Establishing a framework for the implementation of marine biodiversity research in Europe

EC-DG Research / ESF Marine Board / MARS Network
22 to 24 April 1999, Yerseke, Netherlands

Contents

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Acknowledgements

All the participants of the workshop held in Yerseke, Netherlands, 22 – 24 April 1999, are sincerely thanked for their valuable contributions in shaping the framework for the implementation of marine biodiversity research in Europe.

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Foreword

One of the key objectives of the ESF Marine Board is to develop science based strategies on important emergent issues confronting Europe in its quest to better understand the fundamental processes that control the functioning of its contrasting marine environments, as a basis for sustainable exploitation and management of our seas and their resources.

Marine biodiversity is an important case in point for which the ESF Marine Board had undertaken to review and publish its second Position Paper in 1998 entitled *A European Science Plan on Marine Biodiversity*. This contributed to the shape of the EU Fifth Framework Programme and highlighted the need for long-term large-scale research in marine biodiversity. A major challenge for us is to understand the relationships between marine biodiversity and ecosystem functioning in pristine versus impacted locations. This 'functional biodiversity' promises quantitative measures of the goods and services provided by the marine ecosystem to man, and hence their potential socio economic value.

The present implementation report proposes a framework and actions needed for the long-term delivery of a coherent European Science Plan on Marine Biodiversity. This is invaluable for both European and national authorities and research institutions facing the challenge of rapid losses of biodiversity in their marine waters.

I would like to register the ESF Marine Board's thanks to Chairman Dr Carlo Heip, his Panel Members and supporting organisations for their sustained enthusiasm and productivity of this important and influential Report.

Fauzi Mantoura
Chairman, ESF Marine Board

Key points – Position Paper 2:
A European science plan on marine biodiversity

- Marine organisms play crucial roles in many biogeochemical processes that sustain the biosphere, and provide a variety of products (goods) and functions (services) which are essential to mankind's well-being, including the production of food and natural substances, the assimilation of waste and regulation of the world's climate.

- The rate and efficiency of any of the processes that marine organisms mediate, as well as the range of goods and services that they provide, are determined by interactions between organisms, and interactions between organisms and their environment, and therefore by biodiversity. These relationships have not yet been quantified, and we are at present unable to predict the consequences of loss of biodiversity resulting from environmental change in ecological, economic or social terms.

- Marine biodiversity does not necessarily comply with terrestrial paradigms, and our understanding of its role and regulation lags far behind that of terrestrial biodiversity, to such an extent that we do not have enough scientific information to underpin management issues such as conservation and the sustainable use of marine resources.

- The scale of the research efforts needed to remedy this situation demands European-scale collaboration.

- The overall objective of this Science Plan is to develop, through a directed and concerted effort on a European scale, the scientific basis necessary to support the management for sustainable use of the diversity present in the marine environment, for the benefit of present and future generations, and to inform the public about the issues at stake. The three sub-objectives are:

  (i) To describe and characterise marine biodiversity in Europe and to quantify its role in providing goods and services in relatively pristine, as contrasted to impacted, environments, as a baseline for evaluating human impact. This should involve a nested approach to address patterns on a range of temporal and spatial scales.

  (ii) To determine the effects of changes in biodiversity, both natural and man-made, on the goods and services that marine ecosystems provide. This should involve long-term and large-scale studies, as well as experimental manipulations of biodiversity.

  (iii) To provide the scientific concepts and tools for the management of marine resources, living and non-living, including modelling frameworks and rapid assessment protocols.

Executive summary

The need for long-term and large-scale research to solve some of the major problems in inventorying, explaining and modelling marine biodiversity has been well argued in a series of major scientific discussions in Europe as summarised in the EMaPS Position Paper 2 *A European science plan on marine biodiversity*.

The major obstacles for implementing research at adequate temporal and spatial scales and the actions required to overcome them were discussed at a meeting organised from 22 to 24 April 1999 at the Centre for Estuarine and Coastal Ecology of the Netherlands Institute of Ecology in Yerseke (NL).

The meeting was organised with support from EC-DG Research, ESF Marine Board and the European Marine Research Stations Network (MARS). Representatives from 13 European countries, EC, the ESF Marine Board, and the National Association of Marine Laboratories (NAML) in the USA, contributed to the present Action Plan (see Appendix 1 for a list of participants).

It is recognised that in the present funding and institutional situation in Europe large-scale and/or long-term marine biodiversity research is not possible. On the other hand, because the coasts of Europe, spanning a geographical range from subarctic to nearly subtropical climate zones, are well covered geographically, and in terms of scientific personnel and infrastructure, the potential for such research is there.

The co-ordination and networking of the scientific potential in this field in Europe will be attempted in the coming years through a series of actions explained in this document. The core of the effort will be an agreement on a series of European Flagship Sites, spread along Europe's coasts, that will be under the responsibility of a dedicated research institute. Two types of flagship sites are proposed. At intensive flagship or reference sites a complete inventory of marine biodiversity will be attempted, including genetic, species and ecosystem diversity. At extensive flagship sites a selection of indicators will be surveyed for long periods of time using a common methodology.

A first attempt at setting criteria and sites is made for the Intensive Reference Sites. The initiation of (impacted) Extensive Reference Sites is also evaluated. A first outline is given for criteria on indicators of marine and coastal biodiversity.

It is proposed to give responsibility for the long-term support of this programme, under the provisional name of *the European Marine Biodiversity Initiative (EMBI)*, to the European Marine Research Stations Network MARS, and to open it to any interested scientist or institution. Support from the Marine Board of ESF and DG Research of the EC will be requested for the start of the programme. Long-term support can only be achieved through commitment of institutional and therefore national funding. Whether such a commitment can be found will be explored at a Conference of Directors of MARS to be held in Venice in October 2000.

The EMBI will not only provide the basis for sustaining long-term and large-scale research, but also aims at providing a forum for the discussion of results from the numerous smaller scale research efforts that have recently begun in many countries in Europe and in the Fifth Framework Programme of the EU (see Appendix 2). The creation of such a forum will be supported by a concerted action of the EU Fifth Framework Programme (BIOMARE), starting in 2000, two ESF-Euresco meetings in 2001 and 2003, and a platform for discussion and dissemination through (electronic) newsletters and websites. The EMBI will have open communication with end-users, public and policy makers, providing information and scientific advice.

The EMBI should also be supported through a EUROCORES initiative in this field that will be prepared in 2000.

1. Introduction

Since the Convention on Biological Diversity in Rio de Janeiro in 1992 many initiatives for research on biodiversity issues have been launched, most of them local and short term. Until 1996 only one country in Europe, France, had a well-developed nationally co-ordinated science programme on biodiversity that included marine biodiversity, but in 2000 marine biodiversity research on a European scale will begin. Long-term biodiversity research, i.e. for more than 10 years, is very difficult to implement, even at the national level. Some of the major obstacles are the national and European funding systems and also the lack of an internationally agreed methodology for the measurement of marine biodiversity and the choice of indicators for (the degree of) biodiversity.

Nevertheless, there is a great deal of interest in the issue, from the scientific community, from science administrators and from politicians and the general public. The implementation and further development of marine biodiversity research in Europe have been discussed in several meetings organised by the EC and the ESF over the last few years (Table 1). The discussion at this level started at the MAST days in Sorrento (1995) and was followed by workshops in Plymouth (1997) where an inventory of marine biodiversity research was prepared, Yerseke (1997), where the EMaPS Position Paper *A European science plan on marine biodiversity* (Heip et al., 1998) was prepared, and in Lisbon (1998) where these documents were discussed and approved and further action was proposed.

From these meetings a consensus has grown among the scientific community in Europe that in order to achieve the long-term and large-scale research that is needed to answer some of the most important questions in marine biodiversity an important collaboration and co-ordination at the European scale is required. These measures should include comparative inventories of Europe's genetic resources, its species, habitats and landscapes, including marine microbiota, flora and fauna, and the understanding of the mechanisms and consequences of changes in marine biodiversity on large latitudinal and longitudinal gradients and on long time scales.

There are a number of reasons why this co-ordination at the European level needs to be prepared urgently. Several national programmes are running or starting soon and EU projects in the Fifth Framework Programme will be starting as from 2000. These projects are short term (3-4 years) and local. The usefulness of the results from this research will be greatly improved by creating an international forum where they can be discussed. The European contribution to DIVERSITAS and to the International Biodiversity Observation Year (IBOY) in 2001 needs to be prepared now. Therefore there is a need to create a community of marine biodiversity researchers, and because many important research questions cannot be addressed at local levels the establishment of a network of institutes is also required.

The European Network of Marine Stations (MARS) may serve as the backbone of such an effort since its 40-odd member institutes cover most of Europe's coasts. However the initiative must and will be open to all interested parties (not only to MARS member institutes) and can only work if it attracts commitment from an important number of researchers and institutes in Europe. The commitment sought is based on a series of flagship sites covering Europe from Spitsbergen in the north to the Canary Islands and Madeira in the south and to Greece and Turkey in the east.

The research performed through the network of flagship sites should be a major European contribution to the DIVERSITAS programme. The implementation proposal involves both an outline of methodology and an outline of the protocol to be signed by the parties willing to participate. These outlines will be the basis of a formal meeting of European Marine Research Stations to be held in Venice in October 2000 at the invitation of UNESCO to formally launch the network of marine biodiversity research in Europe.

The *objectives* of the Yerseke meeting were:

1. To prepare the implementation of a network of flagship sites as the basis for long-term and large-scale marine biodiversity research in Europe.

2. To provide an updated inventory of ongoing national research programmes and existing large infrastructures in the field of (experimental) marine biodiversity research.

3. To submit a proposal to ESF for a Euroconference on Marine Biodiversity to be held in 2001.

The criteria used for what constitutes a flagship site as well as the parameters, species and perhaps processes that need long-term monitoring (at least 10-15 years) at these sites need to be defined. The form of the commitment needs to be determined.

During the meeting the inventory on ongoing national research programmes and existing large infrastructures in the field of (experimental) marine biodiversity research was updated (objective 2) on the basis of the previous Plymouth inventory (Warwick, Goni and Heip 1997. *An inventory of marine biodiversity projects in the EU/EEA member states.* ISBN 90-74638-04-X)(Appendix 2). The presence of some east European representatives made a particularly valuable extension to the inventory.

