Newsletter No 3 Autumn 2002

BIOMARE

Implementation of large-scale long-term MARine BIOdiversity research in Europe

www.biomareweb.org

A concerted action to establish the infrastructure and conditions required for marine biodiversity research at a European scale.
Contract number: EVR1-CT2000-20002

Final workshop a success

The final BIOMARE workshop, held in Tromsø, Norway, was a major success. It was the last in a series of many regional meetings and workshops, and final decisions were reached on the selection of sites for large-scale, long-term biodiversity studies, biodiversity indicators and ways to disseminate the results.

For workpackage 1 (WP1), consensus was reached on the selection criteria for, and final selection of, the different categories of sites that will be part of the network. The sites will be presented in a full-colour booklet. Much valuable information on biodiversity indicators in the different biogeographic regions of Europe was added to the database of WP2. The new BIOMARE newsletter, a WP3 activity, was distributed and, because of the high quality of the newsletter, it was decided to keep it 'alive' after the end of the project.

The atmosphere during the workshop was very stimulating. The BIOMARE members worked busily, filling in tables and discussing the present products and the future of the project. We have already achieved one very important goal of the project: we've set up a network of researchers who are all willing to cooperate and invest in the establishment of a framework (network) for large-scale, long-term marine biodiversity research at a pan-European scale. This all was made possible thanks to the local organisers of the workshop: Sabine Cochrane, Salve Dahle, and the kind support of Norsk AGIP. The progress of the project is available on our website, biomareweb.org.

Final steering committee meeting

The final Steering Committee meeting was held in Banyuls, France, on 26-28th October 2002.

Members of BIOMARE outside the Polaria aquarium (left) and Polar Environmental Centre (right) in Tromsø, Norway, in September.

Contents

The BIOMARE Newsletter is compiled by: Ecological Consultancy Services (EcoServe) Ltd, Unit B19, KCR Industrial Estate, Kimmage, Dublin 12, Ireland.

Dissemination

A full report on BIOMARE is available on our website www.biomareweb.org

BIOMARE website

Promotion of the project has been through the website (www.biomareweb.org), at BIOMARE regional meetings and through the Marine-B listserver. Both the website and listserver will be maintained as a marine biodiversity resource beyond the duration of the project.

The BIOMARE website has been regularly updated. It includes details of the project objectives, work packages, project participants and the first two newsletters, with links to key marine biodiversity and biodiversity websites.

The website now also includes databases on researchers, managers and institutes involved in marine biodiversity issues, and large-scale, long-term marine biodiversity datasets in Europe.

A brochure on BIOMARE has been produced, outlining the project aims and preliminary results. If you wish to receive a copy, it is available from:

**Chris Emblow,
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KCR Industrial Estate,
Kimmage,
Dublin 12,
Ireland.**

BIOMARE brochure: copies available from EcoServe

BIOMARE listserver

To facilitate communication of the project aims to as broad an audience as possible, and to disseminate the results of the project, the **Marine-B (Marine Biodiversity) electronic mailing list** is being utilised by the project.

To join the list

This process will generate a piece of mail inviting you, as the owner, to add yourself to the list.

Send an email to listserv@listserv.heanet.ie, leaving the subject line blank. In the main part of the mail, type in the command:-

subscribe MARINE-B <firstname surname>

Make sure that you do not add a signature at the end of the mail. You will then receive a message saying you are subscribed to the list.

To send mail to the list

When you want to send mail to the list, just enter MARINE-B@listserv.heanet.ie in the 'To:' field and your mail message will be distributed to the people who have signed on to the list.

If you wish to check the list archives, go to:-

http://listserv.heanet.ie/marine-b.html

The website http://www.lsoft.com/ may be useful if you wish to get further information about listservers and the running of the list. If you have any problems, please email Chris Emblow (cemblow@ecoserve.ie).

Book announcement

Invasive aquatic species of Europe: Distribution, impacts and management
Edited by Erkki Leppäkoski, Stephan Gollasch & Sergej Olenin
Kluwer Academic Publishers
To be published October 2002

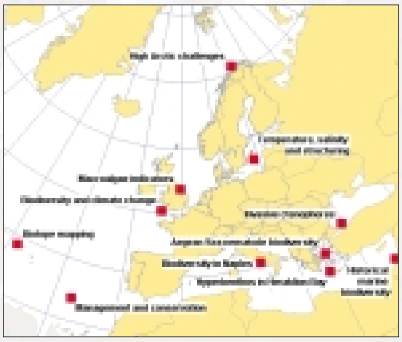
The global scale of alien species invasions is becoming more and more evident in the beginning of the new millennium. Though the problem of biological invasions has become a rapidly growing area of research, there are still large gaps, both geographically and thematically, to be filled in the near future.

This book is the first attempt to provide an overall picture of aquatic species invasions in Europe. Altogether, more than 100 scientists from 24 countries have joined to synthesise the available information on bioinvasions. The geographical scope stretches from Irish waters in the west to the Volga River and the Caspian Sea in the east, and from the Mediterranean in the south up to the Arctic coast of Europe. Not all parts of the continent could be equally covered, as in some countries species invasions are not studied yet.

The book endeavours to represent the full array of major European aquatic systems, and its geographical and ecological scope is as broad as possible - from fully saline seas, semi-enclosed brackish water bodies and coastal lagoons to freshwater lakes, major river systems and waterways. The key objectives include the present status of, and impacts caused by, non-native aquatic species in European waters.

Marine Biodiversity in Europe

This newsletter is publishing a series of articles highlighting regional marine biodiversity issues in and around Europe. In this edition we present eleven articles - one from the high Arctic, one from the Baltic Sea, one from the North Sea coast in north-east England, one from the English Channel, one from the central Mediterranean (Gulf of Naples), three from the eastern Mediterranean (the Cretan Sea, the Aegean Sea and Israel), one from the Caspian and Black Seas, and two from the North Atlantic (the Azores and Madeira).



Madeira's biodiversity: management and conservation

A. Madeira, A. Freitas & A.D. Abreu
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The Madeira Regional Government has launched a three-year project - "Madeira's Biodiversity: Management and Conservation" – to bring up to date the knowledge on Madeira's biodiversity regarding its conservation state, according to international criteria. The regional scientific community - Madeira's University, Whale Museum, Funchal Natural History Museum, and Botanical Garden - are working together on this initiative, co-ordinated by the Environmental Regional Government Department. The motto of the initiative, "Knowing to Conserve," calls on the scientific community and the sphere of influence in the region to participate in a common objective - the conservation of the natural heritage.

Given the small dimensions of the area, Madeira's Archipelago has a high density of species, including a large number of endemics. All compiled data will be available, together with other environmental parameters, in the Environmental Information Regional System. Information will also be made available in such a way that biodiversity can be established as a central theme of nature conservation and education activities, promoting a valorisation and preservation political strategy with regard to Madeira's natural resources.

One of the first outputs of this project are thematic booklets, each describing a group of species and its conservation state in Madeira. The first book published concerns marine mammals in the Madeiran Archipelago and was edited by L. Freitas of the Whale Museum (e-mail: np53vj@mail.telepac.pt).

Since 1986, cetaceans have been protected in Madeira by legislative measures. However, these measures have not been followed by management measures or a monitoring programme to enable the identification of threats to the cetacean populations. In 1999, an EU LIFE-Nature project began and is aimed at the conservation of cetacean populations in Madeira's Archipelago waters.

"Marine Mammals in Madeira's Archipelago Waters," by L. Freitas

At present in Madeira, some problems affecting the species can be pinpointed. Namely, intensive maritime traffic off the south coast, unregulated whale-watching and dolphin-watching activity (performed on a rather opportunistic basis by unprepared operators) and negative interactions between cetaceans and humans (*e.g.*, fishing, litter) resulting in the direct death of animals. In order to overcome these problems, four specific objectives have been established:

- To determine the conservation status of *Tursiops truncates, Stenella frontalis* and *Globicephala macrorhynchus;*
- To determine the impact on cetaceans - especially the above-mentioned species - of whale-watching and dolphin-watching activities which are being carried out by the coastal tourist boats and big-game fishing boats, and to propose measures to reduce their impact;
- To raise awareness among the population - especially among the fishing villages' inhabitants and the users of the sea - of the conservation of cetaceans, and of the concerns about the harmful impact that litter thrown into the sea can have on these animals;
- To raise the awareness of tourists – especially customers of coastal tourists boats and big-game fishing boats - of the disturbance they can cause to cetaceans, so as to encourage them to became agents of conservation.

The monk seal *Monachus monachus* has been protected by legislation implemented by the Madeira Regional Government and was also embraced by a LIFE-Nature project aimed at the conservation of its habitat (desert islands).

According to data collected on marine mammals in Madeira's Archipelago, the existing species and their present conservation status according to IUCN categories (1994) are as follows:

Species	Conservation Status
Eubalaena glacialis	Threatened
Balaenoptera physalus	Threatened
Megaptera novaengliae	Threatened
Balaenoptera acutorostrata	Lower risk
Physeter macrocephalus	Threatened
Kogia breviceps	Data deficient
Ziphius cavirostris	Data deficient
Mesoplodon densirostris	Data deficient
Mesoplodon bidens	Data deficient
Orcinus orca	Lower risk
Pseudorca crassidens	Not evaluated
Globicephala macrorhynchus	Lower risk
Grampus griseus	Data deficient
Tursiops truncatus	Data deficient
Steno bredanensis	Data deficient
Delphinus delphis	Data deficient
Stenella frontalis	Data deficient
Stenella coeruleoalba	Lower risk
Monachus monachus	Threatened

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Macro-algae functional groups as an assessment tool of biodiversity

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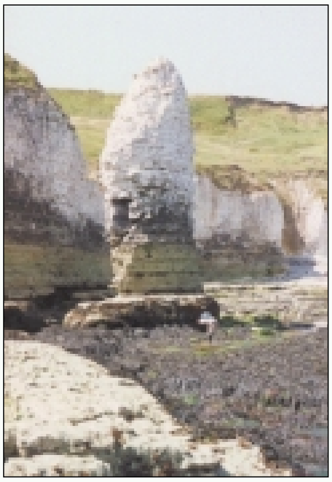

Chalk sea-stack near Flamborough Head on the north-east coast of England

Traditionally, seaweed ecology has relied on the study of individual species and the identification of assemblages. Alternatives to ecological groups are functional groups. In 1975, a simple classification system using three morphological groups of algae was proposed by Dayton. Based on more detailed categories, Littler and Littler (1980) proposed a functional form model to study trends in the successional status of seaweeds. The model they developed integrated the morphological attributes of the thallus in relation to the productivity and the survival of benthic macroalgae. They applied the groups to a subtropical rocky intertidal system and were able to relate the various groups to the stability of the substratum (Littler & Littler, 1984). Steneck & Watling (1982) confirmed that polyphyletic groups based on the anatomical and morphological characteristics of the thallus could be grouped to reflect ecological characteristics. More recently, Steneck and Dethier (1994) studied sites from three biogeographical regions. They suggested that the use of functional groups could provide insights into the structure of communities and could be used to make comparisons in space and time. Such studies have concentrated on the use of functional groups for assessing the response of complex algal communities to disturbances in subtidal environments (Lavorel *et al.*, 1997).

