollution in CZ is certainly that one produced by human activities in the associated river basin. The goal of the paper is to estimate the river impacted zone during the high flow period of the largest Bulgarian Black Sea river. The analysis of data reveals the presence of fresh water low transparency layer with thickness of 3 - 5 m. Vertical distribution of the chemical parameters confirms the location of the impacted area at <1mile. There is a good correlation between nutrient content and salinity.

Keywords : Black Sea, River Input, Coastal Waters.

The coastal zone is a dynamic area of natural changes and increasing human use. One of the main sources of pollution in CZ is certainly the human activity in the associated river basin. Understanding the connection between WQ in CZ and river catchment is important in order to better assess CZ processes and to evaluate various management options leading to improvement of the staus of the coastal ecosystem. The largest national Black Sea rivers, Kamchia River, is the main source of fresh water for the Bulgarian part of the Black Sea (19.25 m3/s). Kamchia River length is 245 km with a catchment area of 5358 km², which covers 40 % of the Black Sea watershed. The catchment of Kamchia River includes some industrial and urban areas as well as regions with agricultural activity [1, 2]. In this regard WQ of the river is affected by human activities (industry, urbanization and agriculture). The river water transports pollutants to the sea and the magnitude of pollutants discharge is often related to watershed changes, utilization and river basin management. There is a lack of knowledge about Kamchia River influence on the coastal waters. Few publications provide information on this subject [3, 4].

The goal of the paper is to estimate the extent of the coastal zone impacted by the river during the high flow period (spring). The study of the interaction between Kamchia River and the related CZ focuses on nutrient emissions and eutrophication.

The study is based on monthly monitoring of Kamchia River, during the period 2005-2006 on the following parameters: BOD₅,nutrients as dissolved phosphorus (P), nitrogen (N) and silica (Si). The investigation of water column in the coastal zone in front of the river mouth was carried out during the high flow period by *in situ* measurements of temperature, salinity, transparency, pH and oxygen. The collected samples were analyzed for nutrients and suspended matter by standard methods [5].

The results for the river show a nutrient content, exceeding the allowed concentration maximums established by Bulgarian WQ standards (more frequently for nitrites). The analysis of data for coastal waters during high flow period reveals a significant influence of the river discharge on the 1 n.m. coastal zone. Several parameters (nutrients and salinity) are used to define the impacted area which spreads in the South and East due to the current circulation along the coast. As a consequence of river discharge the WQ of close coastal zone does not correspond to the Bulgarian standards.

The size of this area, related to the advection of the river plume, depends on the amount of Kamchia River waters discharged into the sea, as well as on the winds and current system in this part of the Western Black Sea. The vertical distribution of the observed parameters confirms the location of the impacted area (Fig. 1 and 2). The main features of the river which influenced the waters in the coastal area are the lower salinity, higher nutrients and suspended matter content. The analysis of the data recorded reveals a presence of fresh water low transparency layer with thickness of 3-5 m. High Si content leads to significant increase of Si:P and Si:N ratios. There is a good correlation between the nutrients and salinity distribution in the coastal area ($r^2=0.57$ for N and $r^2=0.81$ for P and $r^2=0.70$ for Si). The river directly influences the brackish waters in the immediate proximity of the river mouth. Due to the current circulation along the coast the transformed river waters at near mouth stations are characterized by low transparency (0.5-1.5 m), pH values 8.09-8.25, salinity <8.3 psu. The farthest two stations on transect in front of river mouth with distance >1 n.m., have similar vertical distribution of the biogeochemical parameters, showing that the river has no impact in this area.



Fig. 1. Vertical distribution of salinity (psu) a front of Kamchia River.



Fig. 2. Vertical distribution of nitrates (Îijg/l) a front of Kamchia River.

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DYNAMICS OF PHYTOPLANKTON COMMUNITY STRUCTURE IN AN ENCLOSED COASTAL SYSTEM INFLUENCED BY TERRESTRIAL RUNOFF

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Abstract

In situ knowledge of phytoplankton community dynamics and environmental factors remains a powerful tool for determining processes underpinning changes in species assemblages in relation to time, space, resources, and competition. This study aims at investigating changes in phytoplankton assemblages before, after and during the development of blooming in the Kalloni Gulf (Aegean Sea) under the influence of environmental parameters and particularly terrestrial runoff. Links between environmental parameters and species abundance data have been analysed using multivariate methods and biodiversity patterns. Our results indicate that assemblages thriving under nutrient loading from runoff have a different structure in comparison to natural blooms occurring in summer and in autumn. *Keywords : Biodiversity, Blooms, Coastal Waters.*

The Gulf of Kalloni is a semi-enclosed shallow water body, occupying a surface area of 110 km^2 . The climate of the area is typically Mediterranean. During the rainfall period (November to March) a notable amount of nutrients is carried into the gulf through leaching from the surrounding agricultural land. A six station network was sampled monthly from August 2004 to July 2005. Stations 1 and 2 were positioned in the open sea and the inlet of the gulf respectively. Stations 3, 4, and 7 were in the vicinity of three important rivers which discharge at the northern part of the gulf. Station 5 was placed in the middle of the gulf to characterize the overall condition of the gulf water mass.

Data related to physical parameters, nutrients and Chl α were collected from 1 and 5 m depths. Phytoplankton samples were quantitatively analyzed using the Utermöhl method [1] as well as using bright field (BF) in order to identify nanoplankton species at 1000x. Phytoplankton biovolume and biosurface values were also calculated according to Hillebrand et al. [2]. Multivariate analysis of species abundance data were applied using the Primer 6.0 package, and statistical comparisons with the permutational multivariate analysis of variance known as PERMANOVA [3].

We tested the effect of time (month) and space (location of stations) in a two-way multivariate analysis of variance. The effect of month (PER-MANOVA F=37.07, P<0.05) was much stronger than the effect of location of stations (F=2.14, P<0.05) in the grouping of samples, since the latter was found significant only within February and July. Similar results were obtained when the test was applied on presence-absence phytoplankton data. These results suggest that the phytoplankton community of the Kalloni Gulf is well diversified over time through the formation of distinct assemblages, which are however spatially homogeneous within the gulf. Moreover, each assemblage is distinct because of differences in the relative abundance of species as well as in its species composition.

