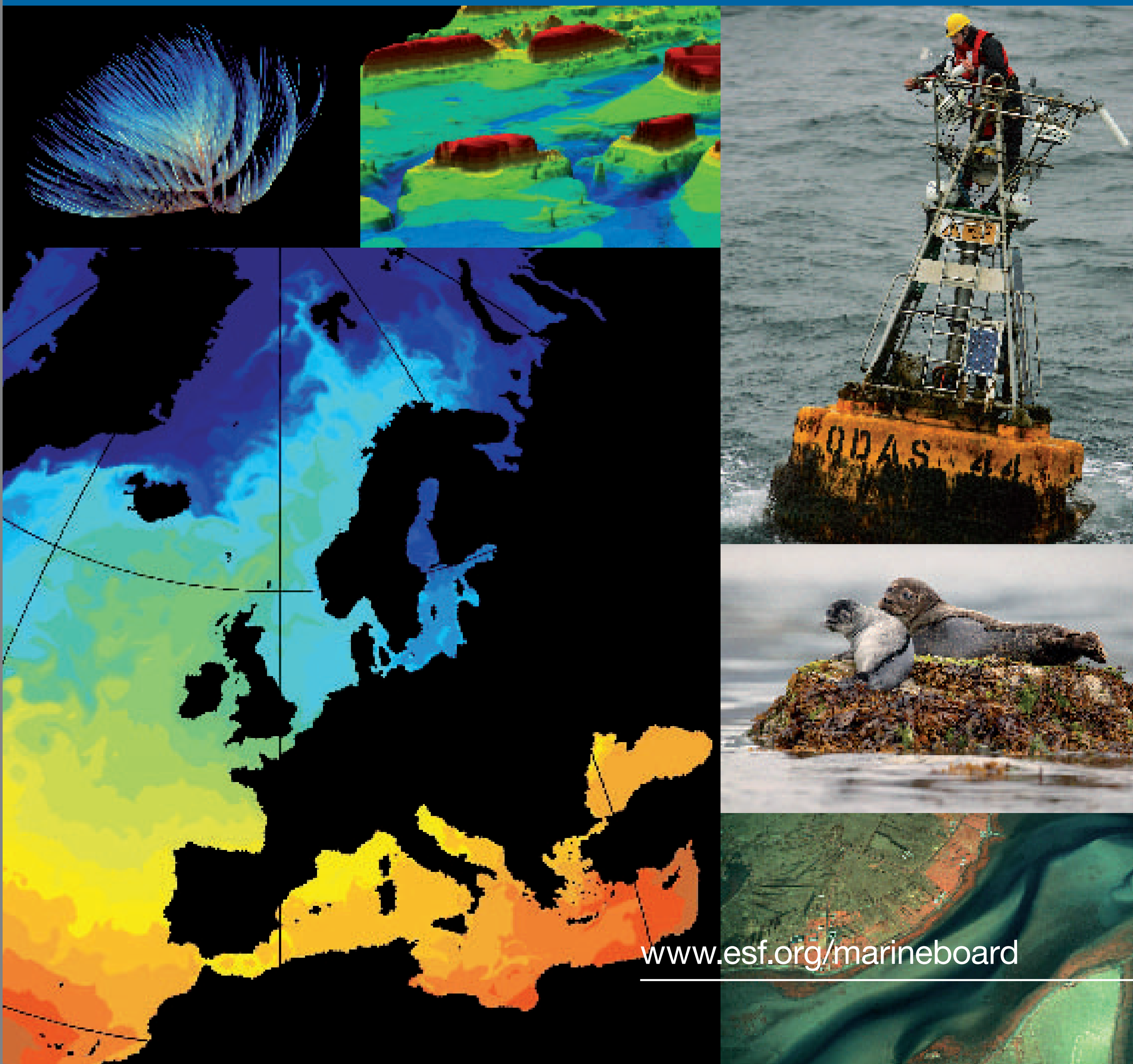
EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

MARINE BOARD

Position Paper 8

Navigating the Future - III

November 2006



www.esf.org/marineboard

Marine Board - ESF

Building on developments resultant from the 1990s *European Grand Challenges in Marine Research* initiative, the Marine Board was established by its Member Organisations in 1995, operating within the European Science Foundation (ESF). The Marine Board's membership is composed of major national marine scientific institutes and/or funding agencies. At present, 17 countries are represented by one or two agencies or institutes per country, giving a total membership of 25.

The Marine Board operates via an Executive Committee, consisting of one Chairperson and four Vice-Chairpersons. The Marine Board also confers permanent observer status to the European Commission Directorate General for Research and the Directorate General for Fisheries and Maritime Affairs.

In developing its objectives, the Marine Board focuses its activities around **four main approaches**:
Forum: bringing together member organisations to share information, to identify common problems and, where appropriate, find solutions, develop common positions, and cooperate on scientific issues.
Strategy: identifying and prioritising emergent disciplinary and interdisciplinary marine scientific issues of strategic European importance, initiating analysis and studies in order to contribute towards a European strategy for marine research.
Voice: expressing a collective vision of the future for European marine science in relation to developments in Europe and world-wide, and improving the public understanding of science.
Synergy: fostering European added value to component national programmes, facilitating access and shared use of national marine research facilities, and promoting synergy with international programmes and organisations.

To date, the principal achievements of the Marine Board have been to:
- facilitate the development of *marine science strategies*;
- improve *access to infrastructure* and the shared use of equipment;
- advise on strategic and scientific policy issues relating to marine science and technology at the European level (e.g. Sixth and Seventh Framework Programme, Green Paper on the future European Maritime Policy, Marine Environment Strategy, European Strategy Forum on Research Infrastructures);
- publish strategic *position papers on key topics* addressing: Marine Biodiversity, Marine Biotechnology, Hydrodynamic Modelling in Coastal and Shelf seas, Integrating Marine Science in Europe etc.;
- provide strategic and operational management of MarinERA (an EU ERA-NET project, ERAC-CT-2004-515871, coordinated by Ifremer- Institut Français de Recherche pour l'Exploitation de la Mer) which aims at facilitating the coordination of national and regional marine RDT programmes in Europe.

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Navigating the Future - III

Updated Synthesis of Perspectives on Marine Science and Technology in Europe

Editors: Jean-François Minster,
Niamh Connolly

Other editors (in alphabetical order):
Aurélien Carbonnière, Jan de Leeuw,
Maud Evrard, Jan Mees, Kostas Nittis,
Geoffrey O'Sullivan, Nicolas Walter.

"Ocean science will have to become more holistic, more interdisciplinary and more international. If we are to adequately address ocean issues at the local, national, regional and global levels, science cannot operate in isolation but will need to integrate more fully a response from society at large. There must also be changes in the way we regulate marine activities, in our social goals and our attitudes to ocean governance. If we are to make the right decisions, however, we must understand how things 'work' in the oceans and how they interact; and we must recognise the role of the oceans in our life-support system and its value for humankind. This will require excellent science, together with the technology for pursuing it, as well as the support of individuals and governments. Ultimately, it calls for a vision of the planet that embraces land, sea, the atmosphere and human societies in all their interactions."

The Ocean, Our Future
Report of the Independent World Commission
of the Oceans (1998)

Acknowledgements

Navigating the Future III is an updated and revised summary of the perspectives on marine science and technology in Europe. Sincere thanks are expressed to DG Research of the European Commission for its encouragement to the Marine Board – ESF to produce a revision of the Marine Board – ESF position paper Integrating Marine Science in Europe, (MB-ESF 2002), incorporating new issues and ideas, and synthesising many recent individual, national and European strategic contributions to marine science and technology.

Acknowledgement is especially due to all scientists and experts who have been involved in the preparation and validation process of this report.

The skills and perseverance of the Secretariat of the Marine Board – ESF were essential during all stages of the preparation and publication of this report and are gratefully acknowledged.

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Foreword

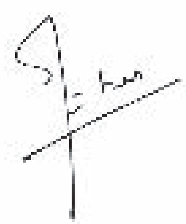
The oceans are of major strategic importance to the economic and social development of Europe. Marine research is a complex domain, requiring large investment in resources, including securing competent human resources, vast observational data, complex numerical models and supercomputers, all of which can best be mobilised by joint efforts. Addressing topics ranging from climate studies to biodiversity, marine research is intrinsically an international activity with opportunities for countries from throughout Europe to cooperate, addressing environmental problems of pan-European relevance and significance. Complementary research should be coordinated to achieve optimal results towards enhanced information and knowledge of the oceans and their environments, a key research output. The European marine research community is increasingly aware of its responsibility to develop a cohesive vision and strategy for marine research, while recognising their parallel responsibility to support the development of policy based on sound scientific advice. To contribute to these objectives, representatives of the marine research community have come together to synthesise a comprehensive perspective on marine science and technology, presented here as *Navigating the Future III*.

In this report, the reader is asked to bear in mind some major spatial-temporal trends, opportunities and challenges for scientific progress in the years to come. In summary, the Marine Board-ESF has identified these as:

- ***Climate change and the oceans***
  - towards enhanced detection and assessment of impacts of climate change on the oceans, particularly on ocean ecosystems;
- ***Continental margins***
  - including specific issues on sediment instabilities, gas hydrate behaviour, deep-sea ecosystems, and the necessity to further develop and implement deep-sea observatories;
- ***Marine biodiversity***
  - its functional role, evolution, protection and exploitation, the latter including biotechnology and bioprospecting;
- ***Coastal ecosystems***
  - specific perspectives concerning toxic algae, viruses, and the ecotoxicological and health impacts of pollutants;
  - development of coastal and marine spatial planning initiatives;
- ***Ecosystem approach to resource management***
  - inclusive of the ocean and its intrinsic resources (including renewable energy), as required by fisheries, aquaculture, harbour development, and addressed in coastal zone management and marine spatial planning;
- ***Operational oceanography***
  - within the framework of GMES (Global Monitoring for Environment and Security), as a major tool for seasonal climate prediction, risk assessment, prediction of coastal algal blooms and impacts of pollution incidents, and support to maritime security;
  - real-time access and exchange of *in situ* data from various observing platforms;
- ***Marine technology***
  - through the development of *in situ* observing systems, of software for data processing and numerical modelling, as well as material and systems for maritime activities, and technology transfer between disciplines;
- ***Marine infrastructures***
  - towards innovating systems and an enhanced use of resources.

As its outgoing Chairman, I welcome the role of the Marine Board-ESF in developing this consultation report, in succession to *Integrating Marine Science in Europe* (IMSE, 2002) and *Navigating the Future II* (2003). Through *Navigating the Future III*, the Marine Board-ESF has endeavoured to harness the European marine research knowledge base and document its support in the management and protection of marine resources.

I hope that Navigating the Future III will be considered as a valuable and pivotal contribution towards strengthening and developing coordination, cooperation and networks in marine science, fostering openness towards a more integrated approach, thus catalysing the advancement of marine research in Europe.



Jean-François Minster, Autumn 2006
Chairman, Marine Board-ESF, 2002-2006

Boxes

To position the points elaborated in *Navigating the Future III* within the European and global context, several reference boxes have been included in the text. These boxes summarise the key points of major initiatives which variously contribute to the progress of marine science and technology, including those which address: (i) European and global policies; (ii) research programmes and projects; and (iii) infrastructure initiatives.

Boxes are colour-coded as follows:

Green - policy and management initiatives

Blue - research initiatives

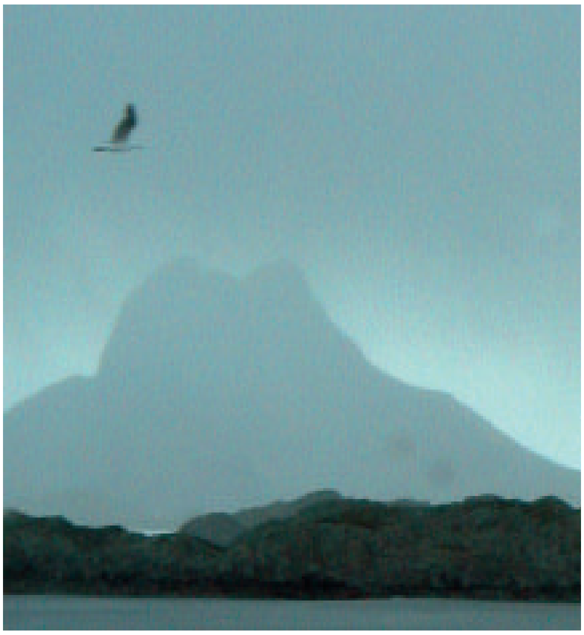
Yellow - technology and infrastructure initiatives

Introduction

The recent publication *Maritime Facts & Figures* (European Commission, 2005) succinctly summarises and draws attention to the importance of the European maritime economy. It notes for example that the seas and oceans cover over 70% of the Earth's surface, and represent over 50% of the territory of the European Union (EU). By virtue of the European Union's Member States' 200-mile economic zones and extended continental shelves, the waters under European jurisdiction (including four seas and two oceans) stretch from the Arctic through the North Sea, Baltic, Atlantic, Mediterranean and the Black Sea. European jurisdiction also includes the waters surrounding Europe's ultra-peripheral regions. This marine world is still relatively unexplored and its resource potential has yet to be realised. The landmass of the European Union has a coastline of 68,000 km, equivalent to seven times that of the USA and four times that of Russia. Twenty of the European Union's 25 Member States have maritime coasts, and the capitals of eight Member States are located on (or within the tidal range of) the coast. Almost half of the European Union's population lives within 50 km of the coast (while 80% of the Norwegian population live in the coastal area). Over the past 50 years, the European population living by the sea has more than doubled, reaching 70 million people. As a result of this close association between European citizens and their seas, our coastal seas are heavily impacted by anthropogenic developments, with potential for increasing conflicts between competing users.