Rocky shores

Such a functional group approach has ecological application on intertidal rocky shores (Tobin *et al.*, 1998; Tobin, 2000). In a preliminary survey of the Yorkshire coast (England), the authors were confronted by the fact that the identification of seaweeds to species level in such complex habitats requires a high level of taxonomic expertise and is time-consuming. Moreover, it was sometimes difficult or even impossible to identify species in the field. Using several sampling sites in north-east England, they showed that these difficulties can be overcome by dividing the biota into functional groups. They compared species-based and group-based descriptions of algae-dominated shores. They demonstrated that, on temperate rocky shores, the functional group approach could help in identifying large-scale factors affecting the distribution and survival of marine macrophytes. They further showed the utility of the functional group approach in temporal studies. Patterns in community structure could be detected, and a degree of stability undetectable at species level could be highlighted.

Recolonisation

Following a landslide which affected the intertidal rock platform, functional groups were used for understanding recolonisation processes of a degraded ecosystem. Looking for a simple protocol, Ducrotoy & Pickaert (2001) suggested that the approach could rely on a simple sampling strategy, including a reduced sampling effort, but could describe recolonisation forces and help in assessing progress in recovery. The hypothesis to be tested was that, rather than occurring as a uniform and progressive process, recolonisation would happen step by step and imply successive attempts from plants to reinstall.

Extensive chalk cliffs at Flamborough Head, BIOMARE European Marine Biodiversity site.

Experiment

An experimental approach to this problem was made possible because a large-scale disturbance took place in the intertidal area of a wave-cut platform where the hypothesis could be tested. In May 1993, the wave-cut platform at Holbeck, Scarborough (North Yorkshire, United Kingdom), was impacted by a landslide from the overhanging cliff. Twenty thousand tonnes of clay were deposited on the rocky shore within minutes. The engineering works that took place over the following year resulted in a complete removal of intertidal organisms over about a 1-ha area.

The simple groupings proposed by Dayton (1975) were adapted to the situation found on the coast of north-east England. Because of its simplicity and the confidence in assigning species to groups, results could easily fit the model of the recolonisation (Sylvand & Ducrotoy, 1998).

Digital photographs

In order to meet the requirements for monitoring the European Natura 2000 site at Flamborough Head, Ducrotoy & Simpson (2001) developed techniques based on the use of computer-processed digital photographs (Malone, 1997; Strong, 1998; Simpson, 1999). Such techniques are now being used at other similar sites throughout Europe, notably SAC and SPA sites designated under European directives (IECS, unpublished).

Flamborough Head is a candidate marine SAC. It was designated for its chalk cliffs and sea caves under the EU Habitats and Species Directive, and as an SPA under the EU Wild Birds Directive, as a Heritage Coast, a Sensitive Marine Area (SMA), a Site of Special Scientific Interest (SSSI) and a Ramsar Site. Recently, it was selected as a Flagship Site for intensive research on biodiversity, in the framework of the European Concerted Action BIOMARE.

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References

Dayton, P.K., 1975. Experimental evaluation of ecological dominance in a rocky intertidal algal community. *Ecological Monographs,* **45:** 137-159.

Ducrotoy, J.P. & Pickaert C., 2000. A functional group approach to seaweed recolonisation of a wave-cut platform. *Journal de Recherche Oceanographiques,* **26:** 43-56.

Ducrotoy, J.P. & Simpson S.D., 2001. Developments in the application of photography to ecological monitoring, with reference to alga beds. *Aquatic Conservation: Marine and Freshwater Ecosystems,* **11:** 123-135.

Lavorel, S., McIntyre, S., Landsberg, J. & Forbes, T.D.A., 1997. Plant functional classification: from general groups to specific groups based on response to disturbance. *TREE,* **12,** (12): 474-477.

Littler, M.M. & Littler, D.S., 1980. The evolution of thallus form and survival strategies in benthic marine alga: Field and laboratory tests of a functional form model. *American Naturalist,* **116** (1): 25-44.

Littler, M.M & Littler, D.S., 1984. Relationships between macroalgal functional form groups and substrata stability in subtropical rocky intertidal systems. *Journal of Experimental Marine Biology and Ecology,* **74:** 13-34.

Malone, R., 1997. A proposed methodology for the long-term monitoring of the intertidal macroalgae on a wave-cut platform, with specific reference to Selwicks Bay, Flamborough Headland, North Humberside. *Heritage Coast Report:* 26 pp.

Simpson, S.D., 1999. A long-term monitoring strategy for the algal beds at Selwicks Bay, Flamborough, England: Unpublished Mres thesis, University of York.

Steneck, R.S. & Watling, L., 1982. Feeding capabilities and limitation of herbivorous molluscs: a functional group approach. *Marine Biology,* **68:** 299-319.

Steneck, R.S. & Dethier, M.N., 1994. A functional group approach to the structure of algal-dominated communities. *Oikos,* **69:** 476-498.

Strong, E., 1998. Broad-scale monitoring of a macroalgal community at Selwicks Bay, Flamborough Head. Unpublished Mres thesis, University of York.

Sylvand, B. & Ducrotoy, J.-P., 1998. Monitoring coastal and estuarine systems: The need for an integrated approach. In: *With rivers to the Sea: Interaction of Land Activities, Freshwater and Enclosed Coastal Sea,* Falkenmark, M. (ed.), Stockholm International Water Institute, Stockholm: 189-204.

Tobin, M., 2000. Applications of a functional group approach to the study of temperate algal communities. Unpublished Dphil Thesis, University of York.

Tobin, M.L., Scott, G.W. & Ducrotoy, J.-P., 1998. Applications of a functional group approach to algal community ecology. In: *Changes in the marine flora of the North Sea,* Scott, G.W. & Titley, I. (eds.), CERCI, University College Scarborough: 135-147.

The invasive ctenophore *Mnemiopsis* problem in the Black and Caspian Seas

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In the 1980s, the introduction of a new species (a lobate ctenophore, *Mnemiopsis leidyi* or *M. mccradyi*) (see Fig. 1) into the Black Sea radically affected the whole ecosystem (Vinogradov *et al.,* 1989; Kideys, 1994).

This species had a negative impact on the most dominant fish of the Black Sea, the anchovy *Engraulis encrasicolus,* through competition for the edible zooplankton as well as consumption of anchovy eggs and larvae. The mass occurrence of *Mnemiopsis* was one of the most important reasons for the sharp decrease of anchovy and other pelagic fish stocks in the Black Sea (Kideys, 1994; Kideys *et al.,* 2000; see Fig. 2). Due to the scale of the problem, UNEP has been involved in order to find a solution for the impact of *Mnemiopsis* on the Black Sea ecosystem (GESAMP, 1997).

Meantime, the possibility of its introduction into other neighbouring sensitive ecosystems, notably the Caspian Sea, has been mentioned (Dumont, 1995; GESAMP, 1997). However, another ctenophore, *Beroe* (either *ovata* or *cucumis,* which is a subject of debate), which arrived in the Black Sea in the late 1990s, seemed a very effective predator of *Mnemiopsis* (see Fig. 3). Several laboratory and field data suggest that *Beroe* feeds exclusively on *Mnemiopsis* in the Black Sea (Finenko *et al.,* 2001).

U. Niermann

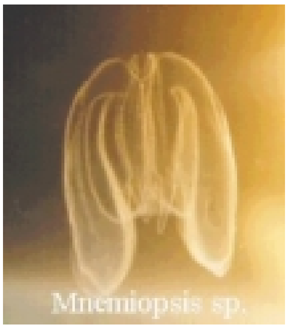

Figure 1. *Mnemiopsis* from the Black Sea

Arrival in the Caspian Sea

As expected, the *Mnemiopsis* ctenophore was reported from the Caspian Sea by November 1999 (Ivanov *et al.*, 2000). However, Iranian fishermen noticed *Mnemiopsis* for the first time in the summer of 1998 (pers. comm. Hasan Fazli, Mazandaran Fisheries Research Center, Sari, Iran).

To catch three species of kilka, Iranian fishermen fish at night using a funnel net and a light. *Mnemiopsis* would be very easily recognised using this method, so we can safely assume that the occurrence of this ctenophore in noticeable numbers dates from 1998 for the Iranian waters of the Caspian Sea.

Ivanov *et al.* (2000) suggested that this ctenophore was transported with ballast water taken aboard in the Black Sea or the Sea of Azov (where *Mnemiopsis* occurs in warm months) and released after ballast-loaded ships passed through the Volga Don Canal and the shallow, freshwater north Caspian Sea and into the saltier central or south Caspian Sea (Ivanov *et al.*, 2000).

The impact of *Mnemiopsis* on the ecosystem of the Caspian Sea is already very significant. Preliminary results from monitoring programmes set up in Azerbaijan and Iran clearly show that zooplankton seems to be the worst-affected component of the ecosystem in the Caspian Sea (Kideys *et al.*, 2001a,b). The impact on lower trophic levels has been, so far, appropriately reflected in the higher trophic levels. Pelagic landing figures pointed to about a 50% reduction for the Iran and Azerbaijan fishery (Kideys *et al.*, 2001a,b). Similar values were presented by Russia with respect to the Russian Caspian fishery. There have also been lower pregnancy figures, higher mortalities and consequently decreases in endemic

The invasive ctenophore problem....

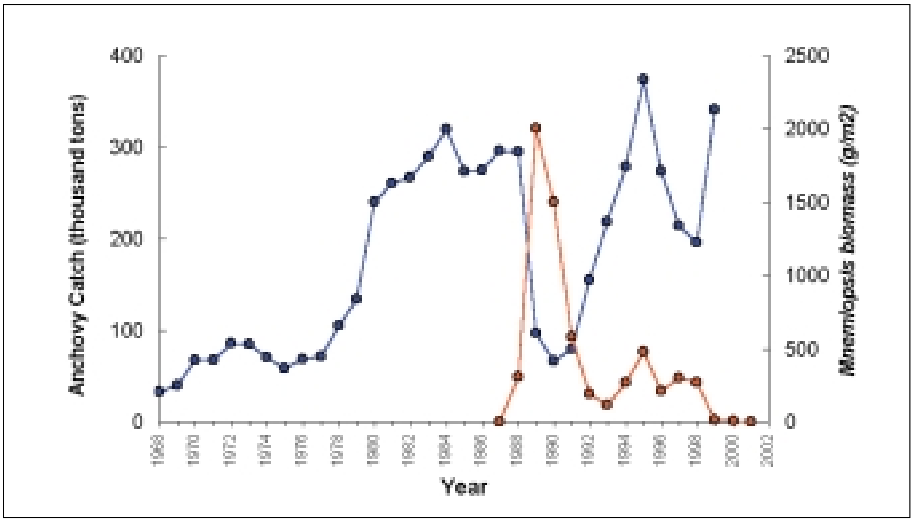

Figure 2. The relationship between *Mnemiopsis* biomass (red) and anchovy catch (blue) in the Black Sea (updated from Kideys *et al.*, 2000).