Samples from late autumn and winter months formed a wide "winter" group characterized by rather low species abundances and without any specific proliferation (Fig. 1). The phytoplankton community sampled in February was particular since it was marked by a *Pseudo-nitzschia calliantha* bloom. Spring and summer assemblages were marked by high densities of the diatom *Chaetoceros diversus* followed by *Proboscia alata f. gracillima* and *Rhizosolenia setigera*. Finally August and October phytoplankton assemblages were characterized by high abundances of small diatoms such as *Cyclotella spp.* and *Thalassionema nitzschioides f. parva*.

Total cell number during the February bloom was higher by three orders of magnitude. However, due to the small biovolume of the blooming species *P. calliantha*, the total biovolume did not differ from that of summer and September assemblages which were dominated by more voluminous cells, such as those of *Rhizosolenia* species. Although the February assemblage maintained relatively high species richness, mainly due to the contribution of dinoflagellate species, it was characterized by significantly lower evenness (J') and diversity (H') values compared to any other assemblage.



Fig. 1. Multidimensional scaling of the stations inside the gulf using the Bray-Curtis similarity index with 40% similarity contours.

The above results indicate that the winter bloom, initiated by high nutrient loading through surface runoff, presented a different phytoplankton assemblage structure than the natural blooms occurring in early summer and early autumn. The development of the early summer bloom as well as its decline was progressive evolving over a time period of more than one month. No apparent relation seemed to exist between available resources and the bloom initiation, apart from the increased light availability during summer. Conversely during the *P. calliantha* winter bloom which lasted for less than 20 days, there was a clear-cut connection between peak abundances and peak nutrient densities, and the bloom declined soon after the nutrients were exhausted. Finally, low values of biodiversity indices during the winter bloom suggest that a sudden heavy nutrient loading into the system may greatly destabilize phytoplankton community structure, however stability is rapidly regained as soon as nutrients are exhausted.

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CONTRÔLE ET ÉVOLUTION DES MILIEUX ÉCOLOGIQUES DE LA LAGUNE DE NADOR (LITTORAL MÉDITERRANÉEN ORIENTAL, MAROC)

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Résumé

L'étude écologique des foraminifères benthiques et des ostracodes de la lagune de Nador (littoral méditerranéen, Maroc) a été réalisée pour la première fois à l'aide de la méthode des courbes des fréquences relatives. Elle a permis de reconstituer les milieux écologiques, de suivre leur évolution spatiale pour l'actuel (hiver 2003, été 2004) et pour une période ancienne (1000 à 1200 ans BP) et de préciser les facteurs naturels (climat, géomorphologie, morphodynamique et hydrologie) et les facteurs anthropiques qui contrôlent leur répartition et leur évolution. Par ailleurs, cette étude a mis en évidence l'existence d'une relation étroite entre l'évolution des ostracodes et celle de la famille des Spiroloculinidae qui pourraient constituer des bio indicateurs de la pollution. *Mots clès : Lagoons, Coastal Systems, Western Mediterranean, Foraminifera.*

Introduction

La lagune de Nador est située dans le littoral méditerranéen marocain oriental, (Fig. 1), elle a fait l'objet d'une étude écologique des foraminifères benthiques [1]. Mais, ces travaux ne tiennent compte ni des périodes de prélèvement ni de la différence d'âge entre les associations des bases et des sommets des carottes pour la reconstitution des milieux écologiques. Il était donc nécessaire d'entreprendre dans le cadre du projet COLASU, une étude de ces microfossiles qui sont d'un grand intérêt écologique. Pour ce faire, une démarche nouvelle a été adoptée, elle est basée sur : 1) l'application pour la première fois de la méthode des courbes des fréquences relatives aux foraminifères et aux ostracodes ayant été déterminés par I Bouimetarhan et A. Slimane, pour l'identification des milieux écologiques et 2) l'étude de l'évolution spatiale des milieux écologiques pour la période actuelle (hiver 2003 et été 2004) et pour une période estimée à 1000 - 1200 ans BP d'après les datations [2].



Fig. 1. Les zones hydrologiques et hydrochimiques de la lagune de Nador.

Les milieux écologiques : caractérisation, évolution et contrôle

Trois milieux écologiques ont été identifiés pour la période actuelle (Hiver 2003), ils corroborent la zonation écologique proposée par l'étude des ostracodes [3].

- Le milieu écologique I correspond à la bordure continentale nord de la lagune (station 14). Il se caractérise par : 1) une association d'ostracodes qui montre des proportions voisines de *Cyprideis* (40.1%) et de *Loxoconcha* (37.7%), une faible densité et une biodiversité assez élevée et 2) une association de foraminifères où prédominent les formes péritidales, en particulier *Ammonia tepida* (68%) comme cela a été signalé [4].

- Le milieu écologique II correspond à l'extrémité NW (stations 4 et 47) et la bordure continentale sud (station 11). Il se caractérise par : 1) une association d'ostracodes où *Loxoconcha* (>50%) prédomine sur *Cyprideis* (20 à 30%), contrairement à ce qui était proposé [3], une faible densité et une biodiversité en général moyenne, et 2) une association de foraminifères dominée par le groupe peritidal où la famille des Nonionidae (*Ammonia tepida* suivie de *Nonion depressulum*), atteint un pourcentage de 60 % et comportant des espèces marines épifauniques (Miliolidae et Bolivinidae).

- Le milieu écologique III correspond à la bordure interne de l'île barrière (stations 23 et 24), la partie centrale (stations 27 et 37) et la zone de la passe (station 31). Il se caractérise par: 1) une association d'ostracodes où Cyprideis (>60%) prédomine sur Loxoconcha (10 à 20%) et généralement une forte biodiversité et une densité movenne et 2) une association de foraminifères avec des espèces péritidales (36 à 48 %) représentées par Ammonia tepida, des Bolivinidae et des Rotaliina qui dominent sur les Miliolidae partout sauf dans la station 37 où les Miliolidae sont dominants. Le contrôle saisonnier ne s'exprime de manière significative que dans la station 23 où le milieu écologique III évolue en milieu écologique II durant l'été. Les conditions estivales entraînent en général une augmentation de Loxoconcha au dépens de Cyprideis et les décharges fluviatiles de l'hiver, affectent la biodiversité et la densité des stations de la bordure continentale. Par ailleurs, l'impact du stress anthropique s'exprime dans les stations proches des cages d'aquaculture et de la bordure continentale, en particulier durant les périodes d'été. Les teneurs élevées en éléments nutritifs engendrées par l'aquaculture, induisent une diminution des pourcentages de Loxoconcha (10.5%) et de Cyprideis (62%) dans la station 31. L'impact des eaux usées de Oued Bouaroug (station 11) et de la station de lagunage (station 14) se traduit par une diminution du pourcentage de Loxoconcha au profit de celui de Cyprideis, la disparition des foraminifères épifauniques marins et l'augmentation des Spiroloculinidae. Enfin, dans la station 4, l'impact de la pollution qui est accentué durant l'été, se traduit par une diminution du pourcentage de Loxoconcha au profit de celui de Cyprideis. La reconstitution des milieux écologiques pour la période ancienne (1000 à 1200 ans BP) a montré que la station 14 se caractérisait par le milieu écologique III et que l'influence marine était plus importante dans les stations 37, 47 et 4 et plus faible dans les stations 31, 27 et 23. Ces résultats s'expliquent par le fait qu'il y a 1000 à 1200 ans, la limite interne de la lagune devait coïncider au moins avec la limite actuelle du marais salant de Taouima et la passe était située au niveau du double tombolo.