The European seas and oceans are clearly of major strategic importance to the economic and social development of Europe, as well as to its defence and security. European maritime regions account for 40% of Europe's Gross Domestic Product (GDP) and maritime related activities provide direct employment to an estimated 3.5 million citizens.

The oceans play a range of essential roles for Europe, including providing energy resources, and the backdrop for maritime transport, and recreation. The oceans are hosts to living resources including those exploited for fishing, aquaculture, genetic resources, etc. There is more energy in the top five metres of the ocean than in the entire atmosphere, while the ocean's volume represents 97% of the biosphere on Earth. The oceans (as the habitat of more than 90% of known species) contain the highest biological diversity on Earth; marine organisms live throughout the water column, to an extreme depth of up to 11 km, and in ocean sediments up to a further 400 m below the seafloor. The oceans generate 70% of the Earth's oxygen, while at the same time inadvertently provide the greatest dumping area for anthropogenic pollution. The oceans are also a fundamental component of planet Earth's systems, particularly in their role in Europe's climate system, being both a major driver and an indicator of global climate change. The impact of the role of the oceans in climate regulation ranges beyond the coastal regions, influencing continental landmasses. The ocean circulation in the North Atlantic plays a key role in regulating the temperate climate of Western Europe.



Norwegian coast

The marine environment thus represents a vast reserve of unexplored natural resources, and offers possibilities that can be considered towards supporting European economic development. The accurate quantification and economic valuation of these ocean resources is required, so that trends can be identified, and appropriate sustainable development policies developed.

The ocean by its nature is challenging and provides the inspiration for curiosity driven research. Furthermore, as a research arena, the ocean is special in two distinct ways: it is costly to access, and highly variable and unpredictable. Because of the ocean's complexity and profound influence on our daily lives, marine research and technology should be addressed in a consistent, holistic and coherent way. At the same time, new discoveries are made at an increasing pace in marine research; they cannot be anticipated, yet many of them will undoubtedly lead to new avenues in the future development of Europe. Accordingly, European citizens (whether politicians, researchers, research administrators, or members of the general public) should adopt long-term perspectives when planning and prioritising marine research and development activities. The

Introduction

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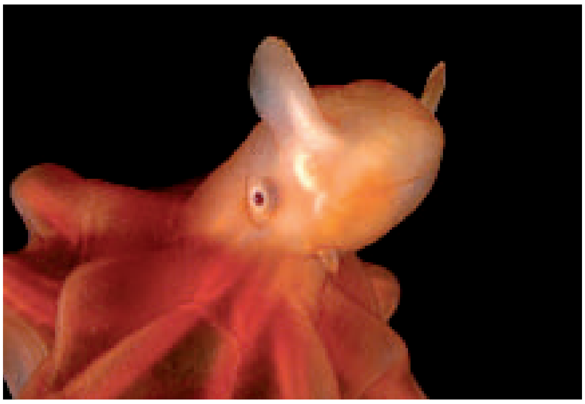

Dumbo octopus, deep-sea species

European Union has a special responsibility in this respect, as it has the organisation and resources to unite European marine research and technology, ensuring a more cohesive uptake and impact of results. Marine research and technology is an even more important tool in achieving the European economic and societal goals as expressed in the Lisbon Agenda (Box 1). Thus, as declared at the EurOCEAN 2004 Conference (an Irish – EU Presidency event in Galway; May 2004; Box 2), Europe can achieve the vision of "*a thriving maritime economy in harmony with the environment supported by excellence in the European Research Area*".

The European Union is developing a maritime policy (Green Paper on the Future European Maritime Policy; Box 3), in which science and technology are considered to be of strategic importance to the development of the European economy. In referring to the Green Paper initiative, Commissioner for Fisheries and Maritime Affairs, J. Borg, has stated that "*Without scientific advice, our common policy – simply put – would just not work.*" (European Parliament, October 2005). The marine research community, recognising the need to focus on supporting improved decision-making through effective integration of information into the policy-making process, is prepared to actively contribute to the debate, given direction, support and resources. Europe should aim to become one of the leading marine and maritime actors in the world, thus serving regional, European and global knowledge needs. Nurturing an informed approach to policy development will ultimately support sustainable development of the marine resource base. This will safeguard the ecosystems which themselves regulate the resource base on which marine-related economic and social activities, and planet Earth, depend.

In considering the marine research agenda for the years to come it is useful to consider the sea as:

- ***An economic area*****:** providing backdrop for energy resources, transport, leisure and a wealth of mineral and bio-resources (fisheries, aquaculture, bio-active compounds of medical, industrial and nutraceutical importance; market and non-market value goods and services) and a challenge and opportunity for industry;
- ***A unique challenge for basic research***: many issues and discoveries remain in the domain of basic science;
- ***A challenge for innovative technologies:*** including opportunities to adapt equipment and instruments that are developed elsewhere towards their use in the marine environment and vice and versa;
- ***A social and cultural space*****:** representing a highway and interface between national boundaries, providing both a regional context, and a natural heritage to be understood, appreciated and protected.

When considering future planning, three major strategic drivers are identified as the cornerstones for facilitating the integration of marine science and technology in Europe:

1. Major fundamental discoveries are continually being made in all aspects of the ocean system. Better understanding of Earth ecosystem functions, physico-chemical interactions, and biological evolution will largely result from basic ocean research;
2. Measuring, monitoring, understanding and being able to predict the mechanisms of ocean-atmosphere feedbacks in climate change and their impacts on the larger ocean environment are critical to the effective management of ocean and coastal seas;
3. The management of maritime activities and sustainable exploitation of natural resources in European seas will be best achieved by adopting a knowledge-based approach.

To best address these three major drivers, basic research in many overlapping disciplines is needed. The scales of investment necessary, including in human

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James Cook research vessel docked at NOCS Southampton quay resources and infrastructure, are such that trans-national cooperation will be crucial to ensure progress. Perspectives and efforts in marine science and technology cannot be presented in a simple way. There are opportunities for close interdisciplinary relations between most scientific developments and issues, as technologies open perspectives simultaneously in many subjects, and as infrastructures are necessarily multipurpose. Cross-references between thematic subjects are thus inevitable, beneficial and necessary. Collective synthesis of results of collaborative research will result in sets of significant scientific and technical advancements on several targeted fronts, as well as a series of multi-disciplinary reports that advance the state of the art for different regions of Europe.

In 2000-2001, the Marine Board-ESF convened a series of workshops and specialist groups to identify scientifically challenging and socio-economically important research themes in marine science and technology. During this consultation process, two reports were produced: *Towards a European Marine Research Area* (December 2000), and *Navigating the Future* (February 2001), both serving as contributions to the preparation of the European Union's Sixth Framework Programme (FP6; 2002-2006). The Marine Board-ESF then elaborated a Position Paper entitled *Integrating Marine Science in Europe* (*IMSE*, Marine Board-ESF, 2002). This Position Paper provided a summary of a Europe-wide reflection on marine science and technology, and detailed specific research actions considered to be of fundamental importance, as identified by this multifaceted consultation process. Derived from *IMSE*, a revised summary of priorities, *Navigating the Future II,* was published in 2003 and was widely distributed and consulted in the preparation of national research funding programmes.

More recently, in preparation for the Seventh Framework Programme (2007 – 2013), the EurOCEAN 2004 Conference (Galway, Ireland) was organised by the European Commission, the Marine Institute (Ireland) and the Marine Board-ESF. This Conference issued recommendations for future marine research in the European Research Area (ERA) in the form of the eight-page *Galway Declaration*. The *Galway Declaration* (summarised in Box 2) emphasises the roles of the European Commission and Member States in recognising the function that the ocean plays in regulating the Earth's ecosystems, the major contribution of maritime industries to economic development and the relevance of marine science and technology in generating the knowledge needed to fuel sustainable socio-economic development.

Many other views, including those from the research community, contribute to our knowledge of marine resources and the scientific and technological challenges and opportunities ahead. Views of particular relevance include those arising from initiatives supported by the European Commission's Framework Programme instruments including: Technology Platforms, ERA-NETs, Networks of Excellence (NoEs), and from organisations such as ICES (International Council for the Exploration of the Sea), CIESM (Conseil International pour l'Exploration Scientifique de la Méditerranée), EFARO (European Fishery and Aquaculture Research Organisations network), EuroCoML (the regional Census of Marine Life in Europe) and EuroGOOS (European Global Ocean Observing Systems). European strategies for the marine environment, fisheries policies and maritime security issues, as well as GMES (Global Monitoring for Environment and Security) have been elaborated. Furthermore, national marine research strategies have been prepared and issued in many countries including France, Germany, Greece, Ireland, the Netherlands, Norway, Poland, Portugal, Sweden and the UK.

Dr. Jean-Francois Minster, Mr. Pierre Mathy, Minister Dermot Ahern (Minister for Communications, Marine & Natural Resources) and Dr. Peter Heffernan (Marine Institute) pictured during the agreement of "The Galway Declaration." (May 2004)

Following the European Commission's recommendation for the need to synthesise the range of views on priorities and challenges in future marine research, the Marine Board-ESF decided to develop an updated and revised summary of various consultations and inputs. The result is presented here as *Navigating the Future III*.

In this context, *Navigating the Future III* profiles the status of, and priorities in, marine research to stakeholders including those representing:

- **Marine research teams** in Europe, detailing a synopsis of research themes that will assist them in integrating their expertise and contribute to new collaborations;
- **National institutes and funding agencies**, to facilitate optimal development of their programmes and to enhance coordination at the pan-European level;

- **Policy makers and the society**, synthesising research output into information, to support the knowledge base required for the development of sound policies.

As with previous Marine Board-ESF publications, *Navigating the Future III* is not presented to be prescriptive or definitive; rather it is intended to inform, contribute to debate and raise awareness on marine research and technology issues. It will be widely distributed among the marine scientific community in Europe and beyond, and among policy makers and other stakeholders. In so doing, the Marine Board-ESF continues to act as a facilitator for marine research, supporting synergy, developing capacities and capabilities, promoting integration between initiatives and catalysing approaches to research management and funding structures in Europe.

The scientific, infrastructural and strategic recommendations outlined in Navigating the Future III are organised into seven chapters:

1. European and societal dimensions
2. Natural marine resources and maritime transport
3. Europe's coastal zones, shelf seas, continental margins and biodiversity
4. Ocean climate interactions and feedback
5. New frontiers in marine science
6. Critical technologies
7. Research infrastructures

Box 1: The Lisbon Agenda

European Union Strategy

The Lisbon strategy to make the European Union (EU) "***the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment by 2010***" was adopted by the European Council of Ministers in 2000. The mid-term review of the Lisbon process (Kok report, November 2004) recommended refocusing the agenda on growth and employment.

http://europa.eu.int/growthandjobs/index_en.htm

Box 2: EurOCEAN 2004: The Galway Declaration

An Irish-EU Presidency Event

In May 2004, over 500 marine scientists, policy-makers and representatives of the marine industry sector gathered in Galway, Ireland, at the EurOCEAN 2004 Conference. The event aimed to determine how marine science and technology could contribute to the achievement of objectives as stated in the Lisbon, Gothenburg and Barcelona Declarations.
The Galway Declaration is the principal output of the EurOCEAN 2004 Conference; it states that the marine science community will work collectively to ensure that *recognition is taken at Member State and European Union level of:*

- *The crucial role of the oceans in climate, carbon cycle and life on Earth;*
- *The major contribution maritime industries can make to the achievement of the objectives outlined in the Lisbon Agenda;*
- *The essential role of marine science and technology in generating the knowledge needed to fuel this economic achievement in harmony with the environment;*
- *The critical role the European Research Area / Seventh Framework Programme must play in supporting world class excellence in marine science and technology.*

http://www.eurocean2004.com

Box 3: European Maritime Policy "Towards a future Maritime Policy for the European Union"

European Commission Green paper

In March 2005, the European Commission initiated work on a Green Paper to develop an all embracing maritime policy (including maritime transport, fishing, aquaculture, oil and gas extraction, use of wind and tidal power, shipbuilding, tourism and marine research issues). On 7 June 2006, the European Commission adopted the Green Paper *Towards a future Maritime Policy for the Union: A European vision for the oceans and seas*. The Green Paper is unprecedented in scale, as it involves 25 countries and 10 Commissioners of the European Union. Through the consultation process stakeholders (individuals, institutions, governments and international organisations) are invited to provide feedback to the Green Paper by 30 June 2007. The resultant synthesis may lead to the publication of a White Paper, translating the conclusions of the debate into practical proposals for European Union action.

http://ec.europa.eu/maritimeaffairs

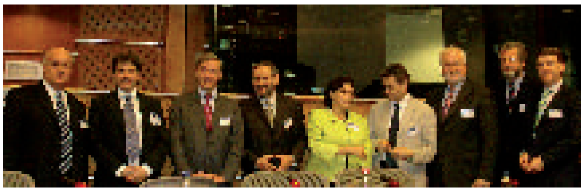
1. European and societal dimensions

Science, society and citizens

1.1. Marine research and its discoveries are of strategic significance to Europe and of importance to its citizens. Much of Europe's prosperity can be traced directly to the development and application of marine science and engineering. Effective governance of maritime activities requires the active participation of informed citizens, policy makers and resource managers. Such maritime related activities include maritime transport, coastal management and leisure activities, exploitation of living and non-living marine resources, ocean-related effects of climate change and development of associated knowledge-based public policies. Lively debate, extensive exchange of views and a real effort to improve collective knowledge and understanding between a diverse set of stakeholders is necessary to ensure realisation and application of the knowledge output of marine research.