Caspian Seal populations recently (Shiganova *et al.,* 2001).

Seeking a solution

The Caspian Environment Programme (CEP) located in Baku, Azerbaijan, has organised very fruitful activities aimed at defining, stating and proposing a solution to the *Mnemiopsis* problem in the Caspian Sea, with the help of riparian countries and *Mnemiopsis* experts from different countries. Among the activities were two meetings organised in Baku specifically to discuss *Mnemiopsis*. These meetings resulted in the setting up of ecosystem monitoring programmes, with particular reference to *Mnemiopsis*, on Azeri coasts (supported by the European TACIS Programme) and in two different regions of the Iran coast in the Caspian Sea (with the support of the Iranian Fisheries Organisation, Shilat). In addition to these, a few basin-wide surveys were taken by the riparian countries to assess the ctenophore distribution in the entire Caspian (Shiganova *et al.,* 2001; Kideys and Moghim, 2002).

Experiments

One of the most important activities, however, has been the laboratory experiments with *Beroe* that were transported to an Iranian laboratory (Sari) on the Caspian (Kideys *et al.,* 2001c); special thanks to CEP and Shilat for supporting this important activity. In these experiments, the adaptation and survival of *Beroe*, and its miscellaneous physiological characteristics (feeding, spawning, respiration), were measured in Caspian water conditions. Thus, for example, we now know the diet and feeding rate of *Beroe* on Caspian *Mnemiopsis*. During these experiments, different physiological aspects of Caspian *Mnemiopsis* were also successfully studied (Kideys *et al.,* 2001c).

A.E. Kideys

Figure 3. Black Sea *Beroe*

The research goes on

We, as a group of scientists, are at present continuing our experiments to assess the impact of *Mnemiopsis* and its control using *Beroe*.

References

Dumont, HJ, 1995. Ecocide in the Caspian. *Nature* **377**: 673-674.

GESAMP (IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection), 1997. Opportunistic settlers and the problem of the ctenophore *Mnemiopsis leidyi* invasion in the Black Sea. *Rep. Stud. GESAMP,* **58**: 84p.

Finenko, G.A., Anninsky, B.E., Romanova, Z. A., Abolmasova, G. I. & Kideys, A. E., 2001. Chemical composition, respiration and feeding rates of the new alien ctenophore, *Beroe ovata*, in the Black Sea. *Hydrobiologia* **451**: 177-186.

Ivanov, P.I., Kamakim A.M., Ushivtzev, V.B., Shiganova, T., Zhukova, O., Aladin, N., Wilson, S.I., Harbison, G.R., Dumont, H.J., 2000. Invasion of Caspian Sea by the comb jellyfish *Mnemiopsis leidyi* (Ctenophora). *Biological Invasions* **2**: 255-258.

Kıdeys, A.E., 1994. Recent dramatic changes in the Black Sea ecosystem: The reason for the sharp decrease in Turkish anchovy fisheries. *Journal of Marine Systems* **5**: 171-181.

Kideys, A.E., Kovalev, A.V., Shulman, G., Gordina, A. & Bingel, F., 2000. A review of zooplankton investigations of the Black Sea over the last decade. *Journal of Marine Systems* **24**: 355-371.

Kideys, A.E., Shahram Ghasemi, Davood Ghninejad, Abulgaseem Roohi & Siamak Bagheri, 2001a. Strategy for combatting *Mnemiopsis* in the Caspian waters of Iran. A report prepared for the Caspian Environment Programme, Baku, Azerbaijan; Final Report, July 2001.

Kideys, A.E., Jafarov, F.M., Kuliyev, Z. & Zarbalieva, T., 2001b. Monitoring *Mnemiopsis* in the Caspian waters of Azerbaijan. A report prepared for the Caspian Environment Programme, Baku, Azerbaijan; Final Report, August 2001.

Kideys, A.E., Finenko, G., Anninski, B., Shiganova, T., Abolgaseem Roohi, M. Roushan-Tabari, M. Youseffyan, M. T. Rostamian, H. Rostami, H. Negarestan, 2001c. Laboratory studies on physiological characteristics of *Beroe ovata* and *Mnemiopsis leidyi* in the Caspian Sea. Report prepared for the Caspian Environment Program (CEP), Baku, Azerbaijan, December 2001.

Kideys, A.E. & Mehdi Moghim, 2002. Distribution of the alien ctenophore *Mnemiopsis leidyi* in the Caspian Sea in August 2001. Submitted to *Marine Biology.*

Shiganova, T.A., Sokolsky, A.F., Kaptyuk, M.I., Kamakin, A.M., Tinenkova, D. & Kuraseva, E.K., 2001. Investigation of invader ctenophore *Mnemiopsis leidyi* and its effect on the Caspian ecosystem in Russia in 2001. A paper presented during the CEP Regional *Mnemiopsis* Advisory Group First Workshop, Baku, Azerbaijan, 3-4 December 2001.

Vinogradov, M.E., Shushkina, E.A., El Musaeva & PYu Sorokin (1989). Ctenophore *Mnemiopsis leidyi* (A. Agassiz) (Ctenophora: Lobata) - a new settler in the Black Sea. *Oceanology* **29**: 293-298 (in Russian).

Left: Mosaic in Archaeological Museum, Sousse, Tunis. Note fishing methods (rod and line, trap, drag net, sling net) and fish so ably depicted as to allow scientific identification. **Right:** Mosaic in same museum showing head of *Oceanus* crowned with lobster legs and surrounded by torpedo, rockfish, moray eel, squid, sea urchin, crab, octopus and penaeid shrimp.

A sea of stone - biodiversity and history

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Ancient mosaics of fish and fishing methods in the Mediterranean Sea illustrate the writings of Aristotle, Pliny and Oppian.

> *'Infinite and beyond ken are the tribes that move and swim in the depths of the sea, and none could name them certainly; for no man hath reached the limit of the sea, but unto three hundred fathoms less or more men know and have explored the deep.'*

With these words, Oppian gives us the ancient world view of the sea. A native of Cilicia, present-day Gulf of Iskendrun, Oppian lived during the latter half of the 2nd century CE and is the author of Halieutica, a five-volume poem on fish and fishing. In 3,500 lines of verse, he classifies and characterises the fish, fishing seasons and ancient fishing methods in the waters of the Mediterranean Sea.

Oppian was not the first to describe the Mediterranean and its fish. The earliest surviving record of the region's marine life appears in a 5th-century BCE collection of essays entitled *Corpus Hippocraticum.* The anonymous author classifies edible fish according to the quality of their flesh and their habitat: rockfish, migratory fish, fish living on the seabed, predators and plant eaters. In the 4th century BCE, the Greek philosopher Aristotle laid the foundations of zoology in his ten-volume work on animal life, *Historia Animalium.* Scholars of marine life relied on his work for the next two millennia. Pliny the Elder devoted a volume of his *Historiae Naturalis* to sea creatures, naming 74 species of fish. Romans considered marine fish superior to freshwater fish, and prices reflected their preference: Pliny the Elder grumbled about the extravagance of his generation and complained that a high-quality fish might cost as much as three cooks. Not surprisingly, the fish preferred in antiquity are also today's favourites: sea bass, grouper, striped sea bream, mullet and meager, as well as oysters, squid, shrimp and sea urchins.

In the 1st century BCE, oysters and fish were raised commercially around the Bay of Naples: six thousand moray eels were dispatched for a victory feast of Julius Caesar's. Affluent Romans boasted ponds stocked with rare imported fish, which they treated as pets. Emperor Claudius' mother is said to have hung gold rings in the nostrils of her favorite moray eel. Mosaic floors from Africa Proconsularis (present-day Algeria, Tunisia and Libya) depict ponds teeming with fish – probably a provincial effort to emulate the fashions of Rome. One marine mosaic discovered in Achola in Tunisia is so accurate as to allow scientific identification of the fish.

Mosaic floors in the ruins of splendid villas in Achola portray the fishing methods of the ancient world as if they were commissioned illustrations of Oppian's four methods of fishing: rod-and-line, harpoon, trap and net. In one mosaic, a fisherman sits on a rock by the seaside, wearing a broad-brimmed straw hat and a short cloak to protect himself from the burning sun or the morning chill; a basket of bait hangs from his waist. He casts his line into the sea, crosses his legs, and tries his luck with the philosophical patience that has characterised fishermen throughout the ages. Another mosaic shows a fisherman, his muscles bulging from the effort of pushing his barque through the surf. In the shallows beside the boat is another fisherman, about to cast his sling net - a circular net with weights fastened around its edge. The fisherman has folded the net onto his right arm, ready for action, and he lies in wait for the fish passing by in the shallow water. When a shoal approaches, he casts his net, and the weights spread it to its full extent; as it lands on the seabed, it traps the fish beneath.

In another section of the same mosaic, a fisherman impales an octopus hidden under a rock with a trident, and, since the octopus may put up a valiant fight, the fisherman has a large club with which to stun his catch. Pliny and Oppian both relate how fishermen locate the hiding place of an octopus from the empty shells strewn roundabout. Two fishermen sit in a small boat depicted in another mosaic. One plies the oars while the other pulls on wickerwork traps. Traps like these were used to catch lobsters and octopuses; they were placed in the sea in the evening and raised at dawn. A fisherman in another boat shows off his prize, a large lobster.

These ancient mosaics of marine life did not pretend to show the natural habitat of the fish. Neither were they produced solely as works of art. Due to their reproductive capacity, fish were considered sacred fertility symbols by the people residing along the shores of the Mediterranean. The various illustrations of sea creatures at the moment they were raised on a hook, or trapped in a net, are a celebration of the abundance and fecundity of the sea.