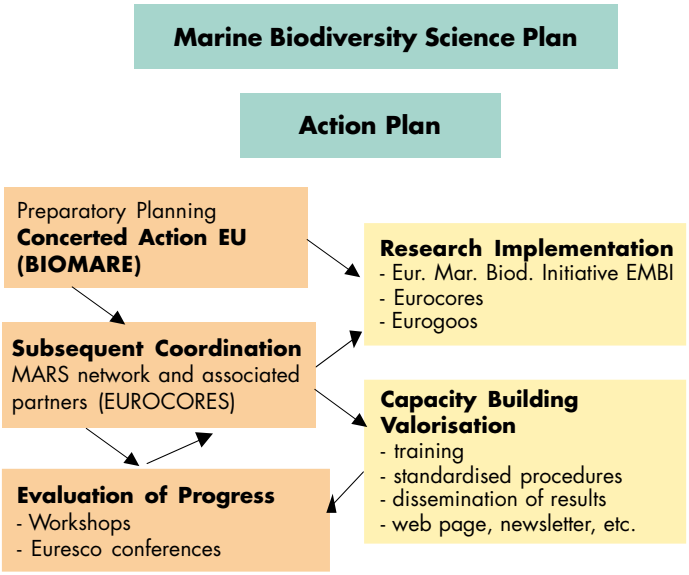
2. Implementation of a network of flagship sites as the basis for long-term and large-scale marine biodiversity research in Europe

2.1. From planning to evaluation

The framework for marine biodiversity research at the European level should be co-ordinated by a network, such as the MARS Network, steering the processes of planning, research implementation, capacity building and evaluation of progress (see scheme).

In the planning stage, the scientific tools for biodiversity research will be identified and fixed.

To achieve this, the questions need to be defined, available data and knowledge reviewed and synthesised, and then the new research conducted. Existing published information is reviewed by individual researchers, while this and unpublished information can be best reviewed through networking and workshops.



In the EMaPS Position Paper 2 the main research topics were identified (Heip et al. 1998). The research topics are now prioritised (Table 1), and a basic research infrastructure, with assigned locations and methods, is given (see 2.2).

Table 1. A summary of the main research topics described in the ESF marine biodiversity research agenda (Heip et al. 1998)
All this research benefits from a European perspective. The relative importance of European co-ordination for these topics is indicated (1 = essential; 2 = desirable; 3 = not required; 4 = useful).

Marine biodiversity research topic	Need for European scale
Characterisation of biodiversity patterns	1
Surveys of biodiversity over space and time	1
Methods, tools, protocols, quality control	1
Inventories of biodiversity at reference sites	2
Dispersal of species and populations	2
Fragmentation of species and populations	2
Mechanisms creating and maintaining biodiversity	3
Species function in ecosystems (e.g. keystone roles)	3
Habitat and seascape diversity	3
Modelling biodiversity within ecosystems	3
Experiments and theory development	3
International and global communication	4

Rocky bottom locality (ca. 20 m depth) at Kongsfjordnesset in Kongsfjorden, Svalbard with the sea urchin *Strongylocentrotus droebachiensis* and the cnidarians *Gersemia rubiformis* and *Urticina eques*. © Bjoern Gulliksen

A considerable amount of research can be achieved through short-term projects, such as those funded by national and EU programmes, and by graduate students in PhD research. It is anticipated that individual researchers will conduct such projects on an ad hoc basis, and it is essential that both EU and national funding is available for such research.

New methods, instruments, experimental and technical protocols, and quality procedures are developed within these projects, and through existing international working groups.

There are also regular international conferences, and short-term projects, which facilitate the exchange of knowledge and technology between researchers in Europe and elsewhere in the world.

However, long-term studies (for more than 10 years), particularly monitoring changes in biodiversity and ecosystems at a European scale, are not funded nationally or by the EU. Long-term studies must span decades and be designed to extend even beyond the lifetimes of individual scientific careers. There is thus a need for a long-term commitment by institutions to conduct such studies. The reality of historical and present funding arrangements has been that long-term commitments at a national and European level to such research are lacking. However, there are established environmental monitoring programmes that may be modified to include measures of biodiversity. A key conclusion of this working group is that a mechanism for the maintenance and management of long-term marine biodiversity research must be established in Europe. This would require the endorsement of the European Science Foundation, and financial support from European countries.

The most effective method of co-ordination of long-term studies may be through the institutions that would conduct such monitoring. It is in the long-term interest of such institutes and organisations to maintain such a programme, justify its costs, and demonstrate its benefits at both local and European scales. This might be efficiently achieved under the ESF EUROCORES scheme and a group such as MARS (European Marine Research Stations) may be, similar to the LabNet in the USA (Appendix 3), a suitable group to lead such an initiative.

Progress on the *European marine biodiversity science plan* should be reviewed at the forthcoming European marine science and global biodiversity conferences (Table 2).

There is a need for regular workshops to review progress in marine biodiversity research so as to prioritise future work, and assist the development of new consortia and research proposals. These reviews should be critical and consider how the research is achieving the aims of the science plan (Heip et al. 1998) and the needs of end-users.

Table 2. Forthcoming European marine science conferences at which progress in marine biodiversity research should be reviewed

Year	Location	Sponsor	Topic
2000	Hamburg	European Commission	Marine science and technology
2001	Corfu	European Science Foundation/ EC/MARS	ESF Euresco/ Euroconference
2003	Blankenberge	European Science Foundation / EC/MARS	ESF Euresco/ Euroconference
2004?	Paris or Venice	DIVERSITAS/UNESCO	Global Marine Biodiversity Meeting

Conclusions

- **There will be a need for regular workshops of scientific experts to critically review progress in marine biodiversity research.**
- **The European Science Foundation and European countries should formally recognise the need for long-term studies on marine biodiversity.**
- **A mechanism for the maintenance and management of long-term marine biodiversity must be established.**
- **The institutes and organisations likely to be most directly involved in long-term studies on marine biodiversity should formally commit themselves to such studies, and in doing so should take into account the constraints of short-term funding arrangements.**
- **A consortium of European organisations who would be involved in long-term studies on marine biodiversity, such as the MARS Network, is necessary to co-ordinate efforts, develop standard methods and quality control procedures, critically review progress, and demonstrate the benefits of the results to end-users.**

2.2. Choice of European flagship sites and methods for biodiversity

2.2.1. Intensive and Extensive Flagship Sites

It is clearly not possible to produce comprehensive inventories of biodiversity throughout Europe at a large number of locations, which cover the full range of taxa and all hierarchical levels of biodiversity (genetic, species and habitat). We therefore recommend a nested approach, making intensive studies at a

Corallium rubrum (Red coral) – the famous "red gold" of ancient history – lives on hard substrates with poor illumination to a depth of 200 m. It is still quite abundant in protected zones such as the Réserve marine de Cerbère-Banyuls and the Medes Islands.
© CNRS-O.O.Banyuls/ J. Lecomte

small number of reference sites and more limited extensive studies at a large number of sites.

The *Intensive Flagship Sites (IFS)* should be areas with a mosaic of habitats that are relatively pristine (unimpacted) when compared with similar areas elsewhere and which are therefore expected to have the comparatively highest diversity. These reference sites will serve to act as baseline end-members against which the status of degraded or impacted sites can be assessed, and subsequent changes monitored.

The exact criteria used to define these flagship sites will be discussed during the initial phase of the BIOMARE project. Some of the criteria that will be discussed are the following:

- They should be pristine (or as nearly so as possible), free from anthropogenic disturbance (pollution, fishing etc.), and also free from natural stressors (reduced salinity, increased turbidity) if these are atypical of the region which the site represents.
- They should comprise a mosaic of representative habitats within a well-defined area.
- Some background information should already be available, so that the inventorying of biodiversity does not start from scratch.
- They should be in areas which are afforded protection by their high conservation status (e.g. under the NATURA 2000 legislation) which will ensure the perpetuation of their pristine status.
- There should be an appropriate infrastructure for biodiversity research (e.g. good accessibility, a field laboratory for working with live organisms, scuba diving facilities etc.).

The series of Intensive Flagship Sites should aim at covering the major habitats in Europe. Relatively small offshore islands may be amongst the favorite locations for IFSs because they are remote from anthropogenic impacts, not subject to freshwater or fine sediment inflows from rivers, have well-defined limits and a long coastline relative to their area. The size of such islands needs to be considered carefully in view of the island effect (dependence of species number on island size). Some coastal environments, such as beach-dune systems, tidal flat systems (west European estuaries and the Wadden Sea), lagoons and deltas (in the Mediterranean) will require a different type of IFS.

A proposition for the objectives of the research at these reference sites will also be formulated during the BIOMARE programme and may contain the following elements:

- To make an exhaustive inventory of the biodiversity present, including e.g. as complete a range of taxa as possible, the genetic diversity of target species and habitat diversity (rocky versus soft/ sandy shores, tidal versus subtidal).

- To establish the underlying phylogenetic pattern of biodiversity (e.g. the apportionment of species among higher taxa) and whether this varies along latitudinal, longitudinal and environmental (salinity) gradients within Europe.

- To develop rapid assessment techniques. A major challenge in marine biodiversity studies within Europe is the need to develop firmer estimates of species numbers and better estimation procedures. One important approach to richness estimation is extrapolation from taxon to taxon, focal group to inclusive group, site to site and sample to inventory, across spatial scales. To calibrate the basis for such an approach requires the establishment of sites with an All-Taxon Biodiversity Inventory (ATBI). To date this has not been achieved, certainly for marine taxa, at any site in the world. Yet surrogacy methods, based on extrapolating information from intensively studied sites, will become the norm in site assessment, because of the impracticality of routinely attempting comprehensive surveys.

- To develop and calibrate biodiversity measures based on relatively coarse data appropriate to the large scales of observation, and produce indices which, unlike species richness, are not strongly dependent on standardised sampling effort. Such indices may include information on trophic groups, distribution of body size, endemicity etc., as well as phylogenetic structure (a discussion on indices is given in the next chapter).

- To serve as a benchmark for the standardisation procedures.

- To initiate long-term observational information in order to establish patterns of temporal change.