The European marine science and technology community must become more proactive not only in promoting innovation, but also in participating in public debates concerning the importance of marine research in supporting European economic development and maritime related issues. Quantification and economic valuation of marine resources is necessary so that economic potential and opportunities will be identified and trends elucidated. Quantification would contribute to enhanced awareness of the reality of the economic contribution of marine resources to Member States' Gross Domestic Product (GDP). Such raised awareness, on transmission to the political and policy making communities, will result in identifying priorities for future investments, including in education.

1.2. With reference to education and outreach to the general public, marine scientists should be encouraged to communicate the implications of their work to the wider public. **Given the need for increased communication, marine scientists should take on the responsibility of elaborating and disseminating scientific information and analyses on issues of societal concern, recognising that they have to deal with uncertainty, complexity of issues, and varying time-scales.** Marine scientists must engage with society, not only with regard to the research outcomes, but also in the process of science, drawing on peoples' natural affinity and curiosity for the sea. Further development of collaborative initiatives whereby artists participate on survey cruises, and produce materials inspired by their experiences onboard to portray their interpretations of the links between marine science and art should be supported. Marine scientists should also be encouraged to translate their findings into information that can be used by experts from other associated disciplines, to support policy advice and awareness raising initiatives. Marine scientists need to engage with the education community and support the development of revised curricula, even at primary school level. Curriculum development is vital to develop the nurturing ground for future scientists, the recruitment of which continues to decline, and yet is fundamental to securing the research and technology skills base. Well founded education is essential to enable the next generation of scientists to meet future challenges not only in marine science, but also in its inherent topics that will become increasingly important to society as a whole. The national marine institutes and university faculties, together with their experts on scientific public awareness, should take an active role in elaborating and disseminating information on the latest marine scientific initiatives, discoveries, technologies and issues. This should be developed in association with educational and political authorities (including local ones), professionals and representatives of industry, and the media.


© Nicole Schmidt /KDM

European Marine Scientific Research: Perspectives 2007-2013 Conference (Ifremer, KDM, NOCS) at the European Parliament, Brussels, October 2005

1.3. Marine scientists should be encouraged and supported to develop an ethical dimension to their research, central to the concept of human stewardship of nature, ecosystem-based management, sustainability and the precautionary principle.

Marine science and technology and European maritime policies

1.4. Enhanced national and European investment in regional marine research could significantly contribute to the policy aim of reducing regional disparity in scientific knowledge, innovation, research and technology development, capacity and competitiveness. **To reduce regional disparity, special attention should be given to developing cooperation within Europe and with its ultra-peripheral regions, as well as with the Russian Federation, eastern European countries, and the countries that border the Mediterranean Sea.**

1.5. Significant research is needed to inform, provide support for and implement existing and emerging robust European policies. Existing and new knowledge should be transferred towards development of evidence-based policy regulation and management. Adoption of a knowledge-based approach is required in the elaboration of a range of European maritime policies, whether sectoral (research, energy, fisheries, transport, security) or general (European Maritime Policy). A knowledge-based approach is also required for the implementation of the Sixth Environmental Action Plan and associated thematic strategies, research framework programmes and directives (e.g. European Marine Environment Strategy, Water Framework Directive, Integrated Coastal Zone Management [ICZM] Strategy, Natura 2000). **Strengthening the science-base of these and related policies should be an inherent requirement in their implementation** *(see also 1.1).*

1.6. The European Commission's Green Paper on Maritime Policy (Box 2) must be supported by excellence in marine research, technology and innovation. The research community must rise to the challenge of delivering effectively to the consultation process for the Maritime Policy, and to involve itself in the discussion fora (e.g. MARE FORUM; Box 4), thereby further supporting the Green Paper debate *(see examples in 2.6, 2.10, 2.17, 3.7, 3.13)*.

1.7. As over 60% of the marine world is beyond the limits of national jurisdiction, it is necessary to address management of the oceans and seas along ecological boundaries rather than political borders. Marine resource management should be coordinated at the eco-region level (Box 5) or in regional seas such as the Arctic, Baltic, Nordic, Eastern Atlantic, Mediterranean, North and Black Seas. Many regional issues are also addressed through regional conventions such as HELCOM, OSPAR (Boxes 6 & 7) or the Barcelona Convention (Box 8). At this level, stakeholders can engage in effective partnerships and commitments, to address factors such as environmental status, biodiversity, and resource monitoring, as well as ocean circulation, wave and ecosystem modelling and predictions, and in so doing best serve socio-economic and societal needs. **The regional specificities included in European policies are the backbone towards developing a comprehensive approach; local issues have to be dealt with at the local level, with local stakeholders. European marine scientists should engage in supporting the construction of required partnerships and services on the scale of eco-regions or regional seas.**

Satellite image of North Achill Sound – Irish National Coastline Survey

1.8. The marine environment is under constant pressure from human activities. Evidence of anthropogenic effects can be seen from the local to the global scale. **Despite the inherent difficulties, identifying and assessing impacts of anthropogenic pressures and predicting their cumulative effects is crucial, as is an assessment of critical thresholds.** To support the required assessments, three categories of indicators should be implemented for development:

(ii) marine science and technology performance indicators;

(iii) socio-economic indicators including their legal framework and boundaries;

(iv) indicators of the status of natural resources and the marine environment, to ultimately contribute to the implementation of effective resource management and protection protocols.

These environmental indicators would in particular address the characterisation of the ecological status of marine waters as defined by the European Union's Water Framework Directive and the Marine Environment Strategy (Boxes 9 & 10). They would encompass biological (including biodiversity), geological, chemical and physical factors, characterising the health of coastal and marine ecosystems. Furthermore, indicators should be developed to address the nature of pollutants and their relation to human activities and population density. Such indicators would support the identification of trends in the marine environment, and provide input to fulfil the aims and objectives of the European Union's Marine Environment Strategy. They would also support compliance with international conventions, particularly those conventions applying to European regional seas.

1.9. The European GMES (Global Monitoring for Environment and Security; Box 11) initiative aims to create information systems for operational service providers, which will in particular support enhanced development of maritime activities. GMES plans to implement a number of public information services, derived from *in situ* and space observations, to support European policies. It will interact closely with the European Commission's proposed INSPIRE Directive (Box 12), to provide data in a harmonised manner. **GMES should include among its key elements, the development of marine core services, allowing the operation of regional and global ocean current and ecosystem prediction systems.** In addition, warning systems for natural hazards and decision-support systems for risk management should be developed. The European political ownership and governance of the marine component of GMES should be consolidated as soon as possible. GMES should constitute a major component of the data network for the future European Maritime Policy. There will be continuous research and technological challenges associated with both the effective implementation of GMES, and the continuous scientific validation and improvement of its products. The marine research community, including technical, socio-economic and institutional elements, should be supported and coordinated to ensure effective involvement in GMES *(see also 3.10, 4.8, 5.3, 5.4, 7.3, 7.4, 7.5)*.

1.10. A forum of marine scientists, policy makers representatives from industry, coastal stakeholders and associations should be convened regularly to ensure effective communication and synergy between sectors. This would lead to more timely delivery of relevant and sound scientific knowledge to policy makers.

Box 4: MARE FORUM

Maritime industry Forum

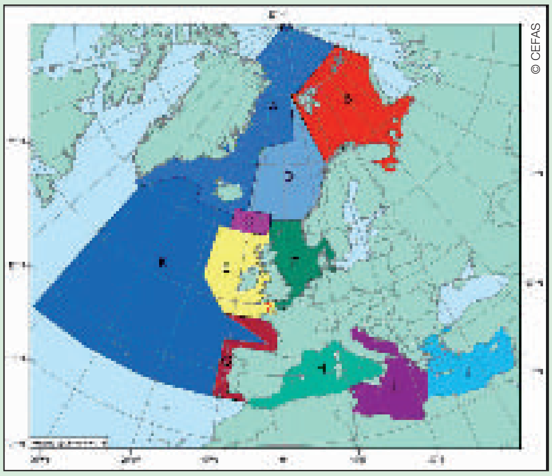
MARE FORUM is a network of maritime industry chief executives and representatives, bringing together policy makers and industry in a forum where business strategy and policy making are considered. MARE FORUM works in close cooperation with the European Commission and the European Network of Maritime Clusters.

http://www.mareforum.com

Box 5: Eco-regions concept: The geographical requirement for implementing the ecosystem approach in European waters.

European Commission - Directorate General for Environment - and ICES

The nominations of eco-regions are based on biogeographic features (composition of faunal communities, patterns of primary production, patterns of land use and distribution and density of human populations) and oceanographic features (depths, basin morphology, tidal and ocean currents, temperature), taking into account existing political, social and management divisions. Eleven eco-regions have been distinguished: Greenland and Iceland Seas, Barents Sea, Faroe Islands, Norwegian Sea, Celtic Seas, North Sea, South European Atlantic Shelf, Western Mediterranean Sea, Adriatic-Ionian Seas, Aegean-Levantine Seas, Oceanic northeast Atlantic.



http://europa.eu.int/comm/environment/index_en.htm and www.ices.dk

Box 6: The Helsinki Convention

International Convention on the Baltic Sea

The 1974 Convention. All sources of pollution within the Baltic were made subject to one single convention, signed in 1974 by the seven Baltic coastal states. The 1974 Convention entered into force on 3 May 1980.
The 1992 Convention. In the light of political changes, a new convention was signed in 1992 by all bordering states of the Baltic Sea, and the European Union. After ratification the Convention *on the Protection of the Marine Environment of the Baltic Sea Area* entered into force on 17 January 2000. The Convention covers the entire Baltic Sea area, including inland waters, sea water and the seabed.
HELCOM. The Helsinki Commission (HELCOM) is the governing body of the Convention - Baltic Marine Environment Protection Commission. The present contracting parties are Denmark, Estonia, European Union, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden.

http://www.helcom.fi

Box 7: The OSPAR Convention

Oslo Paris International Convention on the North-East Atlantic

The 1992 OSPAR Convention is the current instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic. In 2000, OSPAR published the Quality Status Report for the North-East Atlantic (2000). The work of the OSPAR Commission is organised around six axes:

- Protection and Conservation of Marine Biodiversity and Ecosystems;
- Eutrophication;
- Hazardous Substances;
- Offshore Oil and Gas Industry;
- Radioactive Substances;
- Monitoring and Assessment.

http://www.ospar.org

Box 8: The Barcelona Convention

United Nations Environment Programme (UNEP)

The "Convention for the Protection of the Mediterranean Sea against Pollution" (Barcelona Convention), was adopted in 1976 and entered into force in 1978. It was amended by the contracting Parties in 1995 and recorded as the "*Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean*". This entered into force on 9 July 2004. The Convention and six protocols constitute what is known as the Barcelona System, the Mediterranean Action Plan's legal framework. It is in the process of being ratified.

http://www.unepmap.org/home.asp

Box 9: Water Framework Directive (WFD)

EU Directive

The Water Framework Directive (2000/60/EC) established a framework for action in the field of water policy. It is regarded as the most important legal stimulus at EU level for integrated planning, including implementation of Integrated Coastal Zone Management (ICZM), as it applies to waters up to one nautical mile (1.852 km) offshore. The WFD is moving towards minimising the sectoral approach to water quality and biological quality management, protecting ecological quality by incorporating biological and ecological objectives.

http://europa.eu.int/comm/environment/water/water-framework/overview.html

Box 10: Marine Environment Strategy - Thematic Strategy on the Protection and Conservation of the Marine Environment

European Commission - Directorate General for Environment

The Marine Environment Strategy for Europe is consistent with the Water Framework Directive and with the future European Maritime Policy. The Strategy aims to achieve good environmental status of the EU's marine waters by 2021 and to protect the resource base upon which marine-related economic and social activities depend. A Marine Strategy Directive will establish European marine regions on the basis of geographical and environmental criteria. Each relevant Member State, in close cooperation with neighbouring countries within a marine region, will be required to develop a strategy for its marine waters.