Mapping of Marine Biodiversity at Marine Special Areas of Conservation (SACs) in the Azores

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J Fontes (ImagDOP)

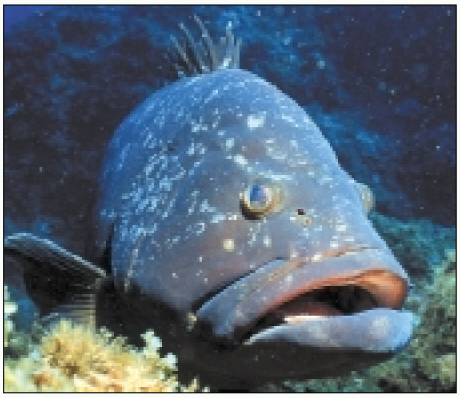

Figure 1. Dusky grouper in Corvo Island voluntary marine protected area

The Azores archipelago consists of nine islands scattered along 600km of the northern part of the Mid-Atlantic Ridge. The Department of Oceanography and Fisheries of the University of the Azores (DOP/UAç) has been working since 1976 to understand the processes that control the marine ecosystems around the islands. European efforts aimed at nature conservation recently provided resources to develop new projects relating to the management of sites included in the Natura 2000 network (*e.g.*, EU LIFE-Nature project B4-3200/98/509: MARÉ - www.horta.uac.pt/projectos/life/).

There are seventeen marine areas classified as Sites of Community Importance in the Azores. IMAR-DOP/UAç put forward projects to develop management schemes for six of them. Background for this work was research undertaken on the sites in previous years (see Santos *et al.*, 1995, for review). Each of the selected sites has special features that contributed to its primary choice: isolation and wilderness (Formigas Bank); particular social context (Corvo Island); unique environment (D. João de Castro Bank); and proximity to research facilities (Monte da Guia, Baixa do Sul and Madalena islets). Along with a series of other Azorean sites, the ones mentioned above are now designated as BIOMARE Sites.

Work in Faial-Pico Channel

The channel between the islands of Faial and Pico contains a series of designated areas (Monte da Guia, Baixa do Sul and Madalena islets) and is located very close to IMAR-DOP/UAç. These areas are used as primary sites, where the scientific techniques are put together, tested and, eventually, implemented. Until now, the work developed has included mainly the visual estimation of abundance and diversity of benthic and fish assemblages by SCUBA-diving, intertidal surveys and hand-seine netting in sheltered bays.

These efforts have resulted in the definition of biotopes and mapping of their distribution. Parallel work allowed the definition of basic models for algal species abundance as a function of physical parameters such as depth, wave exposure and bottom slope. These models are now being entered as basic variables in the Geographic Information System of specific sites around Faial, and the consistency of the prediction provided by these models and the observed distributions will be subject to further discussion and refinement (Tempera *et al*, 2001c).

Together with an analysis of the socio-economical context of the SACs, this research formed the basis for preliminary management plans that will now be subject to public hearing (Tempera *et al.*, 2001d).

Future work includes the use of underwater technologies such as Autonomous Underwater Vehicles (AUV), Autonomous Surface Vehicles (ASV), Remote Operated Vehicle (ROV) (Pascoal *et al.*, 2000) and eco-sounding systems (such as CHIRP and BOOMER: for details, please see Project MAROV website at http://www.horta.uac.pt/projectos/marov) to explore habitats not easily accessible to SCUBA divers.

Management results in Corvo Island

Corvo Island, the smallest island of the archipelago with only 17 km² and a population barely exceeding 400 inhabitants, has provided the setting for a case where the protection of the environment was an unexpected side-effect of successive scientific missions that were closely scrutinised by the local community.

The scientific work developed in Corvo Island extended for several years and allowed the scientific team to understand and describe the habitats around the island. At the same time, informal talks, articles published in popular magazines, and TV news reports on the local environment made the citizens more aware of the need to protect the environment. The bond established is expected to result in a higher commitment and more successful implementation of the set of management measures developed in close co-operation with the local population.

These efforts have also resulted in a transformation of economic activity on the island. A group of young entrepreneurs has changed their exploitative perspective on marine-living resources to a more environmentally-friendly one. They have renounced spearfishing and started a SCUBA-diving company. Together with the fishing community and scientists, the new tourism company has established voluntary rules to

F. Cardigos (ImagDOP)

Figure 2. Algae and *Pseudolepidaplois scrofa* at Dollabarat reef

L. Sebastião (ISR and Grupo E)

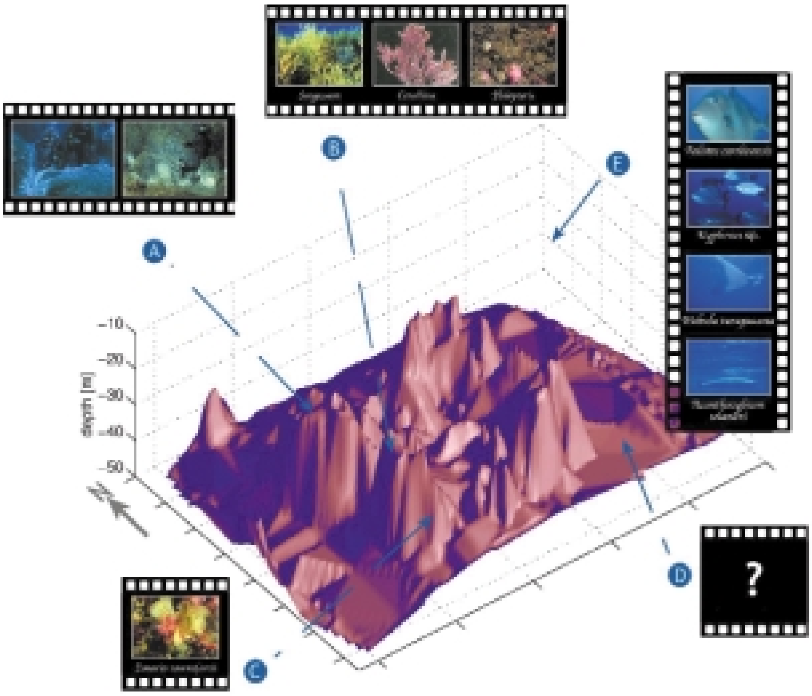

Figure 3. Species assemblages at D. João de Castro Bank

protect an area known to hold large dusky groupers (*Epinephelus marginatus*), a feature that is uncommon on the other islands and very attractive to scuba-divers (Tempera *et al*, 2002a,b) (Fig. 1).

Action on Formigas Bank

The Formigas offshore bank (which comprises both the shallow rocky bottoms around the Formigas islets and the Dollabarat reef) is located between the islands of São Miguel and Santa Maria.

The scientific missions in this area allowed scientists to recognise it as a pristine area with a high value for conservation (Fig. 2). New laws are being created in order to protect this area as a Marine Reserve. The novelty of this new status is of great interest to Azorean politicians who see this as a chance to promote conservation values in the marine environment, which is, after all, the main feature of the Azores. The over-exploitation of neighbouring banks and coasts subjected to heavy fishing reinforces the importance of the protection of this complex, which might serve as the last source of recruits (Tempera *et al.*, 2001a,b).

D. João de Castro Bank

In 1720, an underwater eruption gave birth to an ephemeral island, right between the islands of São Miguel and Terceira. After three years, the island disappeared, but a shallow-water area with hydrothermal activity remains to this day. In order to understand the consequences of this natural process for the ecosystem around it, detailed ecological cartography of the area has been developed. Besides bacterial mats not yet thoroughly identified, no new species have been found, but more than 150 species have already been identified in this area. Mapping of the most interesting species allowed us to draw three main conclusions:

- Despite the presence of chemo-synthetic bacterial mats on the bank, there are no food chains based on these bacteria;
- There are some influences of the vents on the species distribution in the shallow-water area (Ávila *et al.*, submitted);
- Despite the absence of new records of species for the Azores at the bank, there are some distinct species assemblages (Fig. 3).

The current trend for exploring this area is to go deeper in search of other hydrothermal vent areas, which would represent the intermediate between shallow-water and the well-known deep-sea vents.

Future trends

Biodiversity mapping is a basic tool for managing and protecting the marine environment properly. The use of Geographic Information Systems is one of the current trends in ecology studies (Wright, 1999). Using this tool, it will be possible to easily visualise information, modify it instantly, and to superimpose and model some basic interference. The need to use GIS in the Azores has been increasing as a consequence of works such as those mentioned above, which gather large sets of geo-referenced data.

Another future trend is the development and introduction of tools to explore deeper areas and, as a result, acquire a better understanding of the ecosystem as a whole.

Bibliography

Ávila, S.P., Cardigos, F. & Santos, R.S. (submitted). Marine molluscs from 'Banco D. João de Castro,' a shallow-water hydrothermal vent in the Azores: studying vent influence in the ecosystem. ??????

Pascoal, A., Oliveira, P., Silvestre, C., Sebastião, L., Rufino, M., Barroso, V., Gomes, J., Ayela, G., Coince, P., Cardew, M., Ryan, A., Braithwaite, H., Cardew, N., Trepte, J., Seube, S., Champeau, J., Dhaussy, P., Sauce, V., Moitié, R., Santos, R., Cardigos, F., Brussieux, M., Dando, P., 2000. Robotic Ocean Vehicles for Marine Science Applications: the European ASIMOV Project. Presented at OCEANS 2000.

Santos, R.S., Hawkins, S.J., Monteiro, L.R., Alves, M. & Isidro, E.J., 1995. Marine Research, Resources and Conservation in the Azores. Aquatic Conservation: *Freshwater and Marine Ecosystems,* **Vol. 5, No. 4:** 311-354.

Tempera, F., Afonso, P., Gomes, T. & Santos, R., 2001a. Comunidades Biológicas do Sítio de Interesse Comunitário Ilhéus das Formigas e Recife Dollabarat. Departamento de Oceanografia e Pescas da Universidade dos Açores, Horta. Arquivos do DOP. Série Relatórios Internos, No 3/2001, iii+43 pp.

Tempera, F., Afonso, P., Gomes, T. & Santos, R., 2001b. Proposta Técnico-Científica para Ordenamento do Sítio de Interesse Comunitário Ilhéus das Formigas e Recife Dollabarat. Departamento de Oceanografia e Pescas da Universidade dos Açores, Horta. Arquivos do DOP. Série Relatórios Internos, nº 4/2001, v+17pp.

Tempera, F., Afonso, P., Morato, T., Prieto, R., Silva, M., Cruz, A., Gonçalves, J. & Serrão Santos, R., 2001c. Comunidades Biológicas dos Sítios de Interesse Comunitário do Canal Faial-Pico. Departamento de Oceanografia e Pescas da Universidade dos Açores, Horta. Arquivos DOP. Série Relatórios Internos, nº5/2001, viii+76pp.