More extensive but less comprehensive studies of *Extensive Flagship Sites (EFS)* should be made at a much larger number of sites, covering a range of impacted and non-impacted areas, and (hopefully) using the rapid assessment techniques developed at the reference sites and a restricted number of key species. The criteria for the selection of these sites are clearly not so strict, but comparable habitats should cover a wide geographic range (e.g. sandy beaches, seagrass beds etc.).

The objectives of studies at EFSs will be:

- to map the distribution patterns of biodiversity on a relatively fine scale;
- to assess Man's impact on biodiversity;

Rocky bottom locality at about 15 m depth in the tidal rapid Rystraumen near Tromsø, Northern Norway with sponges (*Halichondria panicea*, *Haliclona* sp.) and actinarians (*Urticina eques*, *Metridium senile*). © Bjoern Gulliksen

Approximate position of the three main transects. A range of sampling, surveillance and/or reference sites for selected and well defined coastal habitats (e.g. sandy beaches, seagrass or kelp beds, sandbanks and mudflats, shallow subtidal sediments, etc.) should be selected to represent the variation in biodiversity across Europe. These may be selected to be as similar in their environmental conditions as possible, or to reflect a gradient in day length (latitude), maximum summer sea temperature, water depth, productivity or any other appropriate and quantifiable parameter.

- to undertake long-term monitoring using rapid assessment techniques or biodiversity indicators.

2.2.2. Study locations

It is suggested that an appropriate distribution of sites would initially be along three transects:

- A North–South transect from Svalbard to the Canary Islands, with perhaps 5 to 6 IFSs (present suggestions are Svalbard, Faroes, Scillies, Azores, Canaries) and a number of EFSs along the Atlantic coasts of Iceland, Norway, Scotland, France, Spain and Portugal.

- An East–West transect through the Mediterranean, with perhaps 4 to 5 IFSs (suggestions are Skiathos, Ischia, Cabrera Is., a Greek island) and an appropriate range of EFSs.

- An East–West transect in Middle Europe covering the salinity gradient from the Baltic to the North Sea, with perhaps three IFSs (suggestions are Asko, Helgoland and one other).

It would be appropriate to sample around 30 of the extensive sites along each transect, and as a final phase survey the transects in a continuous way using broad-scale survey techniques (ROVs, remote sensing).

3. Indicators of marine and coastal biodiversity

The composition and structure of the fauna, flora and habitats of the oceans change particularly due to climate and human activity. The latter is the reason for the deterioration of many environments; over the last 50 years the rate and extent of this deterioration has been unprecedented, as were the consequences on biological diversity. There is a need to rapidly detect significant changes in the environment and biodiversity and therefore to discuss and scrutinise the existing indicators (see below) and to evaluate and validate those actually usable at a local and/or at a regional level. Validated bio-indicators will be used in monitoring programmes for:

- giving early warning about environmental problems;
- identifying cause and effect relationships between stress agents and biological responses;
- assessing the organisms' integrated responses to environmental stress;
- assessing the efficacy of remedies for the health of monitored systems;
- defining sustainability criteria.

At present no operational indicator concerning marine and coastal biodiversity on a European (or even regional) scale is available. The inventory of scientific programmes in the EU countries shows (Warwick, Goni and Heip 1997, see Appendix 2) that inventories, and the compilation of databases and studies on stocks, are under way, but that there is no standardised sampling plan, envisaged time and space scales differ and the taxonomic skill involved in projects also differs.

Indicators generally refer to the environmental attributes (often but not always species or species groups) which can be sampled and whose modifications are supposed to reflect a change of biological diversity. Indeed, indicators are measurable substitutes for the larger constituents of biological diversity. They are useful monitoring tools given the impossibility of surveying biological diversity in its entirety. It is thus necessary to assess the total richness in a series of samples and to compare the various situations

Among the causes of loss and degradation of biodiversity are:

Direct threats

- Fragmentation and loss of natural habitats
- Overexploitation of certain species
- Biological invasions, as a consequence of human activity
- Pollution (atmospheric fallout, pollution brought down by rivers, emissions, sea-farming (food remains, antibiotics), hydrocarbons, anti-fouling paint, hot water, pesticides, detergents, heavy metals, radionuclides, waste (industrial: red muds) and macrowaste, viruses and bacteria (waste water), silting, pleasure boats (unauthorised anchorage))
- Climate change
- Destruction of the sedimentary systems through mining and related exploitation
- Catches (fishing, gathering) mostly of wild stock species

Indirect threats

- Development of rivers and the coastline (valorisation and occupation of coasts for industrial, tourist and residential purposes)
- Increase of human population and concomitant exploitation of resources
- Disturbance linked to leisure activities
- Difficulty or impossibility of economic growth in certain countries
- Non-recognition or underrating of marine diversity and natural resources in economic terms
- Weakness of legal systems and institutions
- Absence of adequate scientific knowledge and ineffective transmission of information

A mosaic of habitats: intertidal sand beaches and rocky shores, subtidal sands, seagrass and kelp beds. Eastern Isles, Isles of Scilly, UK.

and track the changes as time goes on. This is the case in which indicator groups (taxonomic or functional) are needed. Regions, habitats, and groups of indicators must be chosen. For this, we will refer to the techniques of rapid assessment of priority areas and rapid biodiversity assessment. Most are being used in the terrestrial domain. A goal of a first action plan could be to evaluate the relative feasibility and efficiency of such methods at sea.

Moreover, indicators must be envisaged in the context of information flow (scientific research, environmental management, decision making or public awareness). Thus the objective is to condense information on biodiversity and clarify the generally complex phenomena dealt with in the environmental sciences.

Bio-indicators will be considered following the model developed by OECD:
- state indicators (extent of ecosystems, quality of ecosystems, relative number of threatened and extinct species, monitoring of genes and genomes related to sea farming and alien species);
- pressure indicators (loss of habitat, overexploitation of natural resources, species introduction, pollution, potential climatic change);
- use indicators (measurements of goods and services provided by ecosystems);
- response indicators (measurement of government's ability to implement recommendations).

A first short-term objective would consist of a:
- survey and critical evaluation of different types of bio-indicators available in Europe (also including so-called indicator and sentinel species, biological indices, biomarkers, lethal and sublethal tests, bio-accumulators);
- survey and evaluation of existing national monitoring networks (e.g. sea water quality: temperature, salinity, nutrients and contaminants, phyto-plankton disturbance (especially by toxic unicellulars), bacteriological quality of shellfish relative to faecal bacteria).

The following stages are recommended in the selection process to obtain standardised approaches and methods:
- determine the target public and its information requirements;
- clarify the criteria to be measured;
- choose the sustainable indicators;
- evaluate how meticulously tested were the indicators;
- set up targets, thresholds and/or marker data that are suitable for these indicators, depending on local or regional scales;
- try out these indicators in the field.

Three regions will be distinguished (following the transects proposed for reference sites):
1. Baltic, Danish Straits, Norwegian Sea, North Sea and the English Channel;
2. Atlantic (and Arctic);

3. Mediterranean Sea (and possibly Black Sea).

Over a two-year period a network, such as MARS, should organise regional workshops and meetings to:

- organise a sequence of meetings aimed at increasingly inclusive information coverage (definition of sustainable indicators and related techniques at regional and European levels);
- determine the geographical unit which must be studied: which should have the same biogeographical history and a certain ecological homogeneity;
- choose the indicator groups according to current knowledge, and explore the availability of standardised sampling techniques;
- express the results in terms of local (alpha) and landscape (gamma) diversity, as well as in terms of beta diversity (e.g. quantification of species substitution between communities);
- produce comparable data, readily available in banks designed for their public use.

The steps have to be:

- Review the state of the art of sustainable indicators in the different regions chosen, competencies (in particular in taxonomy), sampling gear and methods, requirements justifying the proposition of a list of biotopes and possible indicators (according to pre-set criteria). Organisation of an open forum by Internet.
- Regional meetings: organisation of four regional meetings to summarise the results of the Internet consultation and proposition of the recommended standardised methods
  – to establish a homogeneous classification of the marine biotopes in each region;
  – to quickly determine the sites and the indicators according to the results of the conference;
  – to determine the standards of sampling, standardised generation of data, availability of the data to the public;
  – to map selected sites and natural reserves (GIS).
- General meeting: to have the same aims as regional meetings, but at a European level.
- General synthesis and proposal of grids of indicators, adapted to a considered region.
- Planning of long-term monitoring of the coasts of Europe (link with reference sites).

The expected products are standardised and normalised indicators of marine biodiversity at local and European levels, delivered as grids of sustainable indicators. They will also be proposed as a global system of indicators (possible in connection with the International Marine Biodiversity Network).

The ongoing and future activities beyond 2001 aim at a long-term monitoring network.
The objectives fit with the Convention on Biological Diversity (CBD) targets (production of sustainable indicators), and with the topics dealt with by DIVERSITAS-IBOY: Marine Biodiversity / Monitoring and conservation.

4. Supporting measures and infrastructure

4.1. Networking and communication to end-users, public and policy makers

A first step in research on a European scale is making researchers aware of expertise, facilities, study sites, and local scientific knowledge, in different countries. Mechanisms for the communication of this information throughout Europe are thus essential. The published literature is not sufficient for this because of the time lag between the completion of the research and its publication, the fact that much information is not published, and that staff move. The most rapid and lowest cost communication would be through the Internet. It is thus recommended that an electronic news service be used such as the MARINE-B 'listserver' (see below). In addition, a central web site for marine biodiversity research in Europe would be very useful. This would need to be frequently updated to provide links to relevant projects and organisations.

Instructions for subscribing to the European Marine Research Information Network on Biodiversity (MARINE-B)

This is a free and public service for the benefit of marine biodiversity researchers in Europe. It is used for spreading news about opportunities (jobs, training courses, tenders, research contracts), publications, projects, and for seeking information. All messages are automatically archived on a monthly basis on the web site

Send message to: listserv@listserv.heanet.ie
Message text should contain: SUBSCRIBE MARINE-B your name
Await automatic response and follow instructions.

The newsletters of scientific organisations (e.g. Baltic Marine Biologists, Estuarine and Coastal Sciences Association, and the electronic Newsletter EurOcean Science News of the ESF Marine Board), and meetings of relevant working groups (e.g. ICES, European research projects), workshops, and conferences at a national and European level further facilitate this communication. Networking initiatives should make a special effort to bring in new members and young scientists (especially graduate students) who would benefit most from such interactions.