http://europa.eu.int/comm/environment/water/marine.htm

Box 11: Global Monitoring for Environment and Security (GMES)

European Commission and European Space Agency

GMES (Global Monitoring for Environment and Security) is a European initiative for the implementation of information services dealing with environment and security. It is based on observation data received from Earth observation satellites and ground-based information sources. This data will be coordinated, analysed and prepared for end-users.
GMES is intended to monitor the state of the environment and its short, medium and long-term evolution to support policy decisions or investments. It is a set of services for European citizens helping to improve their quality of life regarding environment and security.
GMES is being built gradually: it starts with a pilot phase which targets the availability of a first set of operational GMES services by 2008 followed by the development of an extended range of services which meet user requirements.

http://www.gmes.info

Box 12: Infrastructure for Spatial Information (INSPIRE)

EU Directive proposal

The INSPIRE (Infrastructure for Spatial Information) Directive proposal intends to make available harmonised sources of geographical information in support of the formulation, implementation and evaluation of European Union policies. It will compel public authorities to link all spatial data to a shared infrastructure and also create a one-stop access via a European Union geoportal open to all. The proposal is intended to be adopted by spring 2007.

http://inspire.jrc.it

1. European and societal dimensions

European Marine Research Area

1.11. An estimated 94% of European marine research is funded and supported by national institutes and agencies. Although collaboration across national borders exists at the researcher level, and is also evident at the level of institutional networks (e.g. EFARO, EuroGOOS, Marine Board-ESF), there has not been a tradition of strong collaboration at the level of programme development and funding. The sub-optimal coordination between the national funding bodies is recognised as a current weakness within the European Research Area (ERA), as funding bodies decide individually where, and on what priorities, research funds are spent. The ERA is a platform to regroup and intensify research efforts not only at the European level, but also at national and international levels. It is intended to guide and help coordinate Europe-wide research activities and innovation policy, thus securing each Member State's economic and competitive future. **Considerable benefits would be gained from working towards increased synergy amongst research and technology partnerships within the European Research Area ERA.** This is particularly critical for marine research, which, operating within a spatial dimension beyond the jurisdiction of individual Member States, is not defined by national borders. Furthermore, marine research deals with many issues that require the cooperation and commitment of several partners with different competencies and tools. Funds from the Framework Programme, particularly through the ERA-NET instrument (designed to step up the coordination and cooperation of research activities carried out at national and/or regional level), provide an opportunity to mobilise and coordinate marine research carried out nationally by different Member Sates, supporting the development of the ERA, while facilitating the coordination of national efforts *(see also 1.12; Appendix I).*

1.12. To strengthen the marine component of the European Research Area (ERA), the benefits resultant from synergies amongst institutes and university partnerships, shared investments, networking of data centres, opening of national programmes, regional cooperation (e.g. dealing with regional seas), instruments of the Sixth and Seventh Framework Programme (e.g. mobility programmes, Networks of Excellence [NoEs], ERA-NETs [see Box 13 & Appendix I] and ESF EUROCORES [Appendix II]), and multilateral arrangements for access to marine facilities (e.g. the barter arrangements of the Ocean Facilities Exchange Group - OFEG) should be fully exploited. Governance of the European Research Area will have to take into account the diversity of partners, whether from public or private research, both in size and institutional positioning.

© Marine Board-ESF

Participants at MarinERA meetings, Brest 2005

Concern has been expressed that despite the funding of approximately 242 marine related projects in the Sixth Framework Programme, coordination between these initiatives has not been optimal. Working towards improved coherence of marine research activities will require: (i) enhanced coordination between marine research institutes; (ii) fostering of greater capability in marine technology across the marine sector; (iii) support for long-term observation and national facilities on appropriate timescales; and (iv) strengthened commitment towards supporting long-term oceanographic data centres.

1.13. The Seventh Framework Programme (FP7; 2007 – 2013) provides a timely opportunity to secure the European Marine Research Area, reducing fragmentation and enhancing coherence. **Integration and coordination of marine science across all scientific themes and areas of the Framework Programme is necessary to maximise the benefits for marine research, which will in turn enhance support to policy, in particular the developing European Maritime Policy.** The challenge will be to establish an appropriate method to improve the coordination of marine science and technology topics across the relevant thematic areas and between marine research funding programmes of Member States.

1.14. Europe will benefit from increased interaction between the existing mature networks of marine institutes and agencies including EFARO (European Fisheries and Aquaculture Research Organisations; Box 14), EuroGOOS (Box 15), ICES (International Council for the Exploration of the Sea; Box 16) and the Marine Board-ESF. **These networks should elaborate perspectives on marine science and technology, support and convene regular joint scientific fora, and promote synergies between their membership towards strengthening the voice of marine scientists in the European Research Area.** In moving towards enhanced coordination of their activities, they can together better serve the development of European policies and foresight initiatives in marine science.

1.15. At the European level, commitment to multi-decadal funding (beyond the current three to six-year funding cycle of national programmes and European Union Framework Programmes) to secure both sustained observations and research is essential for many issues, including measuring climate variability and its impacts. Multi-decadal funding is also required for the development of systems such as early warning systems for natural hazards and for operational oceanography. A portion of research funding should be allocated to support these long term objectives, which will build strong foundations for a well-coordinated marine science community *(see also 2.11, 2.23, 3.8, 3.19, 4.3, 4.4, 4.8, 5.3, 5.4, 6.2, 7.3)*.

1.16. Educating students in science through the example of marine issues, attracting and retaining early stage researchers into marine research, facilitating mobility of researchers and technologists, and networking partnerships with industry are all priorities for developing and maintaining Europe's capacity as a leader in global marine research and technology. **Particular attention should be given to attracting (and retaining) early-stage scientists from other disciplines such as the life sciences, information and communication technology and computer sciences, data management, and physical and chemical instrumentation.** Furthermore, graduate schools should reinforce education on multidisciplinary aspects of marine science and technology, as well as on ethical dimensions of science and expertise *(see also 1.2)*. This is particularly important to ensure continued development of European capacity and capability in marine science and technology *(see also section 2, 3.7, 3.12, 3.17, 6.5, 7.2)*.

1.17. Europe should widen its support for integrated marine science by providing incentives for scientific and industrial partnerships. The goal should be to maximise the manufacture, application and exchange of novel technologies within Europe and to maximise European industrial competitiveness, for the benefit of both marine research and society. Academic researchers must be encouraged to develop industrial links (e.g. through the use of instruments such as Technology Platforms and Joint Technology Initiatives; Box 17). This should concern both large groups, such as the petroleum industry and maritime transport, and Small and Medium Sized Enterprises (SMEs). Partnerships could include Public Private Partnerships (PPPs i.e. the collaboration between private industry and governmental agencies).

Box 13: European Research and Innovation Structures

European Research Council
The Seventh Framework Programme (FP7) is being elaborated and will include funding instruments of interest to the marine science and technology community, such as Networks of Excellence (NoEs), Integrated Projects (IPs), Technology Platforms, ERA-NET+, etc. FP7 priorities include exploiting fully the possibilities of the ERA and the European Research Council (ERC) - the first pan-European funding agency for frontier research. It is a Council of research experts that will select individual teams or even individuals for funding, on the basis of the sole criterion of excellence, to carry out creative and innovative basic research that pushes forward the frontiers of our knowledge.

European Institute of Technology
The European Commission recently adopted a proposal to establish a European Institute of Technology (EIT) (subject to approval by the European Parliament and the European Council). The EIT will promote innovation at EU level, by involving and integrating innovation, research and education of the highest standard. It will carry out activities around the three parts of the knowledge triangle aiming to ensure a better commercial exploitation of knowledge and innovation outcomes. Thus, the EIT will be a knowledge and innovation operator, not simply a funding mechanism, working on a trans and/or multidisciplinary basis, with a strong emphasis on economic and societal outcomes. Moreover, the business sector will be an integral partner in the EIT. If approved, the EIT could start as early as 2008, and could have an estimated budget of up to €2.4 billion, financed by both public and private sources, over the period 2008-2013.

http://erc.europa.eu
http://ec.europa.eu/education/policies/educ/eit/ index_en.html

Box 14: EFARO - European Fisheries and Aquaculture Research Organisations

Pan-European network

The European Fisheries and Aquaculture Research Organisations is an association of the directors of the 24 European research institutes from 22 countries involved in the fisheries and aquaculture research and the Directorate General Fisheries and Maritime Affairs of the European Commission. EFARO objectives include to:

- Stimulate cooperation on fisheries and aquaculture science through better information of the partners about their new research projects;
- Better exchange between EU and relevant European research bodies;
- Inform partners about new initiatives and new national strategies;
- Avoid undue competitions in research activities between partners;
- Share tools and means situated in common geographic areas and/or of common thematic interest.

http://www.efaro.org

Box 15: Global Ocean Observing System (GOOS) & European Global Ocean Observing System (EuroGOOS)

International programme

The Global Ocean Observing System (GOOS) is an international programme preparing the permanent global framework of observations, modelling and analysis of ocean variables needed to support operational ocean services wherever they are undertaken around the world.
EuroGOOS is an association of agencies, founded in 1994, to further the goals of GOOS and in particular the development of operational oceanography in the European sea areas and adjacent oceans. EuroGOOS comprises 33 Members from 17 European countries.

http://www.ioc-goos.org
http://www.eurogoos.org

Box 16: The International Council for the Exploration of the Sea (ICES)

International organisation

The International Council for the Exploration of the Sea (ICES) is the organisation that coordinates and promotes marine research in the North Atlantic and the adjacent seas such as the Baltic Sea and North Sea. ICES comprises 19 member countries. The ICES mission calls for:

- Establishing arrangements to provide scientific advice;
- Providing information to interested parties and the public about marine ecosystem issues;
- Coordinating and enhancing physical, chemical, biological, and interdisciplinary research;
- Fostering partnerships with other organisations that share a common interest;
- Developing and maintaining accessible marine databases.

The scientific advice prepared by the Advisory Committee on Fisheries Management (ACFM) of ICES is examined by the Scientific, Technical and Economic Committee for Fisheries, who consults with industry and other parties before formulating proposals for quotas, for discussion at the annual December meetings of the Council of Fisheries Ministers.

http://www.ices.dk

Box 17: European Technology Platforms

FP6 Initiatives

European Technology Platforms (ETPs) bring together stakeholders, led by industry, to define medium to long-term research and technological development objectives and lay down markers for achieving them. ETPs play a key role in better aligning EU research priorities to industry's needs.

There are currently 30 ETPs at various stages of development. ETPs are predominantly led by industry and made up of representatives from the private sector, academia and other interested stakeholders. They provide a framework for stakeholders to set their research and development priorities and can therefore play an important role in shaping the Seventh Framework Programme (FP7). In 2006, many ETPs have moved from producing their Strategic Research Agendas (SRA) to implementing them. Six ETPs had previously been identified by the European Commission to develop from ETPs to Joint Technology Initiatives (JTIs), which would be larger industry led initiatives requiring Member State approval.

http://cordis.europa.eu/technology-platforms/home_en.html

Cooperation at the global level and with developing countries

1.18. Over 60% of the marine world, its associated resources and rich biodiversity, are found beyond the limits of national jurisdiction. Thus, many marine research issues, such as those pertaining to climate change, marine biodiversity, fisheries, exploration of the deep ocean, can only be addressed within the global context, within the framework of international scientific programmes and treaties. Europe has a history as an initiator of, and active partner in, international treaties and programmes dealing with the sea. Development of scientific knowledge, both at the national and collective levels of the European Union, is necessary to help strengthen the position of Member States and of the European Commission in these negotiations, as well as to comply with statutory obligations resulting from these international conventions. **Europe should develop significant contributions and leadership in these international programmes and treaties, developing guidelines and actions, securing its position at the forefront of marine research development, leading towards establishing the crucially important sound scientific basis as the foundation for international treaties** *(see also 3.15, 3.20, 4.7, 4.10, 4.11, 5.8, 5.9, 7.1, 7.4, 7.5)*.

1.19. Cooperation with other countries, particularly developing countries, must be a key activity rather than peripheral to the integration of marine research in Europe. **Europe should provide expertise on sustainability issues in developing countries, in particular where European Union Member States are actively involved in resource exploitation (e.g. European Union fishing vessels working off third country coasts; Box 18). Within this context, the identification and establishment of coastal and Marine Protected Areas (MPAs) in developing countries should also be supported by Europe, as should partnerships to develop training programmes and research.** Such partnerships should in particular support the Intergovernmental Oceanographic Commission (IOC) of UNESCO and Partnership for Observation of the Global Oceans (POGO) programmes, such as those on tsunamis early warning systems and on information networks and ocean teacher training from the International Oceanographic Data and Information Exchange (IODE) programme (Box 19).

1.20. The Global Earth Observation System of Systems (GEOSS; Box 20), as agreed by more than 40 governments and international organisations, including the IOC of UNESCO, provides for commitment to comprehensive, coordinated and sustained Earth observations. **European scientists and institutes should be encouraged to engage in long-term contributions to the marine components of GEOSS.** The IODE programme of IOC/UNESCO should be considered an effective programme to link European data and information management activities with the international community *(see also 6.2)*.