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ARTIFICIAL BEACH NOURISHMENT PROJECTS IN ITALY

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Abstract

The first results of the University of Parma-Enea La Spezia survey on artificial beach nourishment projects in the 8000 km long Italian coasts are shown. The state of the art in 2002 is represented by 72 projects, a database sufficiently large to allow the discussion of the principal types and the main sedimentologic characteristics of the projects. *Keywords : Beach, Coastal Engineering, Erosion, Sediments.*

Introduction

The social-economic consequences of coastal erosion in the Mediterranean coasts are extremely important. Nowadays artificial beach nourishment is a common remedial measure to beach erosion, particularly effective in Spain and Italy [1].

The database discussed below rely on survey data aimed to classify the relevant information on artificial beach nourishment [2]. The preparation of the data-form benefits of the contributions of several investigators from the Enea Centre of La Spezia, the Consortium *Venezia Nuova* and the Regione Emilia-Romagna.

Rationale

This work considers all significant nourishment projects and only part of the fills of relatively small volume. These latter are commonly executed by private beach concessionaires and not always officially recorded. The rationale of the survey is as follows.

1) Simplicity of formulation in order to guarantee reliability and homogeneity of the information collected;

2) The placement of material in the same coastal stretch in separate years with specific financing of the interventions is attributed to distinct projects and recorded on distinct data-forms;

3) Survey of all relevant projects with no temporal limit to the survey given although in Italy significant artificial nourishment works only initiated in the eighties.

Survey data

Data-forms are filled in co-operation with local Administrators. The collected information is presented in the following.

3.1 Project identification

- Municipality, Province (*Prefecture*) and local Administration (*Regione*);

- Aim of the artificial beach nourishment;

- Denomination of the project and year of construction;
- Additional aims pursued by joint projects (e.g. restoration of the dune system).
- 3.2 Technical information
- Length (m) of the restored reach of shore;
- Width (m) of the restored beach;
- Volume (m^3) of fill;
- Total cost of the fill;

- Fill material: sand, gravel and mutual percentage in case of combined use;

- Source of borrow material: land, sea, estuary/port dredging;
- Protective structures: groin, submerged barrier.
- 3.3. Renourishment

Modality of execution and cost of periodic nourishment and monitoring of the restored beach performance.

Discussion

The 72 projects catalogued so far allow some statistically meaningful treatments; a first set of relevant parameters is defined referring to the example of the Poetto project construction in Cagliari (Sardinia).

- Length of restored shore = (L) = 2.500 m
- Average width of restored beach = (W) = 55 m
- Volume of fill = (V) = 370.000 m^3
- Total cost of the fill = (C) = 3.098.741 Euro.
- The parameters above provide the following characteristic indices.
- Length-width ratio L/W = 45,4
- Volume of fill per unit lenght V/L = $148,0 \text{ m}^3/\text{m}$
- Cost per cubic meter of fill C/V = 8,4 Euro/m³.

Characteristic values of Vand L separate two basic categories of

artificially-placed beach materials here named *Fills* (V <100.000 m³ and L <1800 m) and *Nourishments* (V \ge 100.000 m³ and L \ge 1800 m).

Actually among Fills a group of minor interventions characterised by a length-width ratio (L / W) <20 and a volume (V) <40.000 m³ can be distinguished. These projects cannot be considered as real beach replenishments but simply as local sediment pourings.

From the cases considered here the existence of two fundamental categories of artificial Nourishments is shown as a function of the volume of placed materials for unit distance of the restored shore (V/L). Characteristic values are from 10 to 50 m³/m and from 80 to 400 m³/m, here named *Surface* and *Volume* Nourishments, respectively.

Conclusion

Up to year 2002 a total number of 72 Italian beaches has been artificially restored. By project number the ranking of Administrative Regions is Emilia-Romagna (30), Latium (11) and Tuscany and Marche (10). By volume the most important projects are Venice-Pellestrina ($4.000.000 \text{ m}^3$) and Venice-Cavallino ($2.000.000 \text{ m}^3$), Paola ($1.000.000 \text{ m}^3$) in Calabria and Ostia-Levante (950.000 m^3) in Latium.

The purpose of the beach reconstruction projects can be classified in the following four categories: (1) Beach widening for recreation, (2) beach restoration for protecting buildings and roads, (3) beach restoration for protecting parks and natural herritage, (4) removal of groins for realising one of the previous soft restoration projects.

Only projects where the volume of fill is >100.000 m³ and the length of restored shore is >1800 m belong to the generally recognized artificial Nourishments. On the base of the fill Volume-Length ratio these latter can be distinguished in two types named *Surface* and *Volume* Nourishments.

An example of Surface Nourishment is the Cecina project in the Province of Livorno (V/L=26 m^3/m). The highest value of the V/L ratio is provided by the Venice-Pellestrina Volume Nourishment (V/L= 400 m^3/m).

The costs detected here per cubic meter of fill are very informative. They turn out to be particularly low (within 6 Euro/m^3) when the source of borrow material is from dredging an adjacent estuary or port. For the remaining, in most cases the unit costs vary between 10 and 20 Euro/m³.