Tempera, F., Afonso, P., Morato, T., Gubbay, S., Dentinho, T., Silva, M., Prieto, R., Cardigos, F., Pitta, M.J. & Serrão Santos, R., 2001d. Proposta Técnico-Científica de Ordenamento dos Sítios de Interesse Comunitário do Canal Faial-Pico. Departamento de Oceanografia e Pescas da Universidade dos Açores, Horta. Arquivos do DOP. Série Relatórios Internos, nº8/2001, viii+76pp.

Tempera, F., Afonso, P., Morato, T., & Serrão Santos, R., 2002a. Comunidades Biológicas da Envolvente Marinha do Corvo. Departamento de Oceanografia e Pescas da Universidade dos Açores, Horta. Arquivos do DOP. Série Relatórios Internos, nº 1/2002, iv+52pp.

Tempera, F., Cardigos, F., Afonso, P., Morato, T., Pitta, M.J., Gubbay, S. & Serrão Santos, R., 2002b. Proposta Técnico-Científica de Gestão da Envolvente Marinha do Corvo. Departamento de Oceanografia e Pescas da Universidade dos Açores, Horta. Arquivos do DOP. Série Relatórios Internos, nº 2/2001, vi+57pp.

Wright, D.J., 1999. Down to the sea in ships: the emergency of marine GIS. Marine and Coastal Geographic Information Systems, pp 1-10.

MarClim: Marine biodiversity and climate change

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There is little doubt that the Earth's climate is getting warmer. Analysis of global air temperatures from 1856 to present showed the 1990s to be the warmest decade and 1997 and 1998 as the warmest years (Jones *et al.*, 1999). Ocean temperatures have increased in parallel with those of the atmosphere. Long-term records from the English Channel show that from the early 1980s the sea temperature increased slightly until 1990. During the following decade there was an increase of almost 1ºC. This increase was far greater than any change in the previous 100 years.

Not surprisingly, governments and trans-national bodies are becoming increasingly concerned about the implications of global climate change, but to date little attention has been focused on the possible effects on marine biodiversity and the goods and services that biodiversity provides.

New project

In the UK, a broad group of funding bodies has supported an initiative to assess and predict the influence of climatic change on intertidal rocky shore biota. The project, Marine Biodiversity and Climate Change **(MarClim),** is currently bringing together and analysing historical and recent data to establish the extent to which the fauna of rocky seashores has already changed as a response to climate. It will go on to use models developed by the UK Climate Impacts Programme to predict future changes in shore biodiversity. Such predictions are needed for the conservation, management and protection of the marine environment in Britain and Ireland. The broad range of interested parties, combined with the policy-driven nature of the project outputs, has led to MarClim becoming a national forum for marine scientists, marine conservationists and climatic change experts in both Britain and Ireland.

The rocky shore fauna of the British Isles is particularly well documented; as long ago as the 1950s, workers in Britain began to map the distribution of the dominant intertidal rock species (Southward & Crisp, 1956, Crisp & Southward, 1958). They showed that the fauna of the British Isles is composed of a mixture of cool-water boreal and warm-water Lusitanian species and includes a number of common species that are either at, or close to, their northern or southern geographic limits of distribution.

Ultimately, broad-scale patterns of distribution are set by temperature. Lewis (1976) proposed that species close to their northern distributional limits in the UK were prevented from spreading further by the severity of winter conditions; species approaching their southern limit of distribution were limited by summer conditions. If the climate of the British Isles becomes warmer it can be broadly predicted that existing patterns of species distribution will move northwards. The question that MarClim must answer is how far and how fast patterns of distribution will shift.

Changes in species distribution as a response to climate change are unlikely to be a simple northward projection of the current pattern; much will depend on the biological properties of individual species, such as the timing of spawning, the length of the spawning period and the length of larval life. Biological characteristics will interact with coastal topography and inshore hydrography to determine the way in which species will extend their range. Predictions can only be made for species for which we have a good knowledge of their reproductive and recruitment biology, which can be coupled to reliable predictions of the movement of inshore water.

Good rocky-shore record

The biota of the British Isles is one of the most thoroughly researched in the world, but there are surprisingly few species for which we have a sufficient depth of knowledge to make valid predictions of their response to climate warming. The rocky shore is one of the only habitats where such predictions are a realistic proposition. Rocky habitats have been popular areas for ecological study for many years and so there are a good number of long-term data containing a vast store of information on the distribution and temporal variability in their biota. The most complete data-sets are for the barnacles *Semibalanus balanoides, Chthamalus montagui,* and *Chthamalus stellatus,* the limpets *Patella vulgata* and *Patella depressa* and the trochid gastropods *Gibbula umbilicalis* and *Osilinus lineatus.* The main rocky shore data-sets vary greatly in spatial and temporal extent, but over large parts of the British Isles there is moderate to good coverage for the period between the 1950s and 1980s. Unfortunately, there is little information available for the 1990s, the period of greatest change in sea temperatures.

One of the key priorities of the MarClim project is to bring together and analyse as many as possible of the long-term data series to determine the responses of individual species during a period of fluctuating climate.

In view of the lack of data from the 1990s, the first year of the MarClim project has been focused on returning to as many as possible of the long-term study sites in the British Isles to assess the extent of the changes that occurred during the period of greatest temperature change. It is fortunate that among the MarClim team are some of the scientists who made observations in the 1950s and '60s (A.J. Southward) and 1970s and '80s (S.J. Hawkins and M.A. Kendall). Their presence ensures that contemporary studies take place in exactly the same locations and use the same methodology; as a result, historical and modern data are directly comparable.

Clear signs of change

At the end of its first year, the MarClim team has visited approximately 240 sites, from the Isles of Scilly to the north coast of Scotland. Fully replicated quantitative data have been collected on the species for which we hold the most complete data-sets, and abundance-scale (SACFOR) information has been recorded for a further 58 species that have distribution patterns suggesting they are climate-sensitive. Initial results are highly encouraging and show that some of the project's target species have expanded their geographical range by 30-50km since the 1980s. The same animals have increased in abundance by 2-3 times at sites close to their range edges. Further resurvey data will be collected and analysed during 2003. The outputs of analysis will be incorporated into mathematical models coupled to UKCIP predictions of climate change under a range of scenarios to enable predictions to be made of changes in patterns of species distribution on the rocky shore.

Analysis of the MarClim data sets will highlight the most appropriate species to be monitored as sentinels of future marine climate change. The project is charged with setting up an extensive monitoring network to be sustained after MarClim finishes in 2005. It is envisaged that this will involve following changes in selected species at a series of carefully chosen sites around the coastline of the British Isles. Long-term changes in the biota of rocky shores have been shown in the past to match changes in other marine ecosystems that are far more difficult to sample. The outputs from MarClim have the potential to underpin future marine monitoring strategies.

Species diversity patterns of free-living marine nematodes in the Aegean Sea

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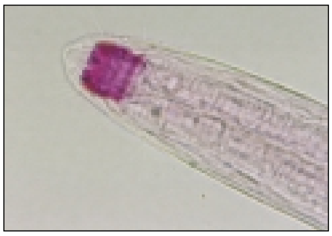

Deep-sea nematode from the Aegean Sea

Nematodes are the most numerous multicellular animals on Earth, inhabiting almost every possible environment. A handful of soil will contain thousands of the microscopic worms, many of them parasites of insects, plants or animals. Free-living marine forms are also very abundant, including nematodes that feed on bacteria, fungi and other nematodes; yet the vast majority of species encountered are poorly understood, biologically.

Today, we can only speculate how many species of nematode exist. For example, there are estimates that they constitute up to 80% (Bongers, 1988) or 90% (Jairajpuri & Ahmad, 1992) of all metazoan life on Earth. More recently, Lambshead (1993) estimated the number of nematode species in the deep seas to be as high as $1x10^8$. It becomes evident that if these estimates are pragmatic, then we only know a tiny fraction of this rich, and successfully resistant to environmental degradation, taxon. Consequently, our interest lies more in what we can learn from their nature itself, since nematodes will probably be one of the last groups that will disappear from the planet.

Over the last few years, the Institute of Marine Biology of Crete (IMBC) has undertaken several studies of the diversity of free-living marine nematodes in the eastern Mediterranean, thus fostering a better understanding of local and regional biodiversity patterns.

There is a long tradition in marine ecology of separating the environment into different zones where certain assemblages occur, which are different from those occurring in other zones. The benthic environment is usually separated into zones according to two different criteria: depth and latitude.

In the following analysis of diversity, the collected samples were separated between six different zones: **1)** littoral zone of the south Aegean (LS); **2)** upper sublittoral zone of the south Aegean (USS); **3)** lower sublittoral zone of the south Aegean (LSS); **4)** bathyal zone of the south Aegean (BS); **5)** lower sublittoral zone of the north Aegean (LSN), and **6)** bathyal zone of the north Aegean (BN).

Data from the littoral and the upper sublittoral zone of the north Aegean do not exist. In marine terminology, littoral is the tidal zone. In areas such as the Mediterranean, where tides are practically non-existent, the limits of the littoral zone correspond to the upper and lower levels of the swash zone. The sublittoral zone extends from the lower watermark to 200m depth, whilst the bathyal zone extends from 200m to 2,000m. Deeper, the abyssal zone (2,000 to 6,000m) and the hadal zone (>6,000m) occur. However, these two zones do not exist in the Aegean Sea.

In the analysis that follows, the sublittoral zone was further separated into two sub-zones, the upper sublittoral (from the lower water mark to 5m depth) and the lower sublittoral (from 5m to 200m depth). In the Aegean, the upper sublittoral zone is generally considered a high-energy zone in terms of water movements, whereas the lower sublittoral is considered a low-energy zone.

The analysis of nematode diversity in the Aegean Sea showed that there was a definite bathymetric pattern, which was not linear. The rarefaction curves (Sanders, 1968) for each zone are presented in Fig. 1. There is a gradual increase in diversity as depth increases. The littoral zone (0 metres) shows the lowest diversity, whereas the highest diversity values are found in the bathyal zone (200-2,000m).

Apart from the rarefaction curves, several other diversity indices were calculated, weighted both for

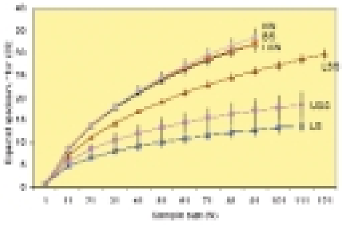

Figure 1. Rarefaction curves for the different zones of the Aegean Sea.

species richness and equitability. A similar pattern of increasing diversity with depth is derived by these indices (Fig. 2). These results were further supported by ANOVA, which demonstrated that these differences were highly significant.