It is essential for the results of scientific research to be published in the international peer-reviewed literature. This provides some quality control on data analysis and interpretation, and ensures the wide availability of the results.

The results can be used to produce manuals of the different selected habitats (structural characteristics, preservations), and reference collections of all species.
Moreover, an atlas may fulfil the need for ready access information on marine climate, physical and chemical oceanography, bathymetry, currents, tides, temperatures, and species distributions on a European scale. This is information needed to interpret observed patterns in marine biodiversity at different study sites in Europe.

The results of research must be provided to end-users in a form they can apply to management, educational and other issues. For example, marine

biodiversity researchers should make clear how their results may contribute to environmental protection, fisheries and aquaculture, nature conservation, and/or sustainable use of marine resources. In addition to published papers, research results should also be communicated at meetings, and through non-specialist articles in the scientific and popular press. It can be difficult for scientists to directly communicate the results to the public, so they should interact regularly with professional science journalists to achieve this dissemination.

Chromodoris luteorosea (purple-yellow spotted Doris). This sea slug (naked snail) is a gastropod mollusc lacking a shell as an adult and having external respiratory appendages on the dorsal surface. It is a characteristic species of the coralligen of western Mediterranean. It lives between about 10 and 50 m deep, often on sponges of the genus *Spongionella* on which it feeds. It is 1 to 2 cm long, but can grow up to 5 cm. © CNRS-O.O.Banyuls/J. Lecomte.

4.2. Facilities and equipment

As a whole, Europe is well equipped with marine research laboratories, ships, and analytical facilities. There may be gaps in facilities for experimental ecology (e.g. mesocosms) at a European level (Heip et al. 1998), and gaps in other facilities within some member states. Marine biodiversity research needs not only equipment for biological analyses, but also tools to characterise the environment, including chemical and physical analyses, remote sensing, and electronic technology (which is an action item for the ESF Marine Board).

While making the case for providing and improving facilities is beyond the scope of this report, there is a need to make the availability of facilities more widely known. A central web site could usefully create links to institutional and project (e.g. EuroGOOS) web sites where facilities and equipment available to researchers would be described. The ESF Marine Board might provide support in this domain.

4.3. Training and mobility

In order to successfully harmonise the methodologies for sampling, analysing and releasing information, training and mobility are essential. The European Union has been very successful in increasing the movement of students and researchers around Europe. There is still a need to increase the proportion of researchers going to countries with smaller and less well-equipped facilities. In this context, some marine biodiversity research is not demanding on expensive facilities, and more pristine marine habitats may occur in the less industrialised countries. Whether there is sufficient mobility of researchers within countries is not clear. Such mobility could give special

Paramuricea clavata (Violescent sea-whip), formed by polyps joined together in a colony, grows very slowly at a maximum of 1 cm a year on shady rock walls at depths between 15 and 50 m. Because of its slow growth rate, it is vulnerable to the activities of scuba divers which damage the organism and retard its recovery. © CNRS-O.O.Banyuls/J. Lecomte

attention to increasing understanding of how marine environments and biodiversity differ within Europe.

Special training courses, within countries and on a European scale, should be held according to the user demand to provide specialist training in field and laboratory skills, data analysis and interpretation. These courses should bring researchers of all ages and experience up to date with the 'state of art' in terms of knowledge, methods, technology, and end-user requirements. As with researcher mobility, these courses should improve students' understanding of marine biodiversity on a European scale.

Conclusions

- **There should be increased use of existing e-mail and electronic newsletters for the communication of information on marine biodiversity research.**
- **A central web site for guiding researchers and end-users to relevant organisations, institutes, societies, projects and information on marine biodiversity should be established.**
- **Researchers should establish contacts with professional science journalists so as to actively facilitate the dissemination of their findings to the public.**
- **Training and mobility of scientists of all ages should be encouraged both within countries and at a European scale.**

5. Actions

In view of the conclusions from the meeting several focal points for action have been defined.

Type of Action	Actions / remaining tasks	Implementation
PREPARING IMPLEMENTATION OF REFERENCE SITES (objective 1)	First outline	April 99
	Submission Concerted Action to EC	June 99
Reference sites		
- *Reference Flagship Sites* (pristine, mosaic of habitats, protected, research infrastructure)	Selection criteria	April 99
	Selection stations	April 99
- *Extensive Comparative Reference Sites* (impacted vs. non-impacted areas, restricted number key species, wide geographic range)	Selection criteria	April 99
	Calibrate biodiversity measures	- (2000)
	Standardise procedures	- (2000)
	Establish pattern of biodiversity	- (2000-2001)
	Initiate long-term observations	- (2000-2001)
Indicators of marine and coastal biodiversity	First outline	- (2000)
	Survey and evaluate types of bio-indicators in Europe	- (2000)
	Survey and evaluate national monitoring networks	- (2000)
	Determine target public and information requirements	- (2000)
	Clarify criteria to be measured	- (2000)
	Choose sustainable indicators	- (2000)
	Determine sites which must be studied	- (2000)
	Standardise sampling techniques	- (2000-2001)
	Establish classification of marine biotopes	- (2000-2001)
	Map selected sites and natural reserves (GIS)	- (2001)
	Try out indicators in the field	- (2001)
	Produce comparable data in banks for public use	- (2001)
UPDATE INVENTORY ON NATIONAL RESEARCH PROGRAMMES (objective 2: on basis of Warwick, Goni & Heip 1997)	First updates	April 99
	Final update	Jan 2000
PREPARING SUBMISSION EUROCONFERENCE PROPOSAL (objective 3)	First submission	Sept. 99
	Approval	Dec. 99
SUPPORTING MEASURES AND INFRASTRUCTURE		
- Overview of facilities and equipment		- (2000)
- Training and mobility of scientists		- (2000-2001)
- Facilitate networking and communication to end-users, public and policy makers		
. Initiate (electronic) newsletter		- (2000)
. Establish contacts with professional science journalists		- (2000)
- Initiate workshops and conferences		- (2000-2001)
- Produce manuals of selected habitats		- (2001
- Produce reference collections of all species		- (2001)

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Appendix 2:
Updated inventory of ongoing national research programmes and existing large infrastructures in the field of (experimental) marine biodiversity research in Europe

(first inventory by Warwick, Goni and Heip 1997. An inventory of marine biodiversity projects in the EU/EEA member states. ISBN 90-74638-04-X)

Belgium (Magda Vincx)

Despite its short coastline, and a consequently restricted range of habitats, Belgium has a large potential for marine biodiversity research.

In total, more than 50 scientific ongoing projects deal with aspects of marine biodiversity. Most of these do not have biodiversity as the main topic but information derived from them is relevant to the DIVERSITAS themes. In 1999, a Biodiversity Platform was created by the Belgian Government (National Committee for DIVERSITAS-OSTC , Belgian Federal Office for Scientific, Technical and Cultural Affairs, Brussels) which has the task of investigating the future challenges for biodiversity research in Belgium (including the marine environment). Through this committee, new research challenges will be encouraged.

The following research Institutes are involved in marine biodiversity research: Koninklijk Belgisch Instituut voor Natuurwetenschappen, Brussel; Instituut voor Natuurbehoud, Brussel; Universiteit Gent; Limburgs Universitair Centrum, Hasselt; Université Libre de Bruxelles, Mons and Vrije Universiteit Brussel. Financial support is given by: OSTC (Belgian Federal Office for Scientific, Technical and Cultural Affairs, Brussels), universities, national science foundations, (Flanders and Wallonie), Flemish Community, Department Nature, Institute of Science and Technology (IWT) and Ministry for Developmental Affairs.

Belgian marine biodiversity research is done both within and outside Europe. The Indo-Pacific region is particularly well covered, largely due to the 'Belgian' field station in Papua-New Guinea and the Kenya Marine Fisheries Research Institute in Mombasa, and the Marine Institute in Zanzibar. Recently, new contacts have been made with Chili, Ecuador and South Africa.

A lot of biodiversity activities are going on within the frame of the Sustainable Development programme of OSTC (1997-2002) both in the North Sea and in Antarctica.

The use of biodiversity for sustainable development is currently being well studied in the shallow sandbank systems of the North Sea (part of it foreseen as a nature reserve) as well as on the sandy beaches. Other planned research is concerned with predicting antropogenic impacts on biodiversity.

All DIVERSITAS core programme elements are represented; inventorying and classification are particularly strong, while three other elements (origin, maintenance and change; monitoring of biodiversity; conservation, restoration and sustainable use) are weaker.
In conclusion it can be stated that

Belgium has great potential in biodiversity research but that so far no international funds and a limited number of national funds have been generated for the direct support of biodiversity research.

France (Jean-Pierre Féral)

The national biodiversity programme Biodiversity dynamics and environment / DIVERSITAS – France (PNDBE) was part of the Interdisciplinary research programme: Environment, Life and Society (PIR-EVS) which ended in May 1998.

The PNDBE covered five major thematic fields:

- mechanisms of evolution and preservation of biodiversity;
- national biosystematics networking;
- biodiversity and ecology of interacting species;
- biodiversity and ecosystem functioning;
- biodiversity and society;

and five fields of application:

- establishment of the present distribution of fauna in western Europe;
- fragmented populations, extinction, habitat selection and conservation biology;
- biodiversity and microbial ecology;
- marine biodiversity;
- fish and their environment.

The marine diversity network (RDM: Réseau Diversité Marine) has helped to organise interdisciplinary groups of scientists specialised in subjects as different as molecular biology, population genetics, systematics, marine ecology and oceanography. The network was jointly supported by IFREMER and CNRS. After approval by the PNDBE Scientific Council, two programmes, Inventory of Flora and Fauna of Metropolitan Marine Stations and Genetics and Marine Diversity, were given support. Other actions concerning effects of fisheries and invasive species, and functional aspects of biodiversity in sediment and seagrass meadows, were launched.