Box 18: Fisheries agreements between the EU and third countries

European Commission - Directorate General for Fisheries and Maritime Affairs

Bilateral fisheries agreements between the European Union and third countries establish the general framework for the access of European Union fleets to the waters of these countries. With countries of Northern Europe, which have the capacity to exploit their resources fully, reciprocity agreements are generally concluded. The agreement then consists of an exchange of fishing opportunities in EU and partner's waters. With other countries, such as African and Indian Ocean countries and Greenland, which do not fully exploit their fishery resources, the agreement consists of a financial contribution to secure access to their fishing zones and establishes targeted actions in order to support partner's fisheries sector. There are currently 22 bilateral fisheries agreements in force.

http://ec.europa.eu/fisheries/cfp/external_relations/bilateral_agreements_en.htm

Box 19: International Oceanographic Data and Information Exchange (IODE) Intergovernmental Oceanographic Commission (IOC) programme

The IOC's International Oceanographic Data and Information Exchange (IODE) was established in 1961 to enhance marine research, exploitation and development by facilitating the exchange of oceanographic data and information between participating Member States and by meeting the needs of users for data and information products. The IODE Programme gives attention to all ocean related data including physical oceanography, chemical, biological, etc. Another major commitment of the IODE Programme is the long-term accessibility and archival of oceanographic data, meta-data and information to safeguard present and future holdings against loss or degradation.

http://www.iode.org

Box 20: Group on Earth Observations (GEO) and Global Earth Observations System of Systems (GEOSS)

Intergovernmental Group

The Group on Earth Observations (GEO), involving 60 countries, the European Commission and 43 international organisations, is leading a worldwide effort to build a Global Earth Observation System of Systems (GEOSS) over the next 10 years. GEOSS aims to build a holistic model to produce meaningful and accurate predictions of climate change. Its success will depend on data and information providers and on sharing data. GMES is developing to provide the European component to GEOSS.

http://www.earthobservations.org/index.html

2. Marine resources and maritime transport

Towards ecologically sustainable fisheries and aquaculture

2.1. Of the estimated 30,000 species of fish that exist world-wide, an estimated 18,000 are salt-water species, and approximately 100 are of relevance to commercial fishing. Capture fisheries are predicted to grow by less than 0.7% by 2020, as many commercial fish stocks are already overexploited and have been depleted to critical levels. The UN's Food and Agriculture Organisation (FAO, 2004) estimate that 76% of the world's major fish resource is fully exploited, overexploited, depleted, or recovering from depletion. Catch capacity is larger than that which is necessary to support the sustainable exploitation of the resources of the sea. For example, cod, marlin and swordfish are estimated to have lost 90% of their global stocks over the past century. Fish stocks in the North-east Atlantic, the North Sea and the Baltic Sea are some of the most heavily over-fished. Despite the decline in the resource, global demand for fish protein continues to rise.

The marine environment has been modified not only by over-fishing and by the impact of fishing gear on deep-sea biota and benthos, but also by climate change and other anthropogenic factors (e.g. pollution). The associated impacts on habitats have resulted in marine ecosystems becoming fragile and less capable of adjusting to further environmental change. As a result, the pressure on European policy and decision-makers in fisheries management is intense. As formulated in the European Union's Common Fisheries Policy (CFP), such advice should be expressed within Regional Advisory Councils (RACs; Box 21), and even at a more local scale. For example, ICES (Box 16) has for the past five years recommended a complete ban on cod fishing in the North Sea, west of Scotland and the Irish Sea. Fisheries research is required (and expected) to provide the necessary knowledge to formulate recommendations and scientific advice. To achieve sustainable and ecologically viable fisheries and protect fisheries resources, research design should be based on ecosystem behaviour. The development of common indicators and indices of multistock assessment, ecological health and functioning of habitat types, in various biogeographical areas, would be of great benefit to fisheries management. The use of such indicators would be of particular relevance in support of the CFP and the development of the European Maritime Policy.

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A fishing boat in the North Atlantic

© Aurelien Carbonnière/Marine Board – ESF

King crabs

2.2. The work of ICES and the EFARO network (Box 14) is critical to the integration of fisheries research in Europe. **An enhanced strategic alliance and collaboration between fisheries, oceanography, marine ecology and socio-economic researchers, institutes and associations in Europe would facilitate further progression from the traditional species-specific research approach towards the elaboration of ecosystem studies and models (Box 22).** Future fisheries research should include aspects of spatial management of fish habitats, and endeavour to: (i) integrate fish stock studies with oceanographic, biogeochemical and biodiversity studies within an ecosystem perspective (Box 22); (ii) evaluate the ecological and socio-economic driving forces, implications and effects of different management regimes on fish stocks and the marine environment, in tandem with the development of indicators; and (iii) develop a visualisation tool to integrate the presentation of data and information from various sources, within the framework of an ecosystem approach to fisheries.

2.3. Long-term observations of fish stocks together with associated non-commercial ecosystem components and environmental parameters are essential to detect anthropogenic and climatic drivers for predicting how natural climate change, greenhouse scenarios,

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A blue whiting catch in the North Atlantic on a research vessel

© Marine Institure, Ireland

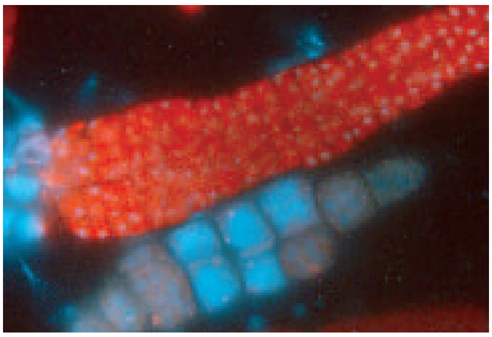
West of Ireland salmonid aquaculture

pollution-induced biodiversity loss and habitat degradation might affect fisheries. New techniques must be adopted to improve knowledge of fisheries and fisheries-environment interactions. Such techniques include: (i) acoustic tools for fish stock assessments; (ii) approaches that deal with ecosystem assessment, including environmental parameters and predictions of change; (iii) integrated ecosystem models (from plankton to mammals); (iv) data assimilation approaches to help adjust such models; (v) application of genetic techniques to stock assessment, resulting in improved characterisation of fish populations, and in detecting population changes and possible restoration of depleted stocks *(see also 4.6).*

2.4. Estimates of by-catch indicate that up to 10,000 dolphins and porpoises are killed in the North Atlantic each year, while globally the UNEP estimates that 250,000 turtles are by-caught annually in fishing nets, and 300,000 seabirds, including 100,000 albatrosses, are killed annually by longline fishing. **Research on technologies for selective and targeted fishing, and reduction of by-catch of other species including birds and mammals, is essential towards enabling the fishing industry to become more sustainable, reducing the impact of fishing on the marine ecosystem, and thereby supporting responsibility for marine stewardship.**

2.5. Technologies for real-time registration of vessel location and transmission of information are needed. Improved security, energy efficiency, and new fishing gear technologies should also be developed for fishing vessels. Improved tools for tracing food products and their quality assessment will be crucial for marketing in an increasingly health and environment conscious society.

2.6. Aquaculture, in particular fish farming, which is often developed in peripheral and rural areas with a traditional dependency on fisheries, is an important economic sector in the European Union. Aquaculture production is rapidly increasing to support Europe's demand for consumption of fish. Further research is required to: (i) identify new aquaculture technologies and techniques for improved husbandry, reproduction and nutrition, species diversification and genetic selection; (ii) ensure compatibility with environmental constraints and reduce negative environmental impacts (such as eutrophication, escapees, alien species, over-exploitation of wild-origin juveniles), through for example, polyculture systems, sustainable feeds, combining ranching with wind farms, on-shore production facilities; (iii) improve the vigour and diversity of stocks (e.g. genetic selection, probiotic food, vaccines, new species, welfare of living animals); (iv) ensure safety of aquaculture products (control of Harmful Algal Blooms [HAB], animal diseases, vaccines) to assure consumers; and (v) ensure compatibility with other coastal and maritime activities, including addressing offshore technology requirements and recirculating systems.



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Epifluorescence of a DAPI (*Di Aminido Phenyl Indol*) stained sporangium

Box 21: EU Common Fisheries Policy (CFP)

European Commission – Directorate General for Fisheries and Maritime Affairs

Through the CFP common measures are agreed in four main areas of fisheries management: conservation, structures, markets, relations with the outside world. In 2003 the CFP evolved to include:

- **Long-term approach:** to attain and/or maintain safe levels of adult fish in EU stocks are set as well as the measures needed to reach these levels;
- **A new policy for the fleets:** to match fishing capacity to fishing possibilities with Member States;
- **Better application of the rules:** to develop cooperation among the various authorities concerned and to strengthen the uniformity of control and sanctions throughout the EU;
- **Stakeholders' involvement:** Regional Advisory Councils (RACs) to enable fishermen and scientists to share their expertise and work together to achieve sustainable fisheries.

The scientific advice prepared by the Advisory Committee on Fisheries Management (ACFM) of ICES is examined by the Scientific, Technical and Economic Committee for Fisheries, for discussion at the December meetings of the Council of Fisheries Ministers, before agreement on quotas. The ACFM 2006 report details encouraging signs from a number of stocks in European waters, in particular northern hake, which has been subject to a recovery plan since 2004. Mackerel stocks also seem to be increasing. However, other stocks such as cod show little sign of improvement. Commissioner for Fisheries and Maritime Affairs J. Borg commenting on the report stated "*first, it shows that our long-term approach to the management of EU fisheries is starting to bear some fruit. Second, it underlines the benefits derived from the growing participation of stakeholders in the scientific process".*

Extending and deepening the long-term approach to management remains a core objective of the Common Fisheries Policy.

http://europa.eu.int/comm/fisheries/doc_et_publ/cfp_en.htm

2.7. State-of-the-art genomics techniques such as Quantitative Trait Loci (QTL) and Amplified Fragment Length Polymorphism (AFLP), which have the potential to rapidly identify species-specific genetic markers for species identification, paternity identification, diagnostics, product identification etc., should be adopted by aquaculture technologists. These developments should aim to facilitate competitive advantage in the aquaculture industry.

2.8. Addressing the often conflicting requirements of sustainable fisheries and aquaculture, environmental protection and other competing human uses (e.g. shipping, recreation and coastal development) of the coastal zone should be a primary focus for marine socio-economic research and modelling. The adoption of marine spatial planning procedures would contribute to supporting the alleviation of potential conflicts in the land-sea interface. This would enable a more rational organisation of the use of marine space and the interactions between its users, taking account of all sectors and activities. **Methodologies should be developed to evaluate the economic impacts of: (i) implementing new policies; (ii) effects of ecosystem changes on resource characteristics; and (iii) the socio-economic drivers of fisheries and aquaculture activities.**

Box 22: Ecosystem Approach to Fisheries - EAF

UN Food and Agriculture Organisation (FAO) concept

The FAO's Reykjavik Declaration of 2001, reinforced at the World Summit on Sustainable Development in Johannesburg in 2002, requires nations to use an ecosystem approach to develop policy governing exploitation of marine resources by year 2010. Nations are further required to restore depleted fish stocks by 2015, and to establish representative networks of Marine Protected Areas by 2012. **Ecosystem Approach to Fisheries** (EAF) aims to plan, develop and manage fisheries in a manner that addresses the multiplicity of societal needs and desires.

http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/006/Y5025E/y5025e13.htm

Marine biotechnology: bioprospecting the planet's largest biotope

2.9. Marine biotechnology has the potential to harness and make available the vast genetic richness of the seas and oceans, and to provide new materials of relevance to the pharmaceutical, agrochemical, food and cosmetic industries. Recently described (and yet to be discovered) organisms are the source of novel bio-products with potential for medical and chemical applications. Marine micro-organisms, particularly those found in extreme environments, produce enzymes, polymers, carbohydrates and other molecules with unique characteristics, by virtue of their species-specific adaptations to the ecosystems in which they live. Given the sessile nature of many marine species, they have developed highly specialised mechanisms of defence, producing antibodies that can protect against predators and diseases. **Europe should actively support the development of networks and partnerships between marine biotechnology R&D groups and the industrial biotechnology sector, in order to further identify and pursue marine biotechnology opportunities.** Enhanced research efforts in marine genomics (Box 23) and post-genomics would contribute to improved competitiveness in this area. Furthermore, efforts to integrate bioprospecting into oceanographic expeditions should be enhanced *(see also 5.1)*.