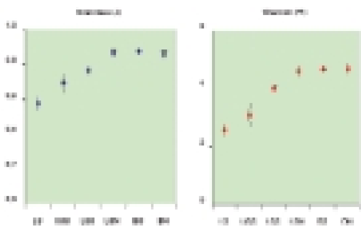

Figure 2. Mean x standard errors for some diversity indices for each zone.

Nonlinear patterns of diversity have been found in several studies. For example, Rex (1983) and Paterson *et al.* (1995) found parabolic distribution patterns of macrobenthic diversity with pick values near the bathyal zone in the Pacific and the Atlantic respectively. Similarly, Boucher & Lambshead (1995), combining data from the literature and Dinet & Vivier (1979), analysing data from the Atlantic, found parabolic diversity patterns for marine nematodes.

It appears, however, that the macrofauna in the Aegean Sea does not follow the above trend. As has been shown by Tselepides (1992) and Karakassis & Eleftheriou (1997), the macrofauna diversity decreases with depth, which they attributed to the decrease of food availability with depth. Therefore, it appears that in the Aegean the two benthic components show an inverse diversity response to depth.

It would be very interesting to examine whether the observed increase of nematode diversity in the Aegean follows the general parabolic pattern found by others. The IMBC has recently started collecting samples from several sites in the eastern Mediterranean, around the 3,500m isobath, since the abyssal and hadal zones are absent from the Aegean Sea. These samples are currently being analysed in order to test whether the nematode diversity starts to decline after the bathyal zone. Nevertheless, abyssal depth is the limit that can be reached for the Mediterranean since no hadal environment exists in the entire basin.

References

Bongers, T., 1988. De Nematoden Van Nederland Koninkliijke Nederlandse. Natuurhistorische Vereniging, Utrecht.

Boucher, G. & Lambshead, P.J.D., 1995. Ecological biodiversity of marine nematodes in samples from temperate, tropical and deep sea regions. *Conservation Biology* **9,** 1594-1604.

Dinet, A. & Vivier, M.H., 1979. Le meiobenthos abyssal du golfe de Gascogne. II. Les peuplements de nematodes et leur diversité specifique. *Cahiers de Biologie Marine* **20:** 109-123.

Jairajpuri, M.S. & Ahmad, W., 1992. Dorylaimida. Free-living predaceous and plant-parasitic nematodes. Oxford & IBH Publishing, New Delhi.

Karakassis, I. & Eleftheriou, A., 1997. The continental shelf of Crete: structure of macrobenthic communities. *Marine Ecology Progress Series* **160,** 185-196.

Lambshead, P.J.D., 1993. Recent developments in marine benthic biodiversity research. *Oceanis* **19,** 5-24.

Paterson, G.L.J., Lambshead, P.J.D. & Gage, J.D., 1995. Bathymetric patterns of polychaete diversity in the Rockall Trough, north-east Atlantic. *Deep-Sea Research* **42,** 1199-1214.

Rex, M.A., 1983. Geographic patterns of species diversity in deep-sea benthos. In: G. T. Rowe, Biology of the Pacific Ocean depths. (pp. 453-472). New York: John Wiley & Sons.

Sanders, H.L., 1968. Marine benthic diversity: a comparative study. *American Naturalist* **102,** 243-282.

Tselepides, A., 1992. Ecological study of the bathyal ecosystem of the Aegean Sea. PhD Thesis, Biology Department, University of Crete, Heraklion.

Preliminary study of hyberbenthos in Heraklion Bay (Cretan Sea)

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The hyperbenthos is a term applied to the association of small-sized, bottom-dependent animals (mainly crustaceans) with good swimming ability and that perform - with varying amplitude, intensity and regularity - seasonal or daily vertical migrations above the seabed (Brunel *et al.*, 1978). Beyer (1958) was the first to refer to "hyperbenthos," a word used in preference to "suprabenthos" as the Greek noun benthos should be preceded by a Greek prefix (hyper-) rather than by its Latin equivalents (supra-, super-).

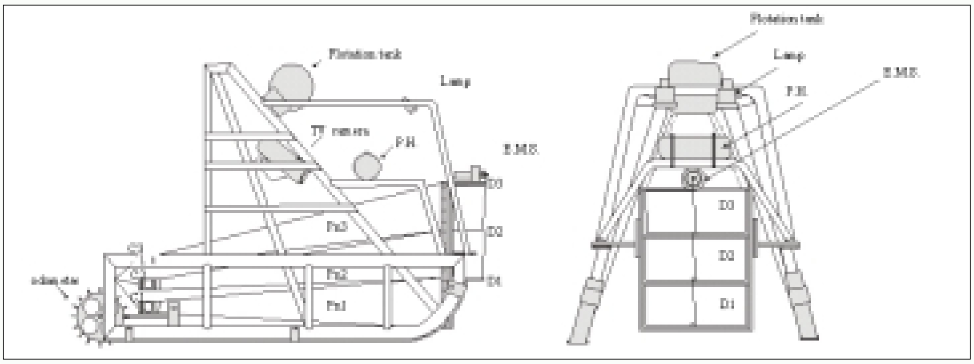
The terms "hyperbenthos" and 'suprabenthos" are used mainly in temperate and northern seas, whereas "swarming," "resident" or "demersal zooplankton" and "benthopelagic plankton" or "benthic boundary layer fauna" are usually preferred to designate the same fauna in tropical areas and the deep sea respectively.

There has been much taxonomic interest in the hyperbenthos. Most of the hyperbenthic species are present in much higher densities than in either the overlying water layers or the adjacent sediment, and most of them are not there accidentally. Beyer (1958) discussed the species found in abundance in the hyperbenthos but which were rare or absent elsewhere.

More recently, there has been recognition of a distinction between the truly hyperbenthic species and a variety of "visiting" or "immigrant" animals that can be classified as endobenthic, epibenthic or planktonic. There has also been increased interest in the role of the hyperbenthos in the functioning of marine ecosystems, mostly because it has been found that many demersal fish and epibenthic crustaceans feed, for at least part of their life, on hyperbenthic animals. Furthermore, there is renewed interest in pre-recruit studies, as many larval and early post-larval fish and crustaceans have a hyperbenthic phase. On the other hand, studies of benthic-pelagic coupling related to energy fluxes rarely include samples taken within a few centimetres above the seabed and may therefore underestimate significantly the flux of particulate organic material (Mees & Jones, 1997).

The often highly mobile hyperbenthic animals living immediately above the seabed are only occasionally caught by conventional benthic or pelagic sampling gear; thus, a plethora of hyperbenthic sampling devices have been constructed and used with varying success. The choice of sampling equipment used depends largely on local conditions, *e.g.*, size of ship, power and capabilities of lifting gear, degree of exposure, depth, bottom relief and sediment structure and the type of sample required for the research topic under investigation (Eleftheriou & Holme, 1984).

Most of the published information refers to temperate and cold-water environments. In recent years, there has been considerable development in hyperbenthic research in the tropics (mostly in coral reef lagoons) and the deep sea. Nevertheless, Mediterranean hyperbenthic studies are scarce and limited to the western basin, referring either to the surf zone or to deep environments (Cartes, 1998; Cartes & Sorbe, 1999; San Vicente & Sorbe, 1999; Cartes *et al.*, 2001). As far as the eastern Mediterranean is concerned, there is a total absence of information on hyperbenthic communities. In the 1990s, a number of studies (Karakassis, 1991; Tselepides, 1992; Tselepides & Eleftheriou, 1992; Koutsoubas *et al.*, 1992; Karakassis & Eleftheriou, 1997) contributed significantly to our knowledge of the macrobenthic fauna from the Cretan Sea. Even so, our knowledge of the hyperbenthic fauna remains nil.



Lateral and frontal schematic view of the hyperbenthic sledge: C1: collector 1; C2: collector 2; C3: collector 3; P.H.: pressuring house containing the battery package and the controller; Pn1: plankton net 1; Pn2: plankton net 2; Pn3: plankton net 3; E.M.S.: electro-mechanical opening-closing system; D1: door 1; D2: door 2; D3: door 3.

In the framework of a multidisciplinary European research project conducted by the Dept. of Technology and Management of the Marine Environment of the Institute of Marine Biology of Crete (IMBC), a sampling programme of five successive cruises of the R.V. *Philia* has been performed on the continental shelf and upper slope of Heraklion Bay (Cretan Sea). The investigation of the hyperbenthic diversity of this area was included among the aims of the project.

Heraklion Bay is situated on the north coast of Crete. Fieldwork included collection of water column, sediment, plankton and macrobenthic samples, as well as measurements of physico-chemical and hydrographic parameters. For the collection of hyperbenthic samples, in particular, a modified three-level towed sledge (see Figure) was used. Technical characteristics are given in Shand & Priestley (1999).

Preliminary results reveal that the hyperbenthic sledge really samples a specific fauna. The hyperbenthic samples comprise different taxonomic groups from the macrobenthic and macro-zooplanktonic ones. Mysidacea, Cumacea, Amphipoda, Decapoda, Copepoda and Isopoda are among the most abundant taxonomic groups of the hyperbenthic habitat of Heraklion Bay.

Further analysis, to species level, will provide new information on the life-cycles and classification of macrofaunal species in endobenthic, epibenthic and hyperbenthic samples. Considering that numerous benthic species - up to now regarded as rare in the area - may prove to be abundant when proper sampling methodology is used, it is expected that results from this project will significantly increase our knowledge concerning the biodiversity of the benthic environment in the continental shelf of the eastern Mediterranean.

References

Beyer, F., 1958. A new, bottom-living Trachymedusa from the Oslo fjörd. Description of the species and a general discussion of the life conditions and fauna of the fjörd deeps. *Nytt Magasin for Zoologi,* **6:** 121-143.

Brunel, P., Besner, M., Messier, D., Poirier, L., Granger, D. & Weinstein, M., 1978. Le traîneau suprabenthique Macer-GIROQ: appareil amélioré pour l'échantillonage quantitatif étagé de al petite faune nageuse au voisinage du fond. *Internationale Revue der Gesamten Hydrobiologie,* **63:** 815-829.

Cartes, J.E., 1998. Dynamics of the bathyal benthic boundary layer in the north-western Mediterranean: depth and temporal variations in macrofaunal-megafaunal communities and their possible connections within deep-sea trophic webs. *Progress in Oceanography,* **41:** 111-139.

Cartes, J.E. & Sorbe, J.C., 1999. Estimating secondary production in bathyal suprabenthic peracarid crustaceans from the Catalan Sea slope (Western Mediterranean; 391-1255m). *Journal of Experimental Marine Biology and Ecology,* **239:** 195-210.

Cartes, J.E., Elizalde, M. & Sorbe, J.C., 2001. Contrasting life-histories, secondary production, and trophic structure of Peracarid assemblages of the bathyal suprabenthos from the Bay of Biscay (NE Atlantic) and the Catalan Sea (NW Mediterranean). *Deep-Sea Research I:* **48:** 2209-2232.