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PRELIMINARY RESULTS OF FORAMINIFERAL ANALYSES: SOLINE BAY (KRK ISLAND, ADRIATIC SEA, CROATIA)

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Abstract

The foraminiferal assemblages were studied at four stations in Soline Bay (Krk Island, Adriatic Sea, Croatia). Soline Bay is a protected lagoon with sediment rich in organic matter, without anthropogenic, industrial, agricultural impact and with negligible water input. The results demonstrated: dominance of hyaline taxa specimens along the Bay with an increase in number toward the shallower part, a decrease in the relative abundance of porcelaneous taxa specimens in the same direction, a low diversity and a high dominance of a very few species at all stations, plankton specimens in the shallow part of the Bay brought by tide currents. *Keywords : Lagoons, Adriatic Sea, Foraminifera, Sediments.*

Study Area

The foraminiferal assemblages from Soline Bay (Krk Island) were studied in May 2006 as a part of seasonal variability of the foraminiferal assemblages monitoring project in the selected localities at the east coast of the Adriatic Sea (Croatian part of the Adriatic Sea). Soline Bay was selected as an example of the protected lagoon with fine-grained sediment rich in organic matter. Origin of the fine-grained sediment is the catchment area of the Bay composed of the Eocene Flysch. There is no anthropogenic, industrial, agricultural impact and there is a negligible water input.

Materials and Methods

Hand collecting by a scuba diver took place in the transect along with the stations from #1 to #4, starting at water depth of 1.2m down to 10.5m. The temperature varied from 17° C in the deeper parts, to 20° C in the shallower parts of the Bay. Two samples were collected from each station. One sample was presently stained with the Rose Bengal, while other sample was left for sedimentological analyses. The stained samples were treated using a standard procedure. Dried fractions were split in aliquots containing at least 300 specimens, which were picked, identified and counted. Living (stained) and dead (empty) foraminiferal specimens were identified. The samples left for sedimentological analyses were processed using a standard procedure.

Results and Discussion

The hypothesis was based on the fact that agglutinated and porcelaneous taxa would decline in abundance toward the shallower part of the Bay with the increase of fine-grained fraction proportion and that hyaline taxa would tolerate the change well [1].

The results have demonstrated a change in the sediment type from sandy mud at the station #1, gravely muddy sand at the stations #2 and #3, to gravely mud at the station #4 [2]. Inverse sediment zonation (fine-grained sediment in the shallower part of the Bay) is explained by the Eocene Flysch sediment supply.

Living (stained) specimens were rare at all four stations, ranging in proportion from 3% at the station #4, to 10% at the station #1. Therefore the interpretation was based on the total assemblage.

The general trends observed at Soline Bay were the following: 1) low diversity and high dominance of a few species at all stations, 2) hyaline taxa specimens domination along the Bay with the maximum at the shallowest station (from 70% at the station #4, to 96% at the station #1), 3) decrease in the relative abundance of porcelaneous specimens in the same direction (from 25% at the station #4, to 3% at the station #1), 4) very low relative abundance of agglutinated species at all stations (1% at the station #2 to 3% at the station #4), 5) high number of genus *Ammonia* specimens along the Bay, 6) decrease in number of genus *Elphidium* specimens toward the shallower part of the Bay, 7) relative abundance of plankton specimens increase toward the inner part of the Bay, most likely brought by tide currents, 8) mechanical damages (fragmentation) of numerous specimens of genera *Elphidium, Ammonia* and *Quinqueloculina*.

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BEACHROCKS IN THE MEDITERRANEAN: MORPHODYNAMIC, ECOLOGICAL AND SOCIO-ECONOMIC IMPACTS

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Abstract

Beachrocks are coastal sedimentary structures formed by the lithification of beach material, due to precipitation of mainly carbonate cements from the coastal sea and/or fresh waters. In this contribution a discussion of their morphological, ecological and socio-economic impacts is taking place, based upon information from the literature, results of morphodynamic modelling and detailed field studies, as well as from a questionnaire survey on foreign tourists at a Greek island. The results of the study show that coastal wave dynamics and beach morphodynamics are significantly influenced by beachrock formation. Regarding the ecology, the transformation of sandy beaches to rocky foreshores, leads to the development of new habitats and fauna and flora assemblages. Finally the questionnaire survey showed that beachrocks may also decrease the amenity value of beaches, and potentially harm tourism. *Keywords : Biodiversity, Erosion, Coastal Management, Coastal Models, Monitoring.*

Beachrocks are coastal formations resulting from the cementation of beach sediments by mainly calcitic or aragonitic cements. The cementation occurs either on the surface or, more commonly, beneath the littoral/intertidal sediments, and the resulting formations can be kilometres long, attain widths of hundreds of meters and thicknesses of up to several meters. Beachrocks have been thoroughly studied in the 60s and 70s from geologists, mainly regarding their formation mechanism, without reaching to solid conclusions (see [1-4]). On the other hand there are significant indications that they affect beach morphodynamics [5], and they often result to transformation of sandy beaches to rocky ones, followed by significant implications to ecology and socio-economy. However it is very interesting that studies on such impacts are very few and given that Mediterranean Sea is a hot spot for the phenomenon of beachrock formation, of high importance. The objective of the present contribution is to present the impacts of beachrock formation on coastal morphology, ecology and socio-economy.



Fig. 1. Typical beachrock formations on Kalithea, Chalkidiki, Greece (a), mapof reported beachrock occurences (from scientific journals) in theMediterranean (b), beach profile envelopes from Vatera beach, LesvosIsland, Greece, demonstrating the 'reduced' dynamics of the profile, aswell as the morphologic control by the beachrock presence.

The 7.5 km long, microtidal beach of Vatera, Lesvos Island, Greece, was chosen as study area, characterized by the presence of extensive beachrock formations. Seasonal ecological sampling, beach levelling and sediment sampling has been carried out all along the beach, while the buried upper beachrock surface was also levelled (after excavation of the beach). A beach profile evolution model based on the Bussinesq equations [6], was specially modified for the case of beachrock infected beaches [8] and was applied in various wave conditions, to compare the morphodynamic response of the beach profile for a 'normal' and a beachrock presence case. Finally in order to investigate the possible impacts of beachrocks on tourism, a questionnaire survey was carried out in the two infected costal areas of Lesvos Island (Plomari and Vatera).

Regarding beach morphodynamics, the overall analysis of the field data

and the modelling results suggest that: (i) beachrock spatial distribution along the beach is controlled (amongst others) by beach sediment size and wave energy levels; (ii) beachrocks drive the formation of big scour steps (range of 0-1 m) that impede shoreward cross-shore sediment transport, and provoke beach erosion; (iii) beachrocks appear to 'lock' the beach profile and control its final shape which is highly correlated to the one of the formations' upper surface; (iv) affect the waterflows through the porous sediment body in a way that facilitates sediment suspension and transport.