A conference entitled Results and Prospective of the French Marine Diversity Network was organised in Paris in December 1996. The proceedings, Biodiversity in Dispersive Environments, were published within one year (Vie Milieu 47(4)). A TMR practical training course, Concepts and Methods for Studying Marine Biodiversity, from gene to ecosystem was held in Banyuls-sur-mer in March 1998. It surveyed major methodologies available for acquisition, treatment and management of biodiversity data. This course was also supported by CNRS, MARS and the Associated European Laboratory Marine Sciences France/ CNRS - Spain/CSIC. It took place under the auspices of DIVERSITAS. *<http://www.cordis.lu/tmr/src/res970307.htm>*

At the end of 1998, a new PIR-EVS was launched. The new national biodiversiy programme (PNDB) is one of its components.

Four topics have been defined:

1. origin, distribution and dynamics of biodiversity;

2. protection and restoration of biodiversity;

3. biodiversity and sustainable development;
4. valuation and appraisal of biodiversity.

The operation of the programme is still under discussion. As to RDM, the activity of the participating teams may correspond to one or several of these topics. Many of the known projects relate to topics 1 and 3. The role of RDM in providing information and co-ordination still appears essential. It is a forum for discussion and a source of proposals. Actions will also be supported by IFREMER. Strong links exist with the French national biosystematics network.

CNRS expects from PNDB the continuation of development and widening of the inter-institutional mobilisation generated by PNDBE, the development of the interfaces between natural sciences and human and social sciences, a contribution to the dynamics of the DIVERSITAS programme and the maintenance of an effective and coherent French position within the framework of CDB following its ratification by France. Two ministries confirmed their interest in biodiversity. The scientific priorities of the Ministry of the Environment aim at operational observatories of the environment, based on research observatories and new research programmes such as those launched in 1998-99 ("*Caulerpa*", Protected areas) concerning the marine realm. The Ministry of Agriculture and Fisheries is concerned with the management of ecosystems harbouring exploited resources and with space management and regulation of various activities in progress in the littoral and in the coastal zone.

Germany (Fred Buchholz)

Biodiversity-related research is conducted at the large coastal units of marine research on the North sea and Baltic Sea, and in land university institutes and natural history museums.

The overview given by Türkay and Fiege in Warwick, Goni and Heip, 1997 is still largely valid. However, a concentration effect will result from the integration of Biologische Anstalt Helgoland (BAH) with the Foundation Alfred Wegener Institute for Polar and Marine Research (AWI) in Bremerhaven. BAH is one of the European forerunners of long-term observation series, as a basis for biodiversity studies. For 36 years, such series have included for example abiotic parameters, nutrients, micro-organisms, phytoplankton and zooplankton. The recent reorganisation of the institute under the auspices of AWI now allows the integration and evaluation of data of further observation series in the North Sea and introduction of new methods, including remote sensing and bio-physical modelling approaches.

Furthermore, the former Taxonomical Working Group (TAG) at BAH was transferred to and is now being headed by Senckenberg Research Institute (FIS), Frankfurt. Early in 2000, the

Centre for Marine Biodiversity will be formally established, integrating TAG and additional personnel, with locations in Wilhelmshaven, Hamburg and Oldenburg. Further input by universities is expected.

A new development is the recent establishment of a national steering committee for the allocation of ship-time of medium-size German research vessels. Here, ship-time can be directly applied for by the marine and university institutions, involved in biodiversity research. Collaboration with European research groups in ship-bound studies is encouraged.

Greece (Eleftheriou Anastasios & Drosos Koutsoubas)

Despite their interesting flora and fauna and the important information for biodiversity studies they can provide, the Greek seas remained until recently among the most poorly studied areas of the Mediterranean.

The information existing on the composition of the marine biota of the Greek seas was very limited even after the research expeditions of *Calypso* in the 1960s (cruises of 1955 and 1960). This led some authors to claim that many species occurring in the western Mediterranean or the adjacent Atlantic coasts do not occur in the eastern Mediterranean and led to the theory of impoverished Eastern Mediterranean.

In the middle of the 1970s an intensive sampling effort started on the marine biota of the Greek seas (mainly in the Aegean). The results of these samplings were realised mainly by research groups of the Departments of Zoology in the National Kapodestrian University of Athens, the Aristotelion University of Thessaloniki, the University of Patras, the University of Crete and the University of the Aegean. Significant contribution in the study of marine biodiversity in the Greek seas was also given by the National Centre of Marine Research located in Athens and the more recently established Institute of Marine Biology of Crete and the NAGREF-Fisheries Research Institute in Kavala (northern Greece). The Hellenic Zoological Society and the Hellenic Botanical Society host nowadays more than 50 scientists working on different aspects of marine biology.

Although few individual projects (coming mainly from the universities and covered in most of the cases by national funds) have the study of marine biodiversity as their principal aim, the numerous studies on inventorying, systematics and taxonomy are the strong point of research on marine biodiversity in Greece over the last 20 years. These include investigations on many taxa of phyto- and zooplankton, and phyto- and zoobenthos, and on the most peculiar and endemic Mediterranean ecosystems. Over the last decade research programmes concerning biodiversity and ecosystem functioning, and origin, maintenance and change of biodiversity have been

performed in the Greek seas. A great deal of research effort has also been devoted to the systematics, environmental variation, genetics, assessment and monitoring of invertebrates of commercial interest (mollusca, crustacea) and fish stocks. Most of these programmes are supported by the FAO, NATO (SFS) and the EU (MAST, MAST-MTP, FAIR, LIFE, CFP STUDIES). It should also be noticed that increased effort has been recently given to projects outside Greece, e.g. the National Centre of Marine Research and the Institute of Marine Biology of Crete with research along the coasts of the Black Sea in the framework of the NATO-SFP programmes. All these programmes fit well within the DIVERSITAS core elements.

Despite the fact that the flora and fauna of the Greek seas play a key role for understanding the biogeography of the Mediterranean marine biota and for identifying patterns of dispersion of the species in the Mediterranean, the Black sea and the Atlantic regions, assessment of the marine biodiversity in Greek seas still remains insufficient, for several reasons such as:

- absence of a large scale national programme for the assessment of biodiversity in Greek waters;
- lack of long-term monitoring studies;
- insufficient investigations of smaller forms such as macro- and meiofauna in the benthic, and pico-, nano- and microplankton in the pelagic domain (the study of their distribution pattern and the species variation could provide substantial information on the mechanisms involved in maintaining biodiversity);
- lack of genetic studies on marine species apart from a few on species of commercial interest (mollusca, small and large pelagic fishes);
- limited research effort in the bathyal zone;
- lack of intensive research in specific biotopes (e.g. coralligenous bottoms, submarine caves, wetlands);
- poor mathematical interpretation of the biological data;
- absence of correlations of distributional patterns of biota with abiotic factors (rare back up of biological sampling with measurements of critical ecological parameters);
- qualitative sampling or use of inappropriate samplers which further complicates the problems of quantification.

A European programme focusing on marine biodiversity would not only promote the scientific knowledge of this issue but could also catalyse the development of a national policy in monitoring biodiversity.

Iceland (Jorundur Svavarsson)

Apart from a few local efforts, the BIOICE (Benthic Invertebrates of Icelandic Waters) project is the main programme dealing with marine biodiversity in Icelandic waters.

The BIOICE project started in 1991 and is planned to run for some years. The BIOICE project deals with Icelandic waters, which is a very important part of the North Atlantic Ocean, being the area where the Nordic seas (Norwegian, Greenland and Iceland seas) meet the North Atlantic proper. The objectives of the project are to revise the systematics of benthic invertebrates in Icelandic waters and to provide information of their distribution and biodiversity, in addition to their ecological role.

The samples have been taken within considerable depth range (about 20 to 3 000 m) and approximately 600 sites will be visited.

The BIOICE programme has a large international participation as approximately 80 scientist all over the world are involved in BIOICE. A strong Nordic element is present, partly seen in a number of cruises of the Norwegian research vessel *Håkon Mosby*. The Nordic Council has further sponsored the project. For the last two years the project has served as part of a Large Scale Facility at the Sandgerdi Marine Centre, Sandgerdi.

Republic of Ireland (Mark J. Costello)

The report of the Plymouth workshop (Warwick, Goni and Heip 1997) reviewed the then current research projects concerning marine biodiversity in Ireland. Several of these projects have been completed and published, and a few new projects have begun.

There has been no concerted national effort to implement the Convention on Biological Diversity, either in terms of management, research or education. However, a framework document for a national marine biodiversity action plan has been drafted, and a wider national biodiversity action plan, is in preparation. There is no national DIVERSITAS committee, or specific mention of biodiversity in national research funding programmes. Because the government department responsible for nature conservation is leading the national biodiversity action plan, there is a general misunderstanding that biodiversity is only concerned with nature conservation.

The largest ever inventory of benthic marine biodiversity in Ireland has been conducted as part of the BioMar-LIFE project (Costello 1995). Almost 900 sublittoral and littoral sites were surveyed around the coast and this data has been published on CD (Picton and Costello 1999). The CD also includes a catalogue, illustrated with colour photographs, of the BioMar-MNCR classification inshore marine benthic biotopes of Britain and Ireland produced by Connor et al. (1997a,

1997b). The European Union INTERREG programme between Wales and Ireland has funded two marine projects that are inventorying marine biodiversity in the southern Irish Sea. The SensMap project is mapping littoral and near-coast sublittoral biotopes (Emblow, Costello and Wyr 1999). The SWISS project is taking benthic samples in the central parts of the southern Irish Sea so as to extend the previous Welsh BioMar survey.

The National Marine Institute established a national marine research funding measure from the European Regional Development Fund. All the projects funded concerned the development of marine resources, particularly fisheries and aquaculture. Projects that contribute to the understanding of marine biodiversity included surveys of the exploitable stocks of single species, including maerl, the seaweed *Ascophyllum nodosum*, brown squid, and herring spawning grounds. A current project is examining the biodiversity of Ascophyllum beds, including the changes in species composition, abundance, and population structure following harvesting of the seaweed.

Continuing studies on aspects of marine biodiversity in Ireland include marine algae (Prof. M. Guiry), fungi (Nick Clipson), phytoplankton (Robin Raine and John Patching, NUIG), introduced aquatic species (Dan Minchin, Marine Institute), and the Dublin Bay ecosystem (Jim Wilson, Trinity College Dublin).