Eleftheriou, A. & Holme, N.A., 1984. Macrofauna techniques. In: N.A. Holme & A.D. McIntyre (Eds.), *Methods for the study of marine benthos,* Oxford, Blackwell Scientific: 140-216.

Karakassis, J., 1991. Contribution to the study of the benthic ecosystem of the continental shelf of Crete. Ph.D thesis, University of Crete, 195 pp (in Greek).

Karakassis, J. & Eleftheriou, A., 1997. The continental shelf of Crete: structure of macrobenthic communities. *Marine Ecology Progress Series,* **160:** 185-196.

Koutsoubas, D., Koukouras, A., Karakassis, J. & Dounas, C., 1992. Contribution to the knowledge of Gastropoda and Bivalvia (Mollusca) of Crete island (S. Aegean Sea). *Bolletino Malacologico,* **28:** 69-82.

Mees, J. & Jones, M.B., 1997. The hyperbenthos. Oceanography and Marine Biology: Annual Review **35:** 221-255.

San Vicente, C. & Sorbe, J.C., 1999. Spatio-temporal structure of the suprabenthic community from Creixell beach (western Mediterranean). *Acta Oecologica,* **20 (4):** 377-389.

Shand, C.W. & Priestley, R., 1999. A towed sledge for benthic surveys. Fisheries Research Services, Information Pamphlet, **No 22:** 8pp.

Tselepides, A., 1992. Ecological study of the bathyal ecosystem of the Aegean Sea. Ph.D thesis, University of Crete, 266 pp (in Greek).

Tselepides, A. & Eleftheriou, A. 1992. South Aegean (eastern Mediterranean) continental slope benthos: macroinfaunal-environmental relationships. In: G.T. Rowe & V. Pariente (Eds.), *Deep-sea food chains and the global carbon cycle,* Dordecht, Kluwer Academic Publications: 139-156.

Temperature and salinity: two essential structuring factors of biodiversity in the Baltic Sea

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The Baltic Sea is a relatively enclosed brackish water body with substantial salinity and temperature gradients. The changeable salinity conditions and the gradient patterns are the main factors influencing the distribution of species. Besides these natural factors, human impact (mainly pollution, eutrophication) plays a significant role in distribution and abundance of the various organisms.

The Baltic Sea is inhabited by natural immigrants of mainly three different origins: marine boreal species (*e.g.,* soft-shell clam *Mya arenaria,* ocean quahog *Arctica islandica,* cod *Gadus morhua callarias,* herring *Clupea harengus membras, Temora longicornis, Pseudocalanus elongatus*), freshwater species (e.g., pike *Esox lucius,* perch *Perca fluviatilis, Daphnia* spp., *Keratella* spp.) and glacial relicts (*e.g.,* fourhorned sculpin *Myoxocephalus quadricornis, Limnocalanus macrurus, Mysis relicta*). Their environmental preferences, and therefore spatial distribution, differ: marine species dominate in the open Baltic and south-western basin; freshwater species prevail in the north-eastern Baltic and coastal areas; and glacial relicts are more abundant in communities in deeper areas of the north-eastern part of the sea. Below, we give two examples of how salinity and temperature affect distribution of the Baltic biota.

Effect of salinity gradient (Meckleburg Bight)

In the western Baltic Sea (Belt Sea) - the transition area between the North Sea and the Baltic proper - high-saline North-Sea water mixes with Baltic-Sea water, which usually has a lower salinity due to the strong freshwater input from the Baltic Sea catchment area. This results in a salinity gradient (25–10) and a pronounced halocline. Salinity as well as oxygen content in the near-bottom layer varies seasonally and between years, depending on the saltwater inflow from the North Sea or the river runoff. Owing to these hydrographical features, this part of the Baltic Sea forms a natural boundary with regard to the distribution of many marine euryhaline organisms, as shown in Table 1 (below) for macrobenthic species.

Area	Macrobenthic taxa	Salinity
Oderhaff	130	7-8
Mecklenburg Bight	c.350	20-10
Kiel Bight	c.500	25-20
Kattegat	c.1,000	25-30
North Sea	c.1,400	32-34

Table 1. Relationship between number of taxa and salinity. At lower salinity, fewer macrobenthis species are present.

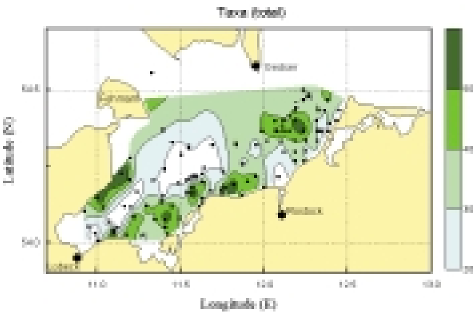

Fig. 1. Benthic biodiversity in the Mecklenburg Bight (Zettler *et al.,* 2000, and Zettler, unpubl.).

Different studies have revealed that biodiversity in the Mecklenburg Bight is representative for the whole southern Baltic Sea (Zettler *et al.,* 2000, and unpubl. data). However, even within the Mecklenburg Bight benthic biodiversity is not uniform, alternating between relatively high (more than 50 taxa) and low values (less than 20 taxa) (Fig. 1).

What are the reasons for this? As first investigations have shown, sediment characters and oxygen availability appear to be important factors (besides salinity) determining the composition of the marine benthic communities in this area.

At present, the function of these “biodiversity islands” for recruitment and resettlement of areas affected by oxygen depletion or human activities (dumping, dredging) are not yet fully understood.

Effect of seasonal thermocline (Gulf of Riga)

In spring, when water temperature starts to increase, the seasonal themocline is formed. In the Gulf of Riga basin (max. depth ca 60m), it is the main factor governing the distribution of organisms, due to the lack of a halocline. The location of the thermocline moves between spring and autumn from ca 5-10m to 25-30m water depth. In late autumn, the thermocline is less pronounced and the convective mixing in winter results in a vertical homothermium.

Of the three different groups of organisms, freshwater fish species stay above the thermocline by following its seasonal course (they descend to deeper layers from spring to autumn) (Fig. 2).

The same distribution pattern is valid for most of the zooplanktonic and benthic taxa of freshwater origin. Many of them tend to prefer warm water. Distribution of marine eurytherm (pelagic) species is closely connected with the temperature front. They are located around the thermocline and in the area marked by the coastal slope and the projection of the thermocline, called the ‘mixing zone’.

Except during their reproduction period in winter, glacial relicts are confined to areas below the seasonal thermocline where the temperature is substantially lower. However, some of them (*e.g.,* smelt *Osmerus eperlanus* and the mysid *Mysis mixta*) can also be found in the mixing zone area: they probably face shortage of food in deeper areas (with preferred temperature conditions) and are forced to move to warmer water in order to find sufficient amounts of food.

Reference

Zettler, M.L., Bönsch, R., Gosselck, F., 2000. Verbreitung des Makrozoobenthos in der Mecklenburger Bucht (südliche Ostsee) - rezent und im historischen Vergleich. *Meereswissenschaftliche Berichte* **42:** 144pp.

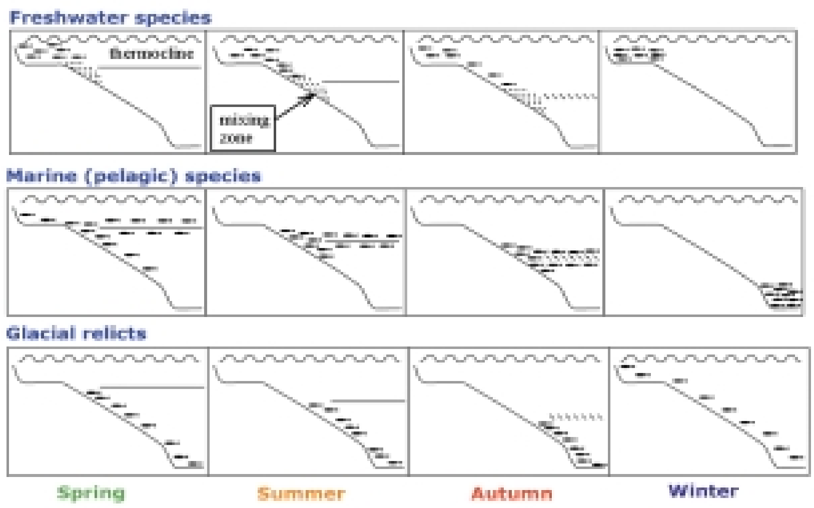

Fig. 2. Seasonal dynamics of the general distribution pattern of fish of different origin in relation to the seasonal thermocline on the coastal slope of the Gulf of Riga.

The high Arctic: challenges for European biodiversity research

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B. Gulliksen

Research activities beside a calving glacier on the volcanic island of Jan Mayen (71°N, 8°E).

The area of interest for European marine biodiversity research extends northwards, beyond the Arctic Circle, to approximately 80°N (Dinter, 2001). Seen within a European perspective, the Arctic contains a number of unique habitats and environmental conditions. Arctic marine biodiversity is characterised by a simplicity in upper trophic levels and highly specialised organisms. Typical Arctic inhabitants are polar bears, seals such as ringed and bearded seals, walrus, whales such as the bowhead, narwhal and white whales, and fish such as polar cod. On the underside of sea-ice are found specialised communities of sympagic (ice-associated) flora and fauna, including filamentous ice-algae and ice-amphipods. The pelagic, and especially benthic, systems are more complex in terms of both types and functions of the organisms present. These environments share many general characteristics with more southerly latitudes, but also contain a variety of taxa that are not found anywhere else in Europe. Research in these areas therefore gives valuable data, but also presents a variety of challenges.

Arctic biodiversity research is by no means a new field, but developed hand-in-hand with Arctic exploration. Some of the earliest biodiversity data are 18th- and 19th-century records of fish and other organisms caught simply for food. However, by the late 19th and early 20th centuries, scientific expeditions were being carried out for oceanographic and biodiversity research, including both benthic and pelagic organisms. The most well-known biodiversity publications of that period include those by M. Sars, G.O. Sars, Malmgren, Krøyer and Nansen. Today, many nations have a committed Arctic biodiversity research programme.

Ocean mixing

The waters around Svalbard are a mixing area where warm Atlantic water from the south meets colder, Arctic water-masses from the north. The precise position of the Polar Front, where these water-masses meet, varies from year to year, but also is greatly influenced by cyclical, circumpolar, wind-driven circulation patterns (Proshutinsky & Johnson, 1997). During warm periods of cyclonic oceanic circulation in the central Arctic, there is thinner ice in the Barents Sea and a greater influx of Atlantic water from the south relative to anti-cyclonic periods, where Arctic water extends further southwards (Polyakov *et al.*, 1999). These fluctuations cause marked changes in the Polar Front and the southern extent of sea ice, which in turn affects productivity and a whole series of biological processes in the water-masses and sea floor. The biogeographic distribution of planktonic and benthic organisms varies with these oceanographic fluctuations. Therefore, biodiversity and biogeographic analyses can offer a means of mapping the relative distribution of the various water-masses in the Arctic.