On the analysis of the ecological samples [8], seven algae taxonomic groups were identified as well as 31 invertebrate taxa, most of which are typical of hardbottom communities. Statistical analysis showed decrease in the population density and biomass towards the coastline, as well as an increase of mobile species' population densities with the depth (especially during the spring period).

The questionnaire survey [8] showed that, beachrock presence influences the interviewees beach quality rating in a negative manner; 64 % of the sample considers that the local authorities and the EU should takemeasures to protect the swimmers from the beachrocks and 51 % the coast as well. Eventhough risk perception appears neutral, 55.4 % of the sample is willing to contribute on financial grounds to research, focused on the phenomenon, with widely ranging contributions.

All the above imply that beachrock formation is a natural phenomenon that may have significant impacts, which have not been studied accordingly yet. Particularly in the Mediterranean area, beachrocks are abundant and the latter combined with the intense development of the coastal zone, intensifies the current and anticipated problems due to their presence.

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PANEL REPORT BY THE MODERATOR

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Keywords : Biodiversity, Gis, Eastern Mediterranean, Western Mediterranean.

Information systems are the new powerful tool to collect, integrate and analyse data from different sources and to make them readily accessible to the scientific community worldwide. This panel focused on issues concerning the management of biodiversity databases on the internet (data integration, accessibility, quality control) and their scientific and educational applications.

The session started on time, all speakers where sharp in their presentations, leaving an hour for discussion with the audience. The first two contributions focused on patterns and trends in the introduction and distribution of alien species based on the analysis of datasets from the CIESM Atlases of Exotic Species. Daniel Golani showed the abrupt increase in exotic fish in the Mediterranean Sea in recent years, with 18 newly introduced species since 2002, mainly through the Suez Canal. Many established species extended considerably their range of distribution and for some species real population explosions occurred in just few years time. As the rate of invasion is likely to increase in the future, D. Golani discussed the need for more research on the impact of exotic fish on native assemblages. In particular, he stressed the importance of long-term monitoring of fish invasions and the need for comparative studies between exotic fish and ecologically similar native species for more reliable assessment of impacts on local diversity.

The rate of invasions in the Mediterranean Sea is steadily increasing also for other taxa, as was clearly shown in the communication by Bella Galil. To date, 66 exotic crustacean decapod and stomatopod species have been recorded in the Mediterranean Sea and the number of introductions increased in the last decade. The Eastern basin is the most affected by species introductions, which have been five times higher than in the Western basin. Marked differences between the two basins in the origin and way of introduction were also outlined. B. Galil finally examined potential determinants of the establishment success of tropical species in the Mediterranean Sea, with special reference to climatic changes.

Marc Verlaque introduced the forthcoming CIESM Atlas on Exotic Macrophytes, which is the first inventory of macroalgal species introduced in the Mediterranean Sea. The Atlas provides comprehensive, referenced information on the morphological features, ecology and biogeography of 110 exotic macroalgal species. The Atlas, soon accessible online, will be regularly updated, dynamically integrating records on new introduced species. Since the Mediterranean Sea harbours the greatest number of exotic macrophytes in the world, and since new species introductions are increasing exponentially mainly due to shellfish farming, this Atlas represents a unique benchmark to assess past and future changes on macroalgal diversity.

Giuseppe Notarbartolo di Sciara presented the joint project between CIESM and ACCOBAMS to develop, in cooperation with the Pelagos Sanctuary, a database on cetacean sightings covering the Mediterranean and Black Seas. The database will integrate historic datasets collected and archived by the CIESM Marine Mammals Task Force with current and future records on the presence, distribution, abundance and habitat of cetaceans. The importance of building a scientifically rigorous cetacean sightings database was underlined by the author, who stressed the need for basin scale observations to further scientific understanding of marine mammals and improve conservation measures.

Key issues concerning data integration, accessibility and ownership in web-based information systems were presented by Christos Arvanitidis on behalf of the panellist Edward Van Berghe (excused). As he pointed out, one of the main problems related to integration of several datasets is the lack of a common taxonomic nomenclature. He then described the European Register of Marine Species, an initiative of the EU Network of Excellence MARBEF to provide a standard taxonomic list of European marine species. This list is available online and should serve as a reference guide when integrating datasets using different terminology. A brief presentation of the MedOBIS database on Mediterranean and Black Sea species was given by her colleague Sarah Faulwetter.

Data integration, however, does not only imply the use of a common terminology. The need to adopt an ecosystem-based approach to study biodiversity has prompted the development of information systems which host datasets of numerous biological and environmental variables.

The new CIESM GIS-based application developed at CIESM Headquarters was presented in a joint paper authored by Paula Moschella and Kaveh Rassoulzadegan. It will integrate CIESM datasets on biodiversity, environmental variables and bibliographic resources into one single information system. The multilayer architecture of the application and the partitioning of the Mediterranean into subregional zones allows an at glance visualization of several datasets in a particular area of interest. P. Moschella also explained that the system was specially conceived to make it accessible and easy to use on both shores of the Mediterranean, and to provide scientific information that would equally serve scientists and non-specialist end users.

The last presentation was given by Stéphane Pesant, who highlighted the importance of integrating datasets that provide information on the different levels of biological diversity (e.g. taxonomy, genetics, ecology) to better understand the functioning of marine ecosystems and the biogeochemical fluxes. The problems of data aggregation, quality control, and metadata standardization were also addressed using examples from EurOcean, SESAME and MARBEF initiatives.

The following is a summary of the main questions, answers and comments raised during the general Panel debate.

Comment: Databases are too difficult to use, and not exactly user-friendly, with the exception of that of CIESM.

Answer: Databases are available through the internet, and so are accessible to all those who can take advantage of a connection with the world wide web. Most databases, however, are just for the scientific community and are often not even available without permission.

Question: Are there biological parameters that can be used to show long term changes, as it happens with oceanography?

Answer: It is possible with the fossil record over the long term. Then there are middle term information, like with alien species, where we can reconstruct the recent history of the Mediterranean in terms of arrival of new species from both Gibraltar and Suez. EurOceans and SESAME are working with this aim in mind, collecting past information and assembling it into a single temporal framework. Long term series have been set up at several places (Naples, Villefranche-Sur-Mer, Plymouth, Helgoland) but are being abandoned because they are costly and not scientifically rewarding over the short term (the term that determines scientific careers and funding availability). They should be fostered because they reconstruct the history of biota and are conducive to the understanding of present-day situations.