Box 23: Marine Genomics Europe (MGE)

EU FP6 NoE

Marine Genomics Europe (MGE) is a Network of Excellence (NoE of 44 institutions from 16 countries) devoted to the development, use and dissemination of high-throughput approaches for the investigation of the biology of marine organisms. Marine Genomics Europe addresses a range of questions related to the functioning of marine ecosystems and to the biology of marine organisms.

http://www.marine-genomics-europe.org

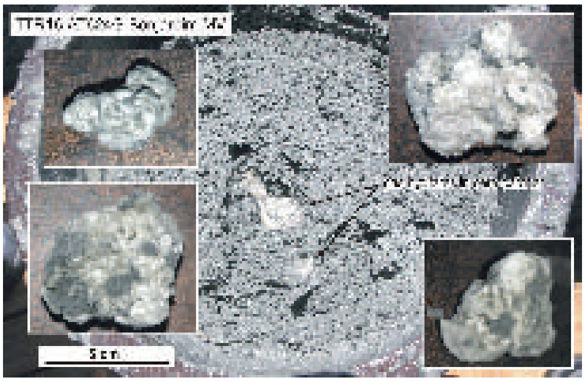
Energy and wealth from the sea

2.10. The ocean holds a vast reservoir of energy and mineral resources in the form of hydrocarbons (oil, gas, gas hydrates etc.), renewable energies (wind, wave, tides, geo-thermal and ocean-thermal etc.) and materials (aggregates, metal deposits etc.), all of which are of strategic value to society. Increasing energy demand and price, the need to import energy from outside the European Union, coupled with issues such as security of supply and increasing awareness of negative environmental impacts (including the economic impacts of climate change), all contribute to the necessity for the European Union to seriously consider its energy consumption, supply and source-options (Box 24). With appropriate incentives, **European marine industries and scientists must forge new partnerships towards enhanced understanding of the origin, location and characteristics of ocean energy resources, as well as to develop technologies, and responsible approaches towards their exploitation.** These partnerships should aim to contribute to minimisation and mitigation of environmental impacts and spatial–use conflicts as well as long-term risks from geological and climatic hazards. This would ultimately support Europe's increasing energy demands, while addressing targets for reduction of greenhouse gas emission, and adherence to the Kyoto Protocol *(see also 3.12* & Box 25*)*.

2.11. A concerted effort to improve cooperation and develop optimal levels of interaction between marine research groups and petroleum companies is required to: (i) explore and understand hydrocarbon reservoirs, especially in deep and ultra-deep offshore areas; (ii) study the stability of the sediment layers of the continental margins; (iii) help understand and reduce the potential impact of hydrocarbon exploitation on the marine ecosystem, particularly the deep benthic ecosystems; and (iv) develop the necessary technology. The resultant synergy will be of benefit to both communities, and to the environment.

2.12. Research is also necessary to improve our understanding of the effect of acoustic disturbance, in particular that from seismic surveys, on ecosystems and on the physiology, behaviour and distribution of fish and marine mammals at various stages of their development (Box 26). Improved observation and prediction systems are required to monitor and manage oil spills and develop an understanding of their potential impact on the environment *(see also 2.19, 3.8, 3.11).*

2.13. The occurrence of large quantities of gas hydrates at continental margins has the potential to provide an additional source of energy for Europe.



© HERMES FP6 project.

Observations on gas hydrates from 16th Training-Through-Research Cruise, RV Professor Logachev

Estimates of marine methane hydrate reserves are comparable to the magnitude of known exploitable fossil energy reserves. However, if released into the atmosphere, methane acts as a powerful greenhouse gas, and would augment global warming. **Support for research on gas hydrates should pay special attention to: (i) their biogeochemical origins; (ii) their occurrence in association with carbonate mounds; (iii) their thermodynamic and mechanic stability; and (iv) novel mapping and exploitation technologies.** The environmental impacts of exploration and exploitation of gas hydrates should also be assessed *(see also 3.14)*.

2.14. Research on the development of energy from off-shore wind, wave and tidal sources deserves support, not only to realise the potential contribution of this energy source to support Europe's increasing energy demand, but also in mitigating impacts of climate change. Offshore renewable energy currently represents a small part of the renewable energy sector, but it is one with a substantial scope for growth, provided technical and environmental challenges can be overcome. Efforts to enhance recovery of energy sources through advanced and improved techniques, and through wider application of existing techniques should be supported. **Research on requirements for effective location, operation and harnessing of renewable energy sites, and optimal integration into domestic energy grids, will be an important contribution to Europe's energy supply (Box 24).** Technology development is required to improve facilities for exploitation of these resources, so that facilities are long-lived, impact resistant and efficient. Further research is required to estimate the impacts of new offshore structures and their hardground and turbulence effects on local sedimentation, marine benthic and pelagic life, seabirds, marine mammals (Box 26) and navigation, as well as the impacts of power transmission systems.

Box 24: A European Strategy for Sustainable, Competitive and Secure Energy

European Commission – Energy Green Paper (March 2006)

This European Commission Green Paper addresses the need to develop a common, coherent European Energy Policy. For renewable energy to fulfil its potential the policy framework needs to be supportive in particular to stimulate increasing competitiveness of such energy sources while fully respecting competition rules. While some sources of low-carbon indigenous energy are already viable, others, such as off-shore wind, wave and tidal energy need positive encouragement to be realised.

http://europa.eu.int/comm/energy/green-paper-energy/index_en.htm

Box 25: Kyoto Protocol

United Nations Protocol

Under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol (adoption: December 1997, entry into force: February 2005), industrialised countries are required to reduce their emissions of six greenhouse gases (CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride) to around 5% below the 1990 level (8% for the EU 25 Member States) from 2008 to 2012.

http://unfccc.int/essential_background/kyoto_protocol/items/2830.php

Box 26: Underwater Sound and Marine Mammals

Report from an International Workshop (JNCC - UK & MMC – USA; September 2004, London, England)

This international workshop addressed the interactions between anthropogenic sound and marine mammals. Given the state of knowledge, the basis for concern refers to:

- The fact that seismic airguns, military sonar, commercial ships, and sound projectors used in large-scale ocean research produce some of the most powerful and pervasive anthropogenic sounds in the oceans;
- The need to better understand the mechanisms that link underwater sound to behavioral and physiological responses by marine mammals;
- The need to understand the type and scale of effects that would have long-term or irreversible consequences for an individual or a population.

While a number of multilateral efforts are ongoing, the workshop considered that significant advances regarding the effects of human-generated sound on marine mammals would be better achieved through national law and management programmes, international collaboration on research, and international coordination of management via regional and industry-based initiatives.

http://www.mmc.gov/sound/internationalwrkshp/internationalwrkshp.html

Aggregates and ore deposits

2.15. Marine aggregates (sands and gravels) are increasingly in demand to meet the needs of the European construction industry (Box 27). Further research should be conducted on the effects of dredging and dumping of sediments, in order to avoid the potential effects of coastal erosion, and to maintain the functioning of natural marine systems, and other activities such as fisheries. Improved procedures and tools for effective environmental impact studies on coastal marine ecosystems are required to accompany exploitation of these deposits *(see also 3.5, 3.16).*

2.16. Ore deposits with high concentrations of rare trace metals are known to occur on the slope of island volcanoes. Options are also being considered to mine for gold and copper in the seafloor. Research to improve our understanding of the geochemical mechanisms at play, as well as of the economic value of these deposits and the environmental impact of their possible exploitation, should be supported.

Box 27: Aggregate extraction

ICES data

According to ICES, in 2004, the majority of marine aggregate extraction took place from the North Sea area with lesser amounts from parts of the Baltic Sea area, the English Channel, the Irish Sea and the North Atlantic. More than 95% of the material extracted has been sand and gravel with limited amounts of maerl. The Netherlands is the principal user of sand for beach re-charge and coastal protection; the UK uses sand and gravel for construction; in other countries such as Denmark and Belgium the use is more variable and significant amounts can be required for specific projects.

http://www.ices.dk/iceswork/wgdetail.asp?wg= WGEXT

Socio-economics of marine resources

2.17. There is a requirement to assess and realise the economic potential of the extensive marine resource-base, to promote sustainable development and to safeguard the resource-base through research and environmental monitoring. Socio-economic activities at sea are strategic to European development as well as constituting a significant portion of Europe's Gross Domestic Product (GDP); 3 – 5% of European GDP is generated from maritime industries. The global maritime industry can be divided into four main areas: services, resources, manufacturing, education and research. The global market for maritime industries for the period 2005-2009 is estimated to be around €4,363 billion (*Marine Industries Global Market Analysis*, Marine Institute, 2005). The economic value of these areas to the European market (2005–2009) can be extracted from global market analysis reports as:

- **Services:**
  €2,454 billion - dominated by the shipping industry and tourism;
- **Resources:**
  €1,306 billion - dominated by fisheries and energy (value of energy produced excluded);
- **Manufacturing:**
  €541 billion - mainly production of equipment for the shipbuilding and oil and gas industries;
- **Education and research:**
  €62 billion - activities associated with education, training and R&D for specific sub-sectors.

Research, knowledge and innovation are essential elements of a new overall vision for Europe's maritime sector. It is hoped that with these developments, Europe will significantly increase the awareness of the value of its ocean based economy. **Accurate and up-to-date financial data on the value and relative importance of the European maritime economy is required. An integrated European initiative to collect and analyse such data on a regular basis would facilitate economic decisions and investments.** Once resources are valued, awareness of their inherent economic benefits will be a driver in developing policies towards sustainable management in the exploitation of these resources.

Salvage operation in Fayal – Azores

2.18. The marine environment has an intrinsic non-market value in terms of the goods and services provided (e.g. seascapes, quality of life, recreational activities, capacity to assimilate pollutants, etc.). **It is essential to estimate the non-market value of marine goods and services, including both use and non-use values, to properly inform decision-making and the development of marine policies.**

Maritime transport

2.19. Maritime transport has historically played a pivotal role in the economic development of Europe, and is one of the most strategic maritime activities for the European economy. Maritime transport and ports are key components of the logistics chain that links the European Union's 25 Member States with the rest of the world economy. Their continued efficiency and vitality is crucial to European competitiveness in a globalising world. More than three million people work in the European maritime transport sector; 80 - 90% of goods imported and exported by Europe are transported by sea, and more than 40% of Europe's internal trade is waterborne. Maritime transport is one of the most economical transportation systems, in terms of energy consumption (at one fifth of that of land transport), and it is likely to continue to increase in the coming decades, as short-sea shipping routes provide an alternative to land-based transportation. As with any activity, maritime transport requires innovation, improved security, new services and understanding of its effect on the marine environment. The Waterborne Technology Platform (Box 28) identifies the following three challenges for the development of maritime transport, each requiring support by R&D:

- Safe, sustainable and efficient waterborne transport;
- A competitive European waterborne transport industry;
- Managing and facilitating the growth in transport volumes and changes in trade pattern.

2.20. Maintaining a competitive ship-building sector in Europe will have to consider novel approaches to the design, construction and operation of new vessels, in-

© Aurelien Carbonnière/Marine Board – ESF

View of Oslo docks

cluding: the need for lower fuel consumption and lower levels of emissions from engines, the use of alternative sources of energy, effective protection strategies and systems for corrosion and wear, increased security and safe and environmentally acceptable recycling procedures. **As Europe's ship-building industry re-locates much of its labour intensive efforts elsewhere, Europe should support a Technology Platform (Box 28) on ship building dealing with these technological issues, so that niche markets for specialised vessels and their requirements can be developed.**

2.21. The transfer of many types of organisms (micro-organisms, algae, molluscs, fish and a variety of other species) by merchant ships, in particular inside ballast waters, is recognised as a major source of invasive species in coastal waters (Box 29). No reliable and economically-viable solution is currently known to mitigate this issue. It is anticipated that international regulations will have to be developed and agreed. Enhanced assessments of the associated risks as well as the development and implementation of new technologies and practices to mitigate this effect are necessary *(see also 3.16)*.

2.22. In view of the steady increase in maritime traffic, security and monitoring of merchant ships have to be progressively tightened, requiring improved technologies to monitor and regulate vessels and their status. Improved sea-state forecasts, in particular of extreme events, and their integration into the decision process for maritime operations is essential for improved security and safety. Techniques and services to detect and monitor oil spills and predict drift patterns of lost containers have to be progressively implemented. An increased understanding of the behaviour of the oceans and effects of the increased variety of chemicals transported by sea, in anticipation of accidents, is required *(see also 4.7).*

2.23. Merchant ships, ferries, naval and coastguard vessels as well as fishing vessels, can be used to carry sensors and sampling equipment for measuring *in situ*, regularly and in large numbers, many critical oceanic environmental parameters and biodiversity (e.g. Ferry Boxes, Continuous Plankton Recorder, etc.). Funding programmes should support an increased implementation of such measuring devices on regular shipping routes across European seas.