Irish researchers have participated in EU research projects that included aspects of biodiversity: under MAST on the littorinids, rocky seashore ecology, phytoplankton dynamics, deep-sea microbial processes; and FAIR (aquaculture and fisheries) on genetics of oysters and salmonids, deep-sea fish stocks. The EU Concerted Action European Register of Marine Species is co-ordinated by Mark J. Costello (Ecological Consultancy Services Ltd/ EcoServe), and the checklists of European macroalgae and fungi have been produced by Mike Guiry (National University of Ireland, Galway) and Nick Clipson (University College Dublin). These and other Irish researchers will probably be involved in forthcoming EU funded research projects under the Fifth Framework Programme.

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Italy (Adriana Zingone)

Update of the Italian initiatives on marine biodiversity*

A series of initiatives has recently been undertaken in the last years in Italy which are relevant to biodiversity, aimed at improving the management of natural resources and fulfilling international agreements:

• Inventory of fauna and flora of Italy, including surrounding seas

A checklist of animal species living in Italy, including surrounding seas, has been prepared with the collaboration of the Nature Conservation Service of the Italian Ministry of Environment and the Italian Fauna Committee of UZI (Union of Italian Zoologists). About 250 experts from 14 countries have contributed to this initiative. The checklist, published by Calderini, Bologna, consists of 110 issues and includes information on the geographic ranges and indication of endemic or endangered species. A total number of 57 344 species are included, of which 9 194 living in the sea.

The compilation of checklists of marine algae and phanerogames has been recently committed by the Italian Ministry of Environment to experts. Professor G. Giaccone (University of Catania) has compiled the checklist for macroalgae and phanerogames, whereas the preparation of a phytoplankton checklist is underway.

• Marine protected areas

Law 979/82 for the defence of the sea dictates criteria for the safeguard of marine and coastal environments from pollution. It also includes the valorisation of marine ecosystems through the establishment of 20 marine reserves. Subsequent laws (394/1991 and 344/97) have earmarked 27 more areas for conservation and protection.

• Inventory of habitats in need of protection

The project Bioitaly funded by the programme LIFE has been conducted following the directive 92/43/CEE for habitat and species conservation. Sites of community (SIC), national (SIN) and regional (SIR) interest have been selected for inclusion in the European inventory Natura 2000. In the suggested list marine sites are scanty and mainly limited to *Posidonia oceanica* and *Cymodocea nodosa* habitats. To be able to expand the list to include more marine biotopes, a working group has been established within the Ministry of Environment to provide a classification of Italian and Mediterranean marine biotopes and to indicate a priority order as to the need for their safeguard.

* The information herewith provided has been extracted from the paper 'Relini, G. 1999. L'Italia e la protezione della biodiversita' in Mediterraneo (Italy and biodiversity Conservation in the Mediterranean Sea). Biol. Mar. Medit., 6: 151-171'.

Lithuania (Sergej Olenin)

The Lithuanian coast is situated in the south-eastern part of the Baltic Sea. Despite its short shoreline (94 km), it comprises a wide range of benthic habitats both in the sea and in the Curonian Lagoon (Kurshiu marios), the largest coastal lagoon in the Baltic Sea.

The offshore waters show typical stratification pattern for the Baltic proper with the upper layer (mean salinity 7-8 ppt) separated by a permanent halocline at 70-80 m depth from the more saline subhalocline water layer which is oxygen deficient. The Strategy and Action Plan for Biodiversity Conservation in Lithuania has been elaborated recently (1998) and considers marine biodiversity issues, however there is as yet no national research programme on biodiversity.

Marine biodiversity research also is not yet co-ordinated. It is conducted by several institututions:

- The Marine Research Centre (Ministry of Environment) carries out biological monitoring in the sea and in the lagoon according to national and international (HELCOM) programmes. Long-term studies (since 1980) are available for phytoplankton and zoobenthos, and recently observations on phytobenthos, protozoans and zooplankton have begun. Besides monitoring, the research is focused on eutrophication effects and the dynamics of potentially toxic species of phytoplankton.

- Since 1993 the Coastal Research and Planning Institute (Klaipeda University) has performed classification and mapping of benthic biotopes and bottom communities both in the coastal zone and deeper parts of the eastern Baltic. Changes in zooplankton communities are studied in relation to temporal and spatial salinity gradients in the Curonian Lagoon. Structural and functional aspects of alien species invasions and the patterns of their dispersal are also important research topics. The institute takes part in an EU-MAST project on Baltic Sea System Studies (BASYS) and a Concerted Action on alien species introductions via ship-ballast waters. The institute also keeps and maintains the Baltic Alien Species Inventory (*http://www.ku.lt/nemo/mainnemo.htm*), which is a product of the Baltic Marine Biologists Working Group on Non-indigenous Estuarine and Marine Organisms.

- The Institute of Ecology (Academy of Sciences) carries out ichthyological and ornithological research in the Curonian Lagoon and in the coastal zone of Lithuania.

- The Institute of Botany (Academy of Sciences) studies diatom species diversity and macrophytes of the Lithuanian coastal zone.

- The Fishery Research Laboratory (Ministry of Agriculture) performs fish stock assessment in the Lithuanian economic zone of the Baltic Sea.

Netherlands (Jeanine Olsen)

Beginning in late 1998 and continuing through 2005, a major new marine biodiversity research programme was initiated in The Netherlands.

Funded under the NWO PRIORITEIT programmes (along with the Netherlands Ministry of Agriculture, Nature Management and Fisheries (LNV) and the Ministry of Traffic and Public Works), the programme Sustainable Use and Conservation of Marine Living Resources supports biodiversity research that will provide greater insight into essential ecological processes that occur in the sea in relation to human management and exploitation. As such it links well with the BIOMARE concerted action plan.

The central theme of the Netherlands programme is the identification and subsequent co-ordination of spatial- and temporal-scale mismatch with respect to ecological processes in relation to international law and economic development. Marine living resources are broadly defined to include traditional fisheries but also to include many aspects of marine biodiversity from population to system. As such it links with the international DIVERSITAS Programme (core elements 1-5 and special target areas 7 and 10). Though emphasis is currently on the North Sea rim, an expansion to include several proposed flagship sites would both facilitate the working programme and enhance the overall, long-term results.

The programme consists of four major research themes:

• Analysis of the spatial scales over which populations of marine organisms interact, and the possible mismatch with the scale of human exploitation systems

The focus is on biological studies and the international legal regulation of the sea. The main research subjects are spatial interactions, dispersal and local adaptations of key organisms as determinants of population units. The consequences of spatial fragmentation of the sea both biologically and jurisdictionally need to be reconciled in such a way as to promote rational exploitation.

• Analysis of the temporal scales of development of populations of marine organisms

This theme focuses on biological research and on socio-economic studies. The aim of this theme is to examine the causes of temporal variability of marine living resources in relation to time scales of human exploitation systems and to investigate the economic consequences of the observed ecological time scales for exploitation and conservation.

• Review and analysis of natural and anthropogenic processes that affect marine species diversity

The aim of this theme is to further develop existing models that describe and explain the processes that determine marine species diversity in the light of sustainability. Research topics include the analysis of selected natural mechanisms such as habitat diversity, meta-population dynamics

and disturbance that determine species diversity. Topics also include the effect of introduced marine species on diversity, the effects of the disappearance of top predators and development of indicators for marine species diversity in relation to sustainable resource use.

• Design of better management systems for the exploitation of marine living resources that ensure sustainability

This theme is about integration of biological, legal, and socio-economic sciences within the first three themes and will come into focus about half way through the programme.

The co-ordinating institution is the University of Groningen's Department of Marine Biology. Consortium members include all Netherlands institutions engaged in marine research. These include the Netherlands Institute of Sea Research (NIOZ) on Texel, the Netherlands Insititute of Ecology-CEMO, the University of Amsterdam, the University of Utrecht, the Free University of Amsterdam, the Catholic University of Nijmegan, Rijksherbarium, the University of Leiden and Dutch Fisheries (RIVO).

Norway (Bjorn Gullikson)

For Norwegian waters, the Directorate for Nature Management has on behalf of the Ministry of Environment developed a plan for monitoring biodiversity.

According to the ministry, the outlined monitoring programmes should be in place by 2003. In the marine environment, the plan calls for regular monitoring of soft and hard bottom communities along gradients (north–south and coast–deep water). The monitoring is motivated both by the need to monitor the benthic biodiversity itself, and to use the benthic communities as tools to monitor the biological effects of climatic change, or any human impact on the marine environment such as pollution and fishery activities.

The ongoing monitoring of benthic communities is as follows:

Coastal marine programmes

Since 1990 national programmes have monitored the coast of southern Norway. The same 15-20 soft bottom stations and 10-15 hard bottom stations have been visited annually. In both cases quantitative methods have been used. The hard bottom stations have been studied by diving and standardised photographic techniques.
In northern Norway (since 1976), Spitsbergen and Bear Island (since 1980) a number of hard bottom localities have been studied annually by diving and standardised photographic techniques.

Open ocean programmes

In Norwegian waters, the impacts from oil and gas installations have to be monitored every third year. The monitoring is carried out according to guidelines prepared by Norwegian

authorities and these guidelines have also been adopted by OSPAR. The monitoring is funded by the oil companies and has to be carried out as long there is any activity on the given petroleum fields. The monitoring includes quantitative analyses of soft bottom communities and the concentration of given contaminants in the top sediment. The monitoring was initiated in the 1970s and 1980s and was undertaken regularly and according to well-documented guidelines by beginning of 1990s. Every year 200-400 stations, each of five replicates, are sampled and reported.
The monitoring programme connected to the petroleum installations extends from the southern part of the Norwegian sector in the North Sea and northwards into the Barents Sea.

Poland (Jan Marcin Weslawski)

National report on research in the field of marine biodiversity in 1999

- **Institute of Oceanology, Polish Academy of Sciences, Sopot**

Studies on littoral organisms, soft bottom fauna in glaciated fjords, plankton communities of ice covered and fjord waters in the Arctic. Participation in international BIODAFF project, initiatives in european littoral biodiversity studies. Expertise in higher crustaceans, copepods, polychaetes, molluscs and phytoplankton species.

- **Centre for Marine Biology, Polish Academy of Sciences**

Studies on genetic diversity of Baltic fish and bivalves, microbiology of sandy sediments. Expertise in mitochondrial DNA studies and microbiology.