Question: There is not enough knowledge of the biodiversity of the south shore. No more taxonomists. What about the species living in the southern shore and that have never been recorded due to lack of observation? If they will widen their distribution range, they will be considered as aliens, and they are not. We have to convince the decision makers that taxonomy is important.

Answer: this is correct. We have information from the northern shore, and sometimes we produce floras and faunas, but they do not cover the situation of the southern shore. The exploration of the Mediterranean is far from having been accomplished. The problem does not reside with

THE BLACK SEA COASTAL ZONE: PRESENT-DAY STATE AND THREATS ARISING FROM GLOBAL CHANGE AND FROM REGIONAL VARIABILITY

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Abstract

The total length of the Black Sea coastline is over 4 400 km and it belongs to 6 states: Bulgaria, Turkey, Georgia, Russian Federation, Ukraine and Romania. The proposed zoning of the Black Sea coastal zone evidences 17 main zones characterised by different geology and morphology, as well as specific littoral water circulation, sediment drift systems and sedimentary budget. These zones belong to three main morphodynamic categories: (1) low, accumulative coasts mostly related to the rivers mouth zones (mainly sandy complex barrier beaches with strong longshore sediment drift systems); (2) Erosive coasts within lowstanding plateaux and plains, with active cliffs with very narrow beaches in front of the cliffs; (3) Mountainous coasts, with cliffs, marine terraces, land slides, sometimes with sandy or gravely beaches. An overview of the coastal erosion in the Black Sea and of factors controlling these erosional processes is given. The threats to the coastal zone generated by global changes and anthropogenic pressure are analysed. The most vulnerable sections of the Black Sea coastal zone exposed to environmental risks are presented and analysed. *Keywords : Coastal Processes, Erosion, Black Sea, Global Change.*

The Black Sea coastline

The total length of the Black Sea coastline is over 4 400 km and it belongs to 6 states: Bulgaria, Turkey, Georgia, Russian Federation, Ukraine and Romania. The Black Sea coastal zone can be divided in 17 main zones characterised by different geology and morphology, as well as specific littoral water circulation, sediment drift systems and sedimentary budget [1].

In a more general approach, the Black Sea coast zone could be subdivided into three main morphodynamic categories, with very specific characteristics and behaviour:

1. Low, accumulative coasts mostly related to the main rivers mouth zones. This type of littoral zone consists of sandy complex barrier beaches with strong longshore sediment drift systems; these zones are generally characterised by isostatic adjustments of overloading by rapid accumulation of sediments (subsidence). To this type belongs the Danube Delta front with a very exposed to erosion littoral of about 240 Km; two sections of the River Dnieper liman - Karkinit Bay unit: the Kinburn spit - Dolgyi Island section (\sim 20 Km) and the Tendra spit - Dzharylgatch Island section (\sim 137 Km); the Taman - Anapa unit (about 200 Km long); the Kolkhida (Rioni) Lowland where the rivers Chobi, Rioni, Inguri and Supsa have built up their deltas; on the Turkish coast there are the deltas of Kizilirmak, Yesilirmak and Sakaraya rivers, and finally, in Bulgaria, sandy accumulative beaches related mainly to the rivers Diavolska, Kamchya, Provadyiska and Batova, summing about 100 Km.

2. Erosive coasts in front of lowstanding plateaux and plains, with active cliffs in lœss and lœss-like deposits, sometimes underlyed by older deposits as Pontian limestones, Meotian clays and Sarmatian lumachelles, with very narrow beaches in front of the cliffs. To this type of coasts could be distributed the north-western unit of the Ukrainian coastal zone (from the northern limit of the Danube Delta to the town of Ochakov or the western limit of the Dnieper liman, summing 232 Km), the southern unit of the Romanian coastal zone (Cape Midia - Vama Veche at the Bulgarian border - about 75 Km long), and the northern part of the Bulgarian coast, from the Romanian border to Caliacra Cape (about 50 Km long) [2].

3. Mountainous coasts, with cliffs, marine terraces, land slides, sometimes with sandy or gravely beaches. This type of coasts is generally subject of isostatic and orogenic uplift. To this type are belonging the coasts of Crimea, Caucasus, Pontides, Strandza and Staro Planina Mountains, as well as of Frangensko and Avrensko plateaux [1,2].

Coastal erosion in the Black Sea: factors controlling the erosional process The coastal erosion in the Black Sea represents one of the main environmental concerns of the riparian countries. The erosion is controlled by: a) Global and natural factors. The Black Sea coastlines erosion is strengthened as everywhere in the World Ocean by the global changes and the general sea level rise. The coast erosion will depend on synergetic effect of factors controlling the littoral processes (meteorological regime, wave energy regime, water circulation, sediment supply and drift etc.), global changes and the consequent modification of the energetic level of the coastal sea, general sea level rise and regional characteristics as shoreline morphology, elevation and geologic constitution, subsidence or/and neotectonic regime.



Fig. 1. Erosion of the Danube delta.

b) Anthropogenic factors. The coast zone erosion and the state of the coastal sea ecosystems are strongly affected by anthropic activities, the effect of which is added to the impact of natural factors. The anthropogenic changes of large rivers hydrologic characteristics (water and, especially sediment supply, regularisation of floods etc.), men-made littoral structures as breakwaters, dykes, groins, harbours etc., which are modifying the littoral circulation cells, the uncontrolled use of beach sand, dredging of sand too close to the beaches or within the river mouth bars and many other activities are causing an enhancement of coastal erosion and endangering of the coastal ecosystems.

The low, accumulative coasts (first category of coasts described above) are the most influenced by global change, specifically by the sea level changes and by the changes in the river sediment inputs [1, 3-5]. The decreasing sediment supply and changes in littoral sediment drift due to anthropic activities (river damming, hydrotechnical regularisation, littoral structures

PANEL REPORT BY THE MODERATOR

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Keywords : Radionuclides, Monitoring, Metals, Petroleum, Aeolian Arc.