Coastal systems

Coastal areas are highly influenced by glacial processes. Along the Norwegian coastline, most fjörds have deep basins, often with very shallow sills at their mouths. Despite this, Arctic Norwegian fjörds usually are well-oxygenated down to the bottom layers all year round. This contrasts with more southerly fjörds, which often have a naturally low oxygen content. From the very north of Norway, above 70°N and beyond, most fjörds do not have a sill and conditions at their mouths resemble the open sea. At the same time, there are complex systems of islands, skerries and side-fjörds, making both the coastline and its resident biodiversity extremely heterogeneous.

Svalbard

Along the Svalbard coastline, 77°N to more than 80°N, most fjörds have actively calving tidal glaciers in their inner parts. This creates a very dynamic marine environment, with often dramatic gradients in temperature, salinity and sedimentation. Most glaciers are retreating, with intermittent periods of surging. Net glacial retreat can be more than a metre per year, and in some cases is up to or more than 100 metres per year (see Svendsen, 2002), such that new marine areas are continually appearing. Therefore, colonisation studies offer a means of experiencing and understanding post-glacial events that took place many thousands of years ago in more southerly areas. The marine fauna and flora are exposed to winter darkness, during which little or no production occurs, alternating with summer periods of 24-hour daylight, during which intensive production surges occur. Ice-scouring along the shore and gouging by icebergs are also regular occurrences. These strong gradients in physical conditions are reflected in strong gradients in biodiversity, from sparse assemblages of organisms that tolerate unstable conditions close to the glacier, to rich faunal and floral assemblages in the outer parts.

An interesting phenomenon occurs in many Svalbard fjörds, particularly along the western shores. Above the water, the environment looks very Arctic indeed, with sub-zero temperatures and calving glaciers. Accordingly, the above-water biodiversity members, such as polar bears and walrus, are typically Arctic. However, in the pelagic, and particularly the benthic, environments there often is a dominance of Atlantic taxa, transported there by the northernmost extent of the Gulf Stream. In the northern and eastern parts of Svalbard, the Arctic water influence is dominant.

To further the understanding of this complex environment of contrasts, changes and mixtures, a review of the physical and biological conditions of Kongsfjorden (78°55'N, 11°56'E) recently was compiled (Svendsen *et al.*, 2002, Hop *et al.*, 2002). Kongsfjorden also is the northernmost of the key BIOMARE sites for biodiversity research.

Research

The questions that Arctic biodiversity research can ask are many. Hypotheses and models may be made of the effects of climatic changes on Arctic processes. Will a shift to a warmer climate regime decrease the role of ice-algae and planktonic organisms in the marine food-web and increase the dependence on benthos as a food source? Can temporal data series of benthic organisms tell us about fluctuations in different water-masses? Because polar areas are subject to atmospheric deposition of contaminants released from southern areas, effect studies on Arctic organisms are an important tool in encouraging the global population to reduce the release of persistent contaminants into the atmosphere. These and other biodiversity issues are studied in Tromsø and Svalbard by institutes including Akvaplan-niva, the University of Tromsø, the Norwegian Polar Institute, the Norwegian Institute of Fisheries and Aquaculture Research, the Norwegian Institute for Nature Research and the university courses on Svalbard. Studies of faunal and floral structure, function and biogeography are carried out by numerous institutes both in Norway and internationally.

For each question answered, however, many further issues arise, some of which cannot yet be answered. For example, because of the practical difficulties of sampling through ice-cover, for many areas of biodiversity there exists almost no winter data at all. The logistics of Arctic research often limits the scope of investigations, which severely limits both the statistical power and representativity of analyses. Therein lies many of the future challenges for Arctic biodiversity research.

The Arctic represents the very northern extent of European marine waters. It is important to document and continue research into its unique fauna and flora, together with the physical environment that influences it. One of the major achievements of the BIOMARE concerted action has been to bring together researchers from all over Europe and to consider the particular challenges and benefits of the different parts of European waters. From the Arctic to the Mediterranean, the Black Sea to the Azores, each area provides unique and valuable information. Developing common goals and common strategies produces integrated European marine biodiversity research that will be better equipped to answer large-scale environmental and biological questions both now and in the future.

References

Dinter, W. P., 2001. Biogeography of the OSPAR maritime area. BfN-Schriftenvertrieb in Landwirtschaftsverlag.

Hop, H., Pearson, T., Nøst Hegseth, E., Kovacs, K.M., Wiencke, C., Kwasniewski, S., Eiane, K., Mehlum, F., Gulliksen, B., Wlodarska-Kowalczuk, M., Lydersen, C., Weslawski, J.M., Cochrane, S., Gabrielsen, G.W., Leakey, R.J.G., Lønne, O.J., Zajaczkowski, M., Falk-Petersen, S., Kendall, M., Wängberg, S.-Å., Bischof, K., Voronkov, A.Y., Kovaltchouk, N.A., Wiktor, J., Poltermann, M., di Prisco, G., Papucci, C. & Gerland, S., 2002. The marine ecosystem of Kongsfjorden, Svalbard. *Polar Research* **21(1):** 167-208.

Polyakov, I.V., Proshutinsky, A.Y. & Johnson, M.A., 1999. Seasonal cycles in two regimes of Arctic climate. *Journal of Geophysical Research* **104 (C11):** 25,761-25,788.

Proshutinsky, A. & Johnson, M., 1997. Two circulation regimes of the wind-driven Arctic Ocean. *Journal of Geophysical Research* **102:** 12,493-12,512.

Svendsen, H., Beszczynska-Møller, A., Hagen, J.O., Lefauconnier, B., Tverberg, V., Gerland, S., Ørbæk, J.B., Bischof, K., Papucci, C., Zajaczkowski, M., Azzolini, R., Bruland, O., Wiencke, C., Winther, J.-G. & Dallmann, W., 2002. The physical environment of Kongsfjorden-Krossfjorden, an Arctic fjord system in Svalbard. *Polar Research* **21:** 133-166.

Biodiversity of the Banco di Santa Croce, a marine protected area in the Gulf of Naples

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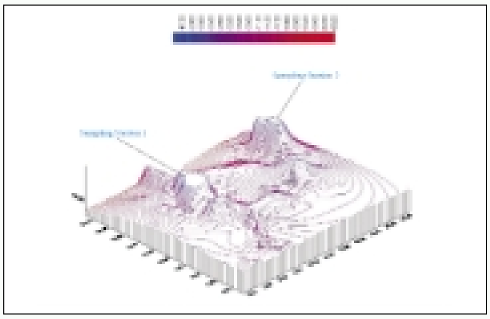
Bank of Santa Croce, Gulf of Naples



Model of the bank, reconstructed using a 'kriging' interpolator.

The Bank of Santa Croce is a protected area located in the Bay of Naples (Fig. 1), characterised by a series of carbonate rock hills (Fig. 2) hosting highly differentiated benthic communities. Photophilic associations with dominance of brown algae (*Padina pavonica* and *Sargassum* sp.) dominate the top of the hills, while macroalgal assemblages typical of sciaphilic environments (*Peyssonellia borneti* and *Flabellina petiolata*) characterise the vertical walls. Zoocenoses are dominated by *Eunicella cavolinii, Parazoanthus axinellae, Paramuricea clavata* and *Gerardia savaglia*. Species characteristic of "very stable" environments (*e.g.*, red coral) are present mainly at the deeper stations (>20m), but also the shallowest sites (11m) contain, almost exclusively, "climax" benthic communities. Benthic fauna is highly diverse (Fig. 3) and the presence of decapods previously known only from the Adriatic Sea (*e.g., Palicus caronii*) was recorded. Abundant fish stocks, mainly represented by members of the families Labridae, Serranidae and Sparidae, characterise the area. However, two young specimens of *Zu cristatus* were recently observed in shallow waters: this species was considered oceanic and mesopelagic.

Our research programme (P.I.V. Zupo and M.C. Buia) was aimed at the characterisation of ecological descriptors and at the investigation of structural and functional relationships in the benthos-nekton-plankton within this protected area, to allow the formulation of an effective management and protection plan.

Several data-sets were collected and analysed (nutrient concentration in the water column, chemical and physical descriptors, water currentometry, fractioned chlorophyll, micro- and macro-zooplankton, fish stocks evaluated by visual census and collections by nets, gut contents of fish and benthic invertebrates, faunistic and floristic composition of benthic assemblages, heavy metal contents of the tissues of fish) to obtain a dynamic model of simulation of the food-web within the area.

The model, based on budget equations for each of the 552 species identified, was calibrated and validated based on the data collected during a three-year investigation. The model demonstrated that, despite the fishing prohibition regime, the area is impacted by the collection of benthic and nektonic organisms.

The programme also recorded the great biodiversity of the area and the function of the bank as an energy transducer, based on the continuous transformation of organic matter deriving from the Sarno River in production of biomasses of high economic value. The productivity peaks in spring and summer and the total export of animal biomass to surrounding systems is about 23kg yr^{-1} m^{-3}. These biomasses are not affected by inorganic pollution, as demonstrated by the analyses of heavy metals. The sensitivity analysis demonstrated that the high productivities of the bank are sustained by both the input of organic matter (transported by strong currents) and the local primary production. The analysis indicated that a higher level of protection of benthic communities and the preservation of the present hydrodynamic patterns will allow an optimal management and an increase of the export of fish biomass.

The coastal areas around the Sarno River are considered amongst the most impacted by organic and inorganic pollution in the whole Mediterranean basin. It was very interesting to detect the highest levels of biodiversity in the bank (which is located within this area). The results of the research programme opened new perspectives on the study of the relationships between human impacts and diversity and highlighted the existence of unresolved ecological paradigms that are worth investigating.

View of shallow communities, illustrating the great biodiversity of the Bank area.

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After BIOMARE

The BIOMARE concerted action has brought together European expertise in marine biodiversity, and linked marine biodiversity knowledge on a larger scale and identified gaps in knowledge.

A follow-up project, MARBENA, will allow further development and implementation of this marine biodiversity knowledge base. A further aim should be to establish a strong and functional network of excellence that will not only focus on scientists but also on those who will use and benefit from this knowledge, such as decision-makers (politicians, civil servants, NGO leaders, planners, funding bodies, communicators, *etc.*) and other shareholders of marine biodiversity information.