2.24. Port development and innovation is necessary to cope with increased maritime traffic. In such development, sustainability principles should be adopted, such as the minimisation of impact on the marine environment including on sediments and ecosystems, the reduction of the induced diffuse pollutants with eco-toxicological effects, implementation of good practices in terms of harbour dredging and dumping at sea (Box 30), monitoring the environmental quality of water in the harbour and its vicinity, etc. Implementing these principles will be part of the European Union's Marine Environment Strategy (Box 10). **Research is necessary towards: (i) enhanced understanding of the effects of harbour developments on coastal and marine environments; (ii) improving best practices; and (iii) developing monitoring tools.**

Box 28: EU FP6 initiatives related to maritime transport

WATERBORNE TP
EU FP6 Technology Platform
WATERBORNE TP has been established to improve the coordination of research related to waterborne transport in Europe (sea and inland). This forum, where stakeholders from the waterborne sector define and share a common medium and long term vision, is driving the innovation efforts, defining and sharing a Strategic Research Agenda (SRA) which describes the initiatives necessary to materialise the vision. The SRA specifies which research topics are relevant and what results are expected in the medium and long term, and was developed to impact on the European Commission's R&D activities within the Seventh Framework Programme (FP7).

http://www.waterborne-tp.org

MARTEC (2006 – 2009)
EU FP6 ERA-NET
MARTEC will support WATERBORNETP by focusing on improving the coordination of funding between national and European research programmes. The project brings together 11 ministries and organisations responsible for funding research in maritime technologies across nine European countries. MARTEC plans to create a lasting network of key agencies that will improve the way in which maritime technologies research is managed and developed.

http://www.martec-era.net

ERA-NET TRANSPORT
EU FP6 ERA-NET
The purpose of the ERA-NET TRANSPORT is to develop a European vision for transport research, promoting cooperation between national transport research programmes by providing joint procedures, joint programming and joint project management models and guidelines.

http://www.transport-era.net

Box 29: Ballast water and invasive species

International Maritime Organisation (IMO)

The Marine Environment Protection Committee (MEPC) of the International Maritime Organisation is expected to consider *Guidelines for approval and oversight of prototype ballast water treatment technology programmes (G10)*, part of a series of guidelines developed to assist in the implementation of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention), which was adopted in February 2004. The International Maritime Organisation is calling for all ballast water to be treated before it is discharged from vessels.

http://www.imo.org/home.asp

Box 30: Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter

International Convention

The 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter signed in 1972, entered into force on 24 March 2006. The 1996 Protocol prohibits dumping, except for materials on an approved list. One of the key issues for discussion under the 1996 Protocol is likely to be a review of the compatibility of CO_2 capture and storage in sub-seabed geological structures, as part of a suite of measures to tackle the challenge of climate change and ocean acidification.

http://www.londonconvention.org/Documents.htm#Texts_of_the_London_Convention

3. Europe's coastal zones, shelf seas, continental margins and biodiversity

Coastal zones

3.1. The seas and oceans have played a formative role in the development of European coastal states and cities. With pressures from increasing population and urbanisation, Europe's coastal areas have changed dramatically during the 20th Century. **Interdisciplinary research is required to address the challenge of implementing Integrated Coastal Zone Management (ICZM; Boxes 31-33) and marine spatial planning (Box 34).** Such interdisciplinary research will require integration of elements that address oceanography, fisheries, geology, ecology, archaeology, social history and economics. This integration should be achieved with the objective to support sustainable resource management, responsible development of maritime transport and offshore industries, and enhanced environmental protection. Information and knowledge should be elaborated and expressed for transmission to all socio-economic, societal and institutional stakeholders and to the wider public (Boxes 32 & 33). This will enhance the development of management tools, of which ICZM and marine spatial planning are key elements, and would further support the resolution of the conflicting requirements associated with multi-user needs.

3.2. Across Europe and its ultra-peripheral regions, coastal development and management actions are impacting on regional biodiversity and ecosystem functioning. **Within ICZM research, priority should be given to investigating the environmental, social and economic impacts of anthropogenic activities in the coastal zone, including: increasing tourism and leisure in the littoral zone, port development, sea and coastal defences, aquaculture, fishing, sand and gravel extraction (Box 27), naval activities, and ocean disposal of domestic, industrial and military wastes (including those of historical origin).** Improved mapping of coastal seas and the land-sea interface, including information on water quality, water masses, biodiversity, habitats, ecological zones and socio-economic use is particularly necessary to support ICZM.

The city of Horta, the Azores

3.3. With coastal development continuing at a rapid pace, society is increasingly vulnerable to rising sea-level, which will contribute to increased storm surges and flooding, and increased erosion. Further research is required towards an improved understanding of sea-level rise and variability, which would help to reduce the associated uncertainties, resulting in more effective management *(see also 4.7, 4.8).*

3.4. Estuaries, shelf seas and ocean margins are interactive highways for the transfer and transformation of products of terrestrial and anthropogenic origin to the oceans' depths. Many of the associated processes are still poorly understood. Research on biogeochemical budgets of nutrients (e.g. carbon, nitrogen, phosphorous) and their ecological effects such as eutrophication, changes in plankton populations (including the balance between harmful versus benign species) and their impacts on benthic ecosystems and habitats, are required for different types of estuaries, shelf systems and regional seas. The development of integrated numerical models of estuarine processes is necessary to support improved management of rivers and estuaries. **Research should focus on: (i) the fate of terrestrial carbon and pollutants in the ocean; (ii) physical and biogeochemical processes along ocean margins and their role in transfer of energy and components between shelf seas and the open ocean; (iii) the role of ocean margins as net sources or sinks of carbon; and (iv) the transfer of carbon to the deep ocean. It is important that such research links with research on sediment budgets** *(see also 3.5, 4.9).*

3.5. There is a requirement to investigate the sources, properties and transport budgets of terrestrial and marine sediments in European coastal areas with emphasis on their biological and physical influence (stabilisation, cohesion, irrigation, storage). Understanding the impacts of variations in river fluxes and sand extraction are of particular importance. **Given the complexity of sand transportation processes influenced by both waves, currents and tide, research is required on the transport of sand grains in the coastal environment. Such research is necessary to yield new insights into, and predictive models for, wave-induced sand transport over rippled beds.** Coastal profile models and coastal morphological models used for designing sand nourishment schemes, coastal defence schemes and coastal reclamation require accurate description of wave induced sand transport *(see also 3.4).*

3.6. The impact of turbulence on abiotic and biotic components of the coastal marine ecosystem is a developing subject. Aspects include the potential importance of small scale turbulence dynamics on a range of fields, such as coastal erosion, sediment re-suspension, waste water dispersion, and impacts on life cycles of species of commercial relevance. **The need for substantial advances in understanding the impacts of turbulence on marine ecosystems will require multidisciplinary experiments with a focussed effort in this field.**

3.7. The coastal seas face a dramatic increase in the number of hazardous substances (natural and man-made organic and biotechnological compounds and pathogens) discharged into the marine environment. The behaviour and impact of these contaminants is still poorly known. These pollutant mixtures exceed the monitoring capabilities of many of Europe's environmental agencies and there is a risk that major impacts on ecosystems or on human health will not be detected. Contaminants such as PCBs and DDT have been shown to inhibit functional ability of mammalian immune systems and the development of young mammals. While the PCB toxicity limit is defined as 50 ppm, tests have revealed levels of up to 400 ppm in killer whales, 3,200 ppm in beluga whales and 6,800 ppm in bottlenose dolphins. **Europe should rapidly adapt new array biotechnological chips to provide non-invasive, affordable, and high-throughput systems for ecotoxicological screening of water quality.** This would allow the implementation of more meaningful toxicity-based discharge licenses, toxicity-directed chemical monitoring strategies and more reliable ecotoxicological indices for European coastal waters. With major novel advances in sequence technologies, it will be possible in the near future to monitor, both qualitatively and quantitatively, microbial biodiversity and changes therein, so that relatively low levels of harmful algal blooms (HABs), pathogenic bacteria and viruses can be detected. Such developments are crucial in the framework of the REACH Directive (Box 35).

Box 31: Integrated Coastal Zone Management (ICZM)

European Commission - Directorate General for Environment

While no single EU Directive or legislative measure applies exclusively to the coastal zone, various EU policies impact directly on the coastal area. These policies include, *inter alia*, the Common Agricultural Policy, Common Fisheries Policy, and the Habitats, Birds and Water Framework Directives. The European Commission published an EU ICZM Strategy in 2000 which defines the EU's role as one of leadership and guidance to support the implementation of ICZM by Member States.

http://europa.eu.int/comm/environment/iczm/home.htm

Box 32: European Network for Coastal Research Coordination Action (ENCORA)

EU FP6 CA

ENCORA, the European platform for sharing knowledge and experience in coastal science, policy and practice, aims to overcome existing fragmentation by supporting two types of networks within 13 European countries:

- National Networks: process oriented, they initiate/facilitate knowledge sharing and cooperation;
- Thematic Networks: content oriented, they analyse the strengths and weaknesses of existing knowledge, policies and practices.

http://www.encora.org

Box 33: Science and Policy Integration for Coastal System Assessment (SPICOSA)

EU FP6 IP

SPICOSA's (2006-2011) overall objective is to develop a self-evolving, holistic research approach and support tools for the assessment of policy options for sustainable management, through a balanced consideration of the ecological, social and economic aspects of Coastal Zone Systems.

Box 34: Marine spatial planning

Concept definition

To achieve a sustainable use of the ocean's resource, all activities which impact on the marine ecosystem should be seen as a whole. As a tool towards implementing this holistic approach, regional marine spatial planning is being adopted by several countries.
The UK Department for Environment, Food and Rural Affairs (Defra) has suggested a definition of a marine spatial plan as "*a strategic plan for regulating, managing and protecting the marine environment that addresses the multiple, cumulative and potentially conflicting uses of the sea*".
The Green Paper on Maritime Policy proposes that Member States should implement a system of spatial planning for maritime activities on the waters under their jurisdiction or control.
The EU Marine Strategy also refers to the use of marine spatial planning to detail spatial and temporal distribution controls in order to adapt future management measures.

http://www.defra.gov.uk/environment/water/marine/ index.htm
http://www.abpmer.net/mspp

Box 35: European chemical policy - REACH

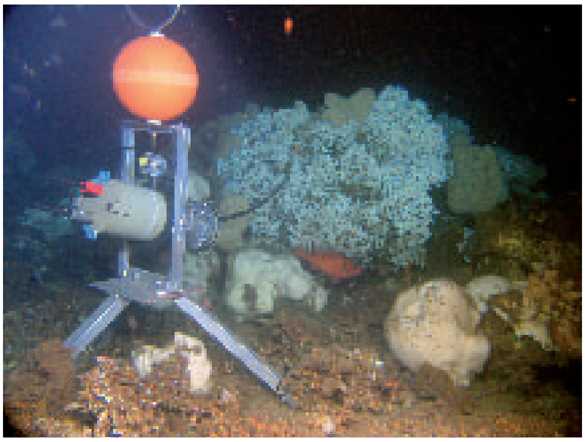
EU Directive proposal

In its *Strategy for a Future Chemicals Policy* (February 2001) the European Commission outlined its strategy for ensuring a high level of safety of chemicals and a competitive chemicals industry through a system for the Registration, Evaluation and Authorisation of Chemicals - the REACH system. Manufacturers and importers will be required to gather information on the properties of their substances, and submit the information in a registration dossier to a central data base. REACH could enter into force in 2007. The adoption of the REACH Directive could for instance help reducing contaminants such as PCBs and DDT.

http://europa.eu.int/eur-lex/en/com/pdf/2003/com2003_0644en.html

Strategic observing, monitoring and prediction systems

3.8. The ability to assess the degree of reversibility of ecosystem change is essential for policy makers. Natural and anthropogenic causes of ecosystem variability should be characterised and distinguished, particularly in coastal seas. **Long-term, high-quality observations of climatic drivers of oceanographic, biogeochemical and biodiversity variability, and associated anthropogenic parameters should be synchronised at critical locations in European coastal and marine areas via networking of observatories.** Such observations should also be linked with observations on the natural variability of biological components and ecosystem function (Boxes 36 & 37; *see also 4.9).*



Camera used to photograph deep-sea coldwater polyps

3.9. Coastal areas are predicted to become increasingly vulnerable to the potential effects of climate change. Such effects include sea level rise, increased wave height, increased frequency and intensity of storms, exposure of littoral zones to extreme storms, flooding of lowlands, urban and populated areas, changing erosion patterns, salt intrusion into ground waters, changing temperature regimes, increased acidity of surface water layers, shifts in species biogeography, increased river flows due to wetter seasons, all with major consequent changes in biology, microbiology and ecology. **Increased research efforts are necessary to inform our understanding of the impacts of climate change on coastal areas** *(see also 4.6).*

3.10. There is an overall requirement for improved prediction of climate, ocean currents and meteorology, at different time scales (seasonal, monthly) (Boxes