During the introductory session, the Panel Moderator noted that at a similar CIESM Congress some 35 years earlier, the famed explorer Jacques Cousteau had drawn international attention to the health of the Mediterranean by stating his observations had led him to believe that the Mediterranean Sea was "dying" and in fact could be "dead" in a few decades if nothing was done to stop the problems of increasing pollution and overfishing. Fortunately 35 years on, the Mediterranean Sea is far from dead but his comments did more to raise public awareness about the problems of protecting the marine environment and spur international actions to stem pollution in the Mediterranean than much of the sound scientific data being produced by scientists studying the problem at that time. Although over the ensuing years much effort has been put into assessing the degree and extent of chemical contamination in the Mediterranean Sea, an overall lack of baseline information still exists for a broad area of its eastern and southern coasts, as well as for new classes of chemical contaminants that are just now coming to light. It was therefore the task of this Panel to probe and analyze those two aspects in detail and finally debate and suggest approaches and mechanisms for better assessing the overall health of the Mediterranean Sea. To accomplish this the panelists, composed of scientists from both leading national and international institutions, gave seven presentations which dealt with measurement and monitoring of conventional and emerging chemical contaminants in the Mediterranean Sea as well as the ways and means to better integrate ongoing studies, and to build analytical capabilities and monitoring expertise in areas where they are lacking.

With respect to contaminants, a presentation by Francesco Regoli discussed the distribution and bioaccumulation of heavy metals in certain sentinel (bio-indicator) species that have been used to assess metal pollution in both industrialized and relatively clean areas of the Mediterranean. He highlighted the fact that mercury appears to be higher in certain Mediterranean species of top predator fish than in similar species from the Atlantic, and that while the reasons for this observation are far from clear, the increased concentrations might be due in part to the natural mercury anomaly that is present off the northwest coast of Italy. Moreover, his presentation stressed the utility of integrating chemical analyses with determining molecular, biochemical and cellular biomarkers in the species analyzed in order to assess biological effects in the different areas. In one example, using caged mussels placed beneath an offshore drilling platform in the Adriatic Sea, it was demonstrated that early warning signals of environmental stress could be readily detected through specific biomarker analysis. The source and origin of petroleum hydrocarbons along the west coast of Algeria was highlighted in the presentation by Sellali et al. These authors reported the presence of heavy oil contamination in sediments in this sector, most likely derived from the petrochemical complex in the Gulf of Arzew. The very high levels of PAHs noted near Oran were believed to originate from industrial and domestic wastes released from the city, whereas near the outflow of various oueds entering the sea, the hydrocarbons contained a land-based, pyrolytic signal. Their dataset represents one of the first reported for an area of the southern shore where data have consistently been lacking, and it clearly indicates a land-based rather than maritime shipping origin of the contamination.

As concerns emerging contaminants in the Mediterranean, the report of Hélene Budzinski highlighted the need for basic information on the various classes of pharmaceutical substances that have been recently identified in seawater. Her studies have focused on developing analytical techniques for their quantitative measurement in seawater, in particular the use of semi-permeable membrane devices for carrying out integrative sampling. Using these techniques her group has found concentrations of a wide variety of pharmaceuticals in seawater collected off Marseille ranging from a few nannograms to several micrograms per liter, with most of the contamination residing in the dissolved phase.

In terms of strategies for undertaking integrated monitoring studies on contaminants, Hervé Thebault and Alessia Rodriguez y Beana presented results of the first phase of the CIESM Mussel Watch monitoring study of radionuclides using the Mediterranean mussel Mytilus galloprovincialis. Some 20 laboratories from 15 countries were involved in the study, and from that network a regional map for ¹³⁷Cs has been produced showing generally very low concentrations in mussels, viz. on the order of 1 Bq kg⁻¹ or less. Somewhat higher levels were found in mussels from the Black Sea and northern Aegean Sea indicating residual concentrations from Chernobyl fallout. During Phase II the programme will be extended to cover the natural radionuclide ²¹⁰Po as well as include some emerging trace contaminants. In connection with the Mussel Watch monitoring approach, Mai Khanh Pham et al. reported that the quality of the data have been verified by ensuring that all laboratories involved participated in a Quality Assurance intercomparison exercise for radionuclides in mussels. The IAEA Marine Environment Laboratories produced a mussel reference material that was analyzed by all the participating laboratories. During the exercise various analytical problems in some laboratories came to light, and capacity building needs were thereby identified. Based on these results and those from nine additional laboratories located outside the region, information values for ¹³⁷Cs and several other radionuclides were determined. Further work is presently underway to certify this intercomparison material as an IAEA Reference Material.

Concerning regional programme activities, Michel Warnau presented a concrete proposal for linking and integrating on a basin-wide scale many of the similar monitoring programmes that are underway in the Mediterranean region. Difficulties in project implementation often arise owing to the participating countries having major industrial, agricultural, cultural and regulatory differences. Furthermore current programmes are supported by several different entities including national, regional, European, and international funding bodies, a fact which often leads to overlap in both scope and efforts. These programmes often run in parallel with little or no information exchange amongst them. The proposal aims to better integrate all these projects having similar objectives by coupling, reinforcing and equipping them in a similar fashion which would ultimately result in a synergistic effect thereby enhancing the overall output. Within this integrated effort, key international organizations with expertise in organizing training and capacity building would furnish similar support to all the programmes involved thus making the entire monitoring effort far more cost effective. Furthermore such an approach would lead to enhanced quality assurance of monitoring data since all parties' analytical techniques and methodologies would be unified through inter-comparison exercises of the various analyses. In support of such of obtaining such an integrated monitoring network, Oscar Acuña from the IAEA Technical Cooperation Department explained how IAEA could support such a proposal through its current and future technical cooperation programmes in the Mediterranean and West Asian regions. The overall goal would be to eventually enhance the level of expertise in trace contaminant measurements in participating groups from the southern and eastern rim, in order to bring it up to par with that available in the more developed Mediterranean regions.

Following these formal presentations, the panel was open to comments and discussion and the panelists were queried on a number of points raised by the participants. Regarding conventional contaminants such as metals and hydrocarbons, some participants felt that many contaminant data had already been gathered from a large portion of the Mediterranean and that perhaps it was time to synthesize what is now known before proceeding with more monitoring surveys. There was general agreement that much information had already been obtained through some 30 years of monitoring within MedPol and other programmes, but it was also acknowledged that the geographical distribution of those data was "patchy" at best, and that reliable data still lacked for large areas of the eastern and southern shores of the Mediterranean. It was in these areas that the group felt

PANEL REPORT BY THE MODERATOR

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Keywords : Deep Sea Ecology, Deep Sea Basins, Deep Sea Processes, Deep Sea Sediments, Biodiversity.

Panel 5 was conceived with the objective of giving a brief but highly interdisciplinary picture of present knowledge and recent advances in Mediterranean deep-sea research, starting from the geosphere and hydrosphere settings, to microbiology and faunal diversity and ecosystem functioning, to conclude with the presentation of Programmes on Mediterranean biodiversity and ecosystem functioning.