- **Institute of Oceanography, University of Gdañsk**

Studies on benthos, fish and plankton of coastal Baltic Sea waters. Diversity of common species from the Baltic and Mediterranean on physiological and genetical level. Expertise in ecophysiology, microphytobenthos, cytogenetics.

- **Sea Fisheries Institute, Gdynia**

Studies on soft bottom fauna, plankton and fish of the Polish economic zone of the Baltic Sea. Expertise in fish, bottom fauna and plankton of the Baltic Sea, mesopelagic Myctophidae of the Atlantic.

- **Department of Paleo-oceanography, University of Szczecin**

Studies on recent and fossil diatoms in marine sediments, with special emphasis on the littoral zone world-wide. Participation in local Baltic Sea programmes and global littoral diatom inventories.

- **Laboratory for Polar Biology, University of Lódz**

Studies on plankton and benthos diversity in Admiralty Bay, South Shetland Islands, an area recommended by SCAR as key region for biological studies in the Antarctic. Expertise of the team is in Malacostraca- Crustacea, Echinodermata, Polychaeta, Diatomea. Participation in activities of the Antarctic Marine Biodiversity Centre (Belgium), UNESCO Register of Marine Organisms

Portugal (Ricardo Serrão Santos)

The report included in Warwick, Goni and Heip 1997: pp. 23-24) still offers an adequate overview of the state of marine biodiversity research in Portugal. Some of the main trends that have developed since that report are as follows.

Portugal, including the archipelagos of the Azores and Madeira, comprises one of the larger EEZ of Europe. Marine research focused traditionally on the study of coastal marine benthic communities and fisheries.

Marine biodiversity research evolved from a traditional descriptive approach to incorporate experimental and technological topics, e.g., molecular biology and genetics, ecosystems modelling, eco-toxicology, etc. At the same time strong emphasis has been on the implementation of marine reserves (including Sites of Special Protection for marine birds) and educational issues.

Exploitation of living marine resources, e.g. fisheries, and other activities related with marine life, such as whale watching, saw an upsurge of legislation concerned with the protection and welfare of marine life and the sustainability of marine resources.

Marine biodiversity research continued to be developed under the funding of EU MAST III and LIFE programmes and national PRAXIS XXI. A consistent effort was made to integrate Portuguese research in multidisciplinary projects and to consolidate cross-geographic/cross-institutional directions. The Ministry of Science and Technology went through a complete renovation of its bodies with a consequent impact on the organisation of scientific research in general.

By the end of 1998 the Ministry of Science and Technology had created the Intersectorial Oceanographic Commission, and by the end of 1999 the National Science Foundation opened a special programme for marine research (PMCTM), which includes marine biodiversity.

The ICN (Instituto da Conservação da Natureza), which is in charge of the implementation and co-ordination of research activities within Protected Areas in mainland Portugal, supported several small to medium research projects on marine biodiversity and conservation. Most of the research was developed under contracts with marine research laboratories of several universities.

The marine environment of the Azores archipelago and its surrounding EEZ, of more than 1 million square kilometres, is highly distinct and of considerable marine biodiversity interest – in a large part because of its isolated position in the middle of the north-eastern Atlantic, the recent age of the archipelago, the abrupt relief of the sea bottom and the pristine nature of some of the marine habitats. Marine biodiversity research in the region was mostly undertaken by the University of the Azores and is integrated in large national and European programmes. The university also keeps a close

co-operation with several departments of the regional administration interested in the monitoring, classification and preservation of marine biodiversity.

Madeira, with a strong tradition of natural history studies, saw an upsurge of marine conservation topics with the creation of a set of marine protected areas. It is expected that marine biodiversity research will expand rapidly now that a new marine facility, which connects the Natural History Museum, the University and the Regional Administration, has been inaugurated.

Marine biodiversity research, which was traditionally focused on the study of littoral benthic ecology and estuaries, has clearly expanded covering pelagic and mesopelagic eco-systems, seamounts, shallow and deep-sea hydrothermal vents, etc. and a large range of taxa.

EXPO'98 in Lisbon, the World Exhibition dedicated to the Oceans, was an important forum where many issues concerning the oceans and marine biodiversity were discussed by specialists and disseminated to a wide public.

Russia (Boris Sirenko, Andrei Naumov)

Investigations on the biodiversity of the European (sub)Arctic are carried out at the Zoological Institute St. Petersburg (Berger), the Murmansk Marine Biological Institute (Matishov, Denisenko), the St. Petersburg State University and the Moscow State University (Novikov).

Members of the above institutes have produced a multivolume work on *Illustrated keys for identification of free-living invertebrates of Eurasian Arctic seas from Barents up to Chukchi Seas*. Beside 30 taxonomists of the Zoological Institute, 25 specialists from other institutes are involved in this work. The base for the *Illustrated Keys* is material collected in Arctic seas over 200 years and kept in the Zoological Institute. Overall, the *Illustrated Keys* show that there are 3 700 free-living species of invertebrates in the Eurasian Arctic. New keys should show our present knowledge of the Arctic fauna and will include all species which we came across in the studied areas. The *Illustrated Keys* will be published on paper in Russian and English separately and on CD-rom. The editor of *Illustrated Keys* is B. Sirenko.

The structure of *Illustrated Keys* is :

- short common characteristics of groups of animals;
- keys;
- short information on size, zoogeography characteristics, horizontal and vertical distribution and very short data on the ecology of each species;
- drawings;
- main references.

The first step of this programme is 'A check list of free-living invertebrates of Eurasian Seas of Arctic' which will be ready in October 1999.

The present work of the Zoological Institute in the (sub)Arctic area includes:

• The biodiversity of the White Sea benthos.
This activity includes the inventory of fauna and flora of the sea floor from the intertidal area to the maximum depth of the sea. These investigations are carried out by quantitative methods in parallel with hydrological observations. The spatial pattern of bottom communities, the abundance of benthic organisms and community structure are studied as well. The data on the biodiversity of 816 stations are included in a database.

• Monitoring of zooplankton at standard points in Chupa Bay (White Sea).
About 40 years of quantitative sampling to a depth of 70 m every ten days during the shipping season, and every month when the sea is covered with ice. Simultaneously hydrological observations are made.

• Monitoring of intertidal communities of the sandy and muddy intertidal zone in Chupa Bay (White Sea).
Since 1987 quantitative samples of macro zoo- and phytobentos are taken four times a year in March, May, August and October at four levels from the low to middle intertidal zone. The long-term and seasonal dynamics of the intertidal species abundance are studied.

• Monitoring of benthos and zooplankton species near an oil terminal in the White Sea (Kandalaksha region).
During the last five years quantitative sampling once a year from the intertidal to a depth of 20 m is carried out, together with hydrological observations and oil pollution measurements. Both polluted and pristine sites are included in this work.

Recently, a database including the number, biomass and species diversity of phyto-, zooplankton and zoobenthos of the Gulf of Finland has been made (covering the period from 1974 to 1989) (Vadim Panov, Zoological Institute RAS, St.Petersburg / Valentina Galtsova, Zoological Institute, St.Petersburg).

The Gulf of Finland is one of the most polluted parts of the Baltic Sea and has become increasingly important for the protection of the Baltic Sea. The main problem in the Gulf is eutrophication, due to the high nutrient load discharged mainly into its eastern part. The Gulf of Finland is a vital part of the Baltic Sea and the decisions made there are relevant to the Baltic proper. The pollution discharge into the Baltic Sea has to be reduced urgently. Hydrobiological observations of the eastern Gulf of Finland are the important part of the Baltic Floating University (BFU) programme. During the BFU cruises in the summers of 1993-98 the phytoplankton, zooplankton and macro- and meiobenthos were sampled and observed at a series of oceanographic stations in the Luzhskaya and Koporskaya area and in the waters surrounding some of the islands in the eastern Gulf of Finland. The period of BFU cruises is connected with the maximum species diversity of the zooplankton and its maximum population density. For the near-island benthic zone around small islands a general impression of the bottom

landscape has been obtained. The bottom biocoenosis around these islands may be described as having a belt-like form following the nature and character of the substrates. Meiobenthos was studied for the first time in the Gulf of Finland. The dominant group of the meiobenthos (freeliving marine nematodes) is of great taxonomic interest.

The problem of alien species invasions has been recently recognised by the Baltic scientific community. In the Baltic Sea region the association of Baltic Marine Biologists established a Working Group on Non-Indigenous Estuarine and Marine Organisms (BMB WG 30 NEMO) in 1994 (see Internet Page *http://www.ku.lt/nemo/mainnemo.htm*). The Gulf of Finland can be considered as a hot-spot in the Baltic Sea area with a high rate of alien species. Preliminary studies carried out within the Russian State Programme on Biodiversity (*http://www.zin.ru/projects/invasions/*) and the Nordic Council of Ministers' Project Risk Assessment for Alien Species in the Nordic Area showed a high level of invasibility of the Gulf of Finland.

Spain (Carlos Duarte)

The first inventory (Warwick, Goni and Heip 1997) still contains an adequate overview of the activities ongoing within Spanish national waters.

No specific national programme on marine (or general) biodiversity were started, and there are no plans to initiate dedicated national programmes in Spain in the next five years. However, major actions for large-scale biodiversity projects are being planned and are about to be implemented. The Spanish Government has decided to allocate about 60 million Euros to fund a project, ARAUCARIA, dedicated to the study of biodiversity in Hispano-America. The programme will contain components of marine biodiversity in Mexico, Panama, and Venezuela. In addition, a smaller project (1.5 million Euros), but focused on marine biodiversity, is in the planning phase for the Philippine waters, one of the areas of highest marine biodiversity in the ocean. These actions will be funded by the Ministry of Foreign Affairs and the Ministry of Environment.

Sweden (Björn Ganning)

Since the compilation of the European marine biodiversity activities made in Plymouth 1996, the Swedish approach has been to carry on with minor research projects and with marine monitoring, mainly financed by the Swedish Environmental Protection Agency.

The latter is carried out by Swedish universities, the Museum of Natural History in Stockholm, the Fisheries Board of Sweden and the Swedish Meteorological and Hydrological Institute. The monitoring programme has run for between 5 and 25 years in different areas and environments. Measurements are made between 1 and 25 times per year. Included are nutrients (since 1976), plankton algae (since 1976), macrofauna benthos

(since 1994), vegetated bottoms (since 1993), coastal fish populations (since 1989), populations of top consumers, seals and white tailed eagles (since 1989), and metals and organic toxicants in top consumers (since 1979). Results are available shortly after collection via the Internet from database hosts.