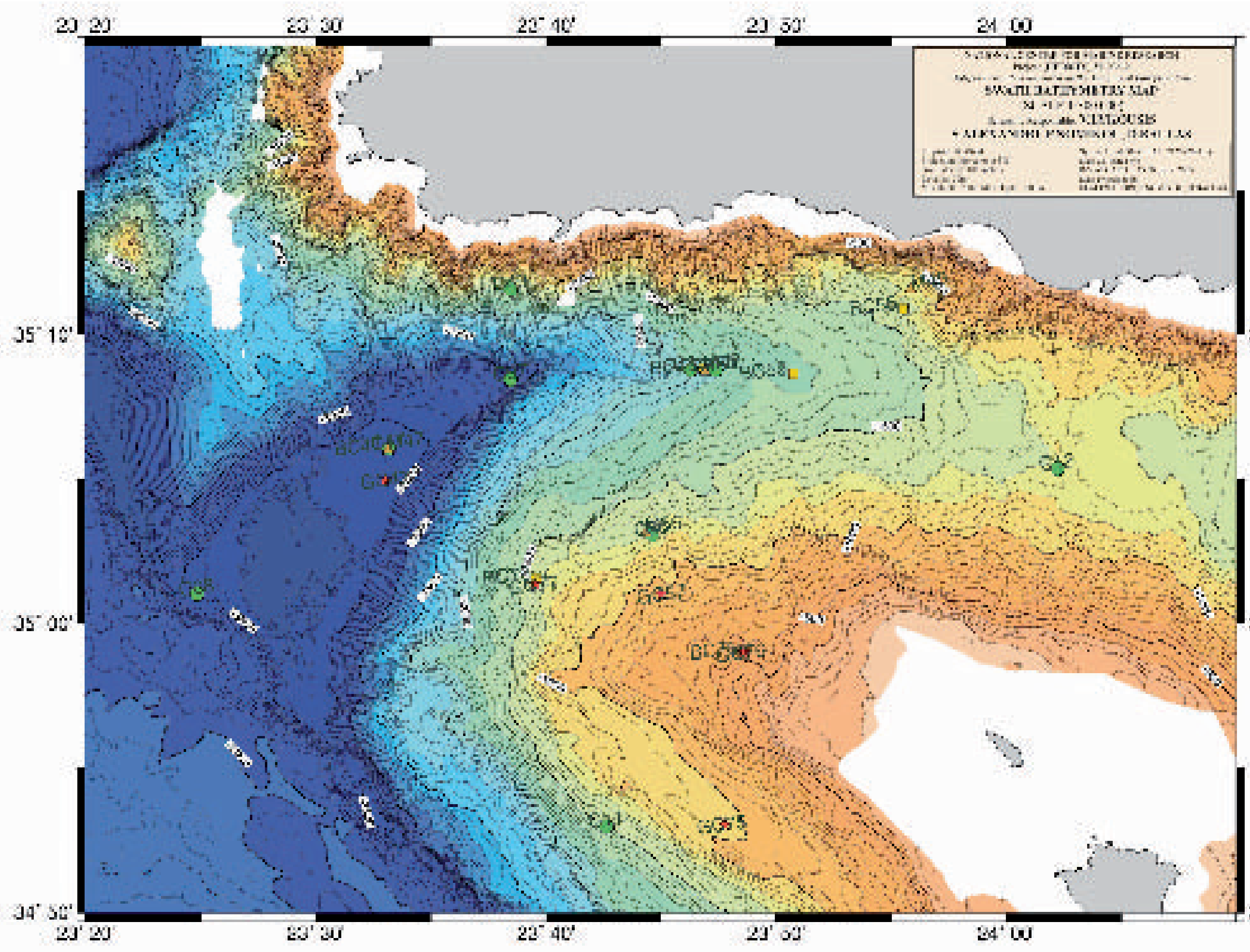


Image courtesy HCMR and the HERMES FP6 project (multibeam data collected by RV Aegaeo)

Swath bathmetry map

38 & 39). Research is required to improve observing and modelling methods and technologies, particularly in the coastal zones. This includes research and development for real-time data collection, processing, data merging, and data and product delivery. Recommendations in the Green Paper on European Maritime Policy include establishing a European Marine Observation and Data Network, which would provide a sustainable focus for improving systematic observation (*in situ* and remotely sensed), interoperability and increasing access to data. Updating European bathymetric charts is necessary to contribute to the development of more accurate models of the coastal ocean. Modelling efforts have to be devoted to coupling the range of processes, such as circulation, air-sea interface processes associated with sea-state, turbulence, morphodynamic changes on the seabed, sea-level change, and evolution of habitats with sediment type.

3.11. Given the availability of a new array of acoustic techniques and the development of a standard seabed habitat classification system (European Environment Agency, European Nature Information System [EUNIS]), Europe now has the ability to gather seabed habitat information in a consistent manner, to develop international standards and protocols for seabed mapping studies and to become a world leader in this field. **The ability to prepare detailed bathymetric and seabed habitat maps of Europe's marine territories is now within reach, as is the creation of a European marine atlas.**

Box 36: ARGO experiment "A Global Array of Profiling Floats"

International Project

ARGO is a US project aiming to deploy globally by 2006 approximately 3000 profiling floats measuring temperature and salinity (giving a spatial resolution of about 3° or 300 km). This global array of profiling floats will result in the systematic measurement of the physical state of the upper ocean as well as enabling assimilation of data in near real-time.

EURO-ARGO is planned as the future European component of the ARGO in situ global ocean observing system. EURO-ARGO will develop around 250 buoys per year as well as the operation of the CORIOLIS data centre. The first open access is foreseen for 2010.

http://www.argo.ucsd.edu
http://www.coriolis.eu.org

Box 37: Data Integration System for Marine Pollution and Water Quality (DISMAR)

EU FP6 IP

DISMAR aims to develop an advanced monitoring and forecasting information system for marine pollution. It aims to support public administrations and emergency services responsible for prevention, mitigation and recovery of crises such as oil spill pollution and harmful algal blooms (HABs).

http://www.nersc.no/Projects/dismar

Box 38: Global Ocean Data Assimilation Experiment (GODAE)

International project

The Global Ocean Data Assimilation Experiment (GODAE) is a practical demonstration of near-real-time, global ocean data assimilation that provides regular and complete descriptions of the temperature, salinity and velocity structures of the ocean. GODAE supports operational oceanography, seasonal-to-decadal climate forecasts and analyses, and oceanographic research. This international experiment gathers the inputs of several national or international observing systems pilot projects such as the French Mercator-Ocean project.

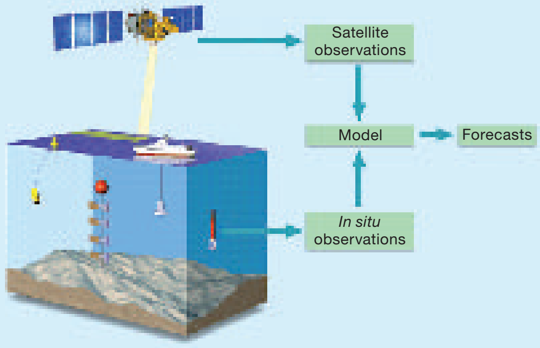
http://www.bom.gov.au/GODAE

Box 39: Mercator-Ocean

French project

Mercator-Ocean is a French project built and operated under the auspices of a multidisciplinary consortium since 2002. It was founded to set up an operational system for describing the state of the ocean at any given time and at any place. Input for the Mercator system comes from ocean observations measured by satellites or *in situ* observations. These measurements are assimilated by the analysis and forecasting model. The assimilation of observation data in a model is used to describe and forecast the state of the ocean for up to 14 days in advance. The mission assigned to the project is to contribute to make the demonstration phase of the international GODAE experiment a success.

www.mercator-ocean.fr

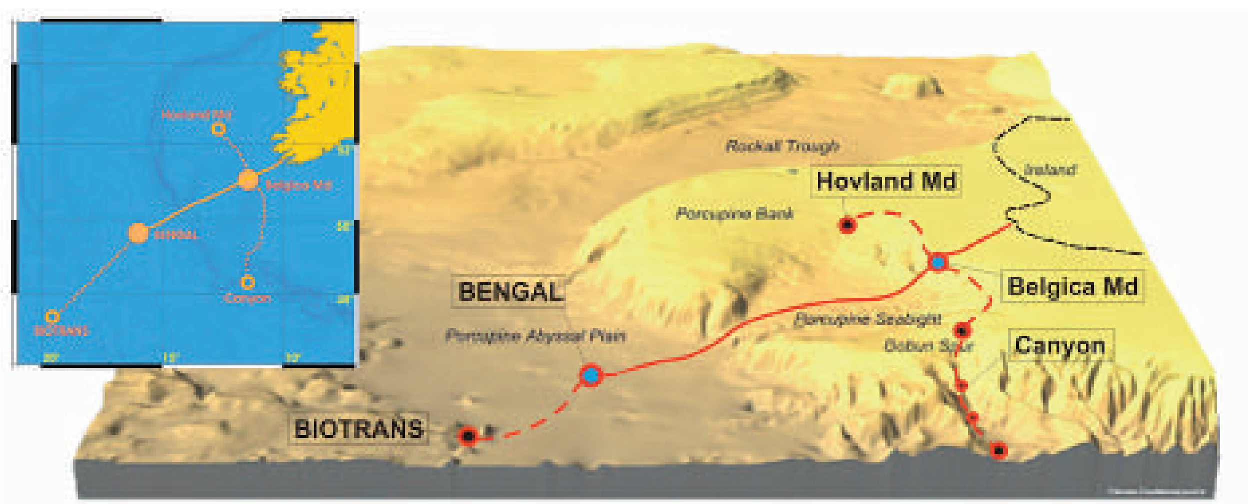


Ocean margin geological processes and geohazards

3.12. Europe's deep-ocean margin - where the continental shelf plunges from a depth of 200 m to the abyssal plain 4,000 m below - stretches for 15,000 km, from the Arctic to the Iberian peninsula, extending through the Mediterranean and into the Black Sea. European ultra-peripheral territories greatly extend Europe jurisdiction over the deep ocean's domain. The majority of Europe's deep-ocean margin frontier lies within Europe's Exclusive Economic Zone (EEZ) and the extended continental shelves of a number of Member States, and its biological, energy and mineral resources are of great strategic importance. Exploiting these resources in a sustainable manner requires a thorough understanding of the ocean margin ecosystem. Seabed operations such as those used for oil extraction and communication cables are susceptible to be damaged by geohazards, including gravity slides and deep canyon formation, earthquakes, volcanic eruptions on islands and sudden release of methane from gas hydrates. Deep ocean observation, tools and systems fitted with advanced geotechnical sensors are required to supply data on sediment dynamics, fluid circulation in the sediments and stability at ocean margins. The resulting information would contribute to improving risk assessment for submarine cables, hydrocarbon exploitation and other deep-sea operations. **Telecommunication and fibre-optic cabled networks for oil and gas platforms and offshore wind farms should be efficiently adapted to provide observation data on shelf ecosystems as well as for monitoring pollution, with clear benefits for marine science, technology and industry in Europe.**

3.13. Tsunamis propagate major risks induced by geohazards, and can cause massive fatalities (evidenced by the South-East Asian tsunami in December 2004, with an estimated 230,000 fatalities; that in Java Island, Indonesia, July 2006, with an estimated 650 fatalities; Box 40). Historical records show that European coasts, particularly those on the Mediterranean Sea and the Portugese Atlantic coast, are not immune to such risks. **Improved multi-risk monitoring and warning systems, better description of the tectonic faults and associated seismic activity, and identification of zones of sediment instability are essential for risk management of geohazards.** Assessment of the coastal risk depends on the mapping of local effects of tsunami waves, their propagation and sphere of impact. Particular emphasis has to be placed on developing effective decision-making processes for prevention and mitigation of natural disasters and the effective use of early warning systems. Education of coastal populations is crucial to reduce loss of human lives, as is effective timing and delivery of warnings to coastal communities, in an accessible and appropriate manner.

3.14. Research is required to analyse the role of gas hydrate reservoirs as dynamic components of the global carbon cycle, recharge and discharge fluxes and their controlling factors. There is a requirement to investigate the microbial processes involved in gas hydrate dynamics and the mechanism of gas hydrate thermodynamics, destabilisation and potential geo-climatic hazards and to evaluate the impact of gas hydrates on slope destabilisation *(see also 2.10, 2.13)*



A 1350 km glass fibre optical cabled network to monitor environmental changes on decadal scales in North East Atlantic

3. Europe's coastal zones, shelf seas, continental margins and biodiversity

Box 40: Tsunami Warning

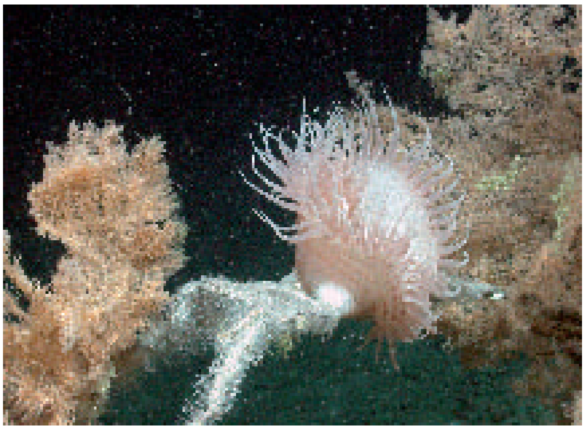
IOC/UNESCO initiative

Working with key partners at the international, regional, and national levels, the IOC of UNESCO runs the Pacific Tsunami Warning System (ICG/ITSU). This international ocean service supported by the International Tsunami Information Centre (IOC/ITIC) has, until now, been the only tsunami warning system anywhere in the world. Through the Member States of the IOC, this experience is currently being fast-tracked to help the Indian Ocean countries to benefit from an interim tsunami