The Panel started with a general overview on deep seas presented by the moderator Roberto Danovaro. Deep-sea sediments, covering 65% of the world surface, are the largest ecosystem on Earth. Here microbial processes, driving nutrient regeneration and global biogeochemical cycles, are essential to sustain primary and secondary production of the oceans. Deep-sea ecosystems are also the largest reservoirs of biomass and key elements/compounds. There are no direct estimates of the value of deep seas. However, since the deep-sea floor covers an area ~ 100 larger than that of shelf, even assuming a deep-sea dollar/ha/yr value 10 times lower than that of shelf, the value of deep sea functions is 10 times higher than that of shelves, and potentially higher than actual estimates of world total ecosystem value. In addition, the census of life in the deep sea is just at the beginning and the largest portion of its biodiversity is still unknown (from 0.3 to 8.3x10⁶ species to be discovered). The moderator illustrated also the reasons why the deep Mediterranean Sea can be considered the best existing model to investigate the impact of changes at global scale. The main reasons can be summarized as follows:

1. The Mediterranean is a miniature Ocean (therefore a model of circulation and processes occur at much smaller time scales);

2. There is a long-term history of investigations and impacts in the Mediterranean basin (but not in the deep sea);

3. High deep-sea temperatures, which imply faster responses.

4. Susceptible and sensitive to climate changes (already evident in the deep, relevance of episodic events; EMT, Gulf of Lion);

5. High biological diversity in coastal systems vs. very low biodiversity in the deep.

6. Strong environmental and biodiversity gradients (e.g., West-East gradient in trophic conditions);

7. Complex paleo-ecological history, with periodic mortality events (sapropel formation): scenarios of recolonization;

8. The Mediterranean is the ideal basin for testing factors forcing the evolution of deep-sea life: large proportion of continental margins - source sink hypothesis;

9. The deep-Med contains the most extreme environments for life (e.g., DHABs);

10. The deep-Med is full of hot spot ecosystems at very short distance (cold seeps, deep corals, canyons, slopes, slides, seamounts, anoxic etc).

Deep-sea ecosystems, and the Mediterranean in particular, are highly vulnerable, and increasingly subject to direct and indirect anthropogenic impacts (deep-sea trawling, dumping, oil, gas and mineral extraction, other pollution sources). Moreover, recent findings have revealed that climate change can exert also a significant and rapid impact on deep-sea Mediterranean biodiversity.

The presentation of the first panelist (Miquel Canals) focused on the description of the drivers of Mediterranean deep water sedimentation. Recent observations suggest that the functioning of deep Mediterranean benthic systems, as expressed by particulate fluxes and benthic variables, are characterised by a large interannual variability, which is highlighted by the evidence of episodic or stochastic events, or long-term climate change. Two such large events - the Eastern Mediterranean Transient and the Gulf of Lions cascading - affected significant parts of the eastern and western basins respectively. M. Canals described in detail a highly significant massive sediment transport and seafloor shaping process, not previously documented, and illustrated how Dense Shelf Waters (DSW),

flowing down submarine canyons and slopes, carried large amounts of coarse sediment that eroded and shaped canyon floors (e.g. giant furrows). The main conclusions coming out from this presentation were:

1. This is a mechanism of massive transfer of fresh organic matter, and hence C sequestration, to the deep ocean;

2. DSW flowing down canyons may carry large amounts of highly nutritive fresh organic matter that in intense events (twice from 1993 to 2005 in the Gulf of Lion) reaches the very deep basin thus massively injecting C into the deep ocean;

3. Submarine canyons in the Gulf of Lion drive the deep Western Mediterranean Sea;

DSWC in the Gulf of Lion imprints intermediate and deep waters, and the functioning of the deep ecosystem in the Western Mediterranean Sea;

4. According to predictive models, climate change holds the potential to significantly modify dense shelf water cascading;

5. Global warming will likely lead to a lowering in the frequency of dense shelf water formation, thus reducing the frequency of cascading processes which in turn will cause a severe reduction of the episodes of massive injection of organic matter into the deep ecosystem. The example reported here on the cascade event in the Gulf of Lion is providing new perspectives of investigation and management of the Mediterranean.

Jean Mascle illustrated the geosphere component of the deep-Mediterranean Sea and discussed the present knowledge on the topographic description of the deep Mediterranean seafloor, which is a prerequisite for any subsequent investigation on deep-sea life and ecosystem functioning. He showed the recently published (2005) CIESM/Ifremer high resolution multibeam maps which cover large portions of the seabed morpho-bathymetry in both the Western and Eastern Basin. Additional maps detailing specific areas of the Mediterranean Sea such as the Nile Deep Sea Fan were produced under the same scientific collaboration. J. Mascle also underlined the high scientific value of these maps which provide detailed information on large scale geological processes of the Mediterranean Basin and reveal specific features of the seabed (e.g. mud volcanoes, gas and fluid seepages) which are extremely important to understand biogeochemical processes occurring in the deep.

Anastasios Tselepides illustrated some peculiar aspects of the biology and ecology of deep-sea benthic biota in the Mediterranean, with a specific focus on benthic community structure and function of the deep Eastern Mediterranean Sea. High temperature, high salinity and the strong oligotrophy make this ecosystem very different from all other ocean deep-seas. This difference is also reflected in the species diversity and functional role of the macro- and microbiota of the deep Mediterranean, as illustrated by the author. He also focused on main drivers and recent changes related to climatic events such as the Eastern Mediterranean Transient, which indirectly affected the deep benthic communities. The high vulnerability of the Mediterranean deep sea ecosystem to environmental changes and its close interactions with the upper water column and the coastal ecosystems were underlined.

This talk was followed by a summary on the present knowledge and recent advances in deep Mediterranean microbiology by Christian Tamburini and Gerhard Herndl. They reported the key role of deep-sea prokaryotes (DSP), which are a virtually untapped resource for industrial purposes. Recently, a number of novel metabolic pathways have been discovered, shedding new light on the dark ocean prokaryotes. Non-thermophilic Archaea have been recently found to represent the major source of autochthonously produced organic carbon in the deep sea and play a major role in deep-water nitrification outnumbering bacterial nitrifiers in the oxygen minimum zones of the mesopelagic ocean. Anaerobic anmonium and methane oxidizers have been found in the dark ocean sediments and even more recently, in the deep oceanic water column. The Mediter-