In 1996 the Government of Sweden adopted an action plan on biodiversity containing goals for defining environmental criteria for marine ecosystems. In 1997 Objectives and Measures for the Conservation of Biodiversity in the Swedish Marine Environment were published (Swedish Environmental Protection Agency, Report 4599, 134 pp, in Swedish with English summary). It states that Sweden has an international as well as a national responsibility for marine biodiversity, both in the Baltic Sea and in large parts of the Kattegat and the Skagerak. The major threats at present are eutrophication, toxic pollutants, overexploitation of resources (fishing, aquaculture, shipping, construction, and extraction of mineral resources). Also the spread of alien species and climate change may have serious consequences in the future.

Environmental quality objectives are given as well as load objectives and action objectives and measures are proposed for protection and maintenance of ecosystems, species and genetic variation. The action plan includes research proposals on the population/genetic level, species level, plant and animal community/habitat level, landscape level and as multidisciplinary research.
In 1999 the Nordic Council of Ministers requested an outline for a Nordic Environmental Research Programme on Nordic and Baltic Sea Coastal Environments. The aim of the programme is to discover results, which can be used to evaluate the environmental status and to establish quality goals for biodiversity and sustainable use of different coastal areas in the Nordic countries and in the Baltic region. The three main research topics are on biodiversity, protection and user conflicts in the coastal zone; competing interests and activities in the coastal zone; and environmental status and valuation of the coastal zone in a longer perspective. The financing of the programme of 1.5 - 2 million USD per year is planned to be based on national, Nordic and EU support and the intentions are also to involve Baltic Republics and Polish scientists to start in the year 2000.

Of the biodiversity-related research projects described in the 1996 inventory the majority are still running and very few have been added. Most of these projects are nationally funded and each involves only one or a few scientists. Swedish EPA funding has stopped due to lack of government support but most of the projects have found other sources. This has reduced the possibilities of starting new small, individual research projects. A pilot study on the impact of commercial fishing on Baltic Sea fish biodiversity has been carried out financed by the Nordic Council of Ministers.

Ukraine (Nataliya Milchakova)

The extensive surveys on biodiversity of the Institute of Biology of the Southern Seas, (Sevastopol, Crimea, Ukraine) include :

- comparative inventories of bottom vegetation in the Black Sea;
- long-term monitoring (15-35 years) of populations;
- biodiversity and taxonomic composition of macrophytes and seagrass of the Black Sea.

The data are stored in a computer database (Access98; Herbarium of the macrophytes of the World Ocean). The studies were conducted in the five largest bays and gulfs (1964-98) of the Black Sea. The results highlight changes in the main seaweed belts and seagrass communities of the Black Sea growing in waters which differ in eutrophication and diversity.

Community and population structure changed most dramatically at 10-15 m depth where perennial species have been replaced by species with a short life cycle. Stabilisation and restoration do occur in coastal Cystoseira populations but in deep water Phyllophora communities these processes were not found. Seagrass restoration develops when silting decreases and water transparency increases. It is suggested that *Cystoseira* and *Zostera* subsp. are more environmentally flexible and better adapted to anthropogenic impacts than *Phyllophora* subsp.

United Kingdom (Richard Warwick)

Since the publication of the inventory of European marine biodiversity research activities, a major new research programme has been initiated by the NERC Centre for Coastal and Marine Sciences (CCMS) in Plymouth (England) and Oban (Scotland). This proposal addresses three challenging questions:

- How many species are there (i.e. what characterises species-area-distance relationships in the marine environment), how are these species apportioned taxonomically and functionally, and how are Man's activities affecting biodiversity?

The CCMS is developing methods of defining and measuring biodiversity at various spatial and temporal scales with a view to detecting change, focusing on: (1) new and valid statistical techniques for estimating species richness within a region, and (2) defining indices which incorporate other important biodiversity features. To calibrate rapid assessment techniques using 'surrogacy' methods they are establishing an All-Taxon Biodiversity Inventory (ATBI) for a pristine location, and using the rapid assessment methods they will evaluate loss of biodiversity in degraded locations. Taxonomic underpinning of this work involves the production of user-friendly keys and computerised methods that can be used by non-specialists, and also the development of novel methodologies such as molecular probes and genetic techniques. Important products delivered here will

be data compilations and generic software for biodiversity studies.

• What are the main processes that determine and maintain biodiversity at different spatial and temporal scales?

Experimental studies in the field and in laboratory mesocosms and microcosms are being conducted on (1) ecological processes acting at the level of individual species over small spatial and temporal scales, e.g. choice of location and survival, and (2) emergent community characteristics which are more than just the cumulative properties of the component species, e.g. experiments on the relatively small-scale effects of both natural and anthropogenic disturbances, exploring hypotheses linked to dynamic equilibrium models of biodiversity maintenance. Such studies will allow the comparison of predictions arising from the community level approach with those generated by the consideration of the individual species involved.

• What are the ecological consequences of biodiversity change?

The CCMS is investigating how genetic diversity within species may confer adaptive consequences for animal performance, including how environmental factors interact with genotype and protein metabolism to affect growth performance, stress tolerance, population dynamics and species distribution, particularly in bivalve molluscs. Many marine organisms play crucial roles in biogeochemical transformations that influence blooms of phytoplankton and macroalgae, benthic-pelagic fluxes, mineralisation of organic matter etc. The CCMS is conducting experiments to determine the extent to which the number of species within the same broad functional group can be reduced before those transformations are impaired in terms of either rate or efficiency, and also on the relationship between the diversity of available prey species and predator performance.

EC research on marine biodiversity (Paloma Martin)

During recent years marine biodiversity has been a research priority for the European Commission. Thus, in the previous Fourth Framework Programme for Research (1994-1998), the Marine Science and Technology Programme MAST- III included 'Studies on marine biodiversity as a basis for understanding ecosystem structure, dynamics and resilience'.

In the Fifth Framework Programme (FP5) (1998-2002), research on marine biodiversity is addressed mainly in the programme Energy, Environment and Sustainable Development, with its Key Actions on Global Change, Climate and Biodiversity and Sustainable Marine Ecosystems

Information on MAST-III projects is available under:
http://europa.eu.int/comm/dg12/marine/mast3-pr.html

Information on FP5 new projects is available through the home page of the Energy, Environment and Sustainable Development Programme.
http://www.cordis.lu/fp5/home.html

Running EU projects

- Biodiversity and genetics of algal populations (BIOGAP);
- MIcrobial Diversity in Aquatic Systems (MIDAS);
- Molecular Ecology of the *Procaryote prochlorococcus*, a Key Organism of Oceanic Ecosystems (PROMOLEC);
- Integrating environmental and population variations: a model for biodiversity studies (AMBIOS);
- Interactions of physical and biological factors in the surf and swash zone of European rocky shores (EUROROCK);
- European Marine Species Register, etc.

Information on these projects is available under :

http://europa.eu.int/comm/dg12/marine/mast3-a1.html

http://europa.eu.int/comm/dg12/marine/mast3-a2.html

http://europa.eu.int/comm/dg12/marine/mast3-d1.html

Appendix 3: The LabNet initiative of NAML in the USA (Ken Tenore)

In the United States the National Association of Marine Laboratories (NAML), an organisation of marine laboratories is implementing the LabNet initiative. LabNet seeks to network and integrate targeted data sets from local monitoring programmes at coastal laboratories to provide information necessary to answer research, management, and educational outreach needs at a variety of system, regional, and national spatial and temporal scales of interest.

NAML, similar to the European MARS, is an association of over 110 marine laboratories spread across the diverse mosaic of habitats across all the coasts (including the Great Lakes) of the United States. NAML seeks to: (1) encourage and support the recognition of the unique roles of coastal laboratories in competent environmental research, academic and outreach education, and public service; (2) promote efficient information exchange, constructive co-operation, and productive co-ordinated effort among member institutions; and (3) provide a contact and forum for efficient utilisation of expertise between member institutions and state and federal government environmental agencies. NAML recognises that the whole is greater than the sum of its parts and has targeted infrastructure, programmatic, and resource sharing as a way to enhance contributing to the national marine agenda in environmental monitoring, research, and education.

At a national workshop in Sarasota, Florida representatives of a cross-section of stakeholders in the marine research community outlined the potential roles that marine laboratories could contribute to the national agenda in the marine sciences. As a result of that workshop LabNet is a major initiative undertaken by NAML in collaboration with federal agency partners (NOAA, EPA, NSF, NASA) that supports all three objectives listed above. LabNet is envisaged as an integrated and interactive network displaying selected environmental databases from participating coastal laboratories. The purpose of LabNet is to go beyond a simple indexing of data into an environment where data collected and residing at separate coastal laboratories can be integrated and exchanged in a nearly seamless visualisation and analytic environment. Technologies such as the Word Wide Web are necessary but not sufficient to make such data integration possible. LabNet seeks to provide the additional infrastructure needed to support such integration.

Most coastal laboratories emphasise studies of organisms and environmental systems in the laboratory's immediate locale; data sets at a coastal laboratory are therefore typically confined to a small geographic region. However, by collating and integrating the data sets collected independently by separate groups we are able to address scientific, management, and educational outreach questions at broader spatial and temporal scales.

The formal conceptual and technological design and implementation steps for LabNet stem from a 1997 workshop in Charleston,

South Carolina, that brought together representatives of key federal and state agencies, the scientific/education community, and systems engineers/ computer experts with networking experience. That workshop: (1) explored issues such as data quality control/assurance, data proprietary use, etc. for which protocols would have to be introduced; (2) evaluated and identified web-based technologies that could serve as the technological infrastructure for LabNet; and (3) developed the scope and format for a survey to identify the technological capabilities and environmental data sets available at the coastal labs to support a viable and germane LabNet. The results from the survey were used to identify several environmental data sets to use as pilot projects to test the LabNet infrastructure. These pilot projects are now being tested and will be reported on later in 1999 at a final workshop inaugurating LabNet as a service for those interested in funding projects to provide availability of data information sets, whether historical, or real time, to the general community.

More information on LabNet is available on the web page for NAML, *http://NAML.mbl.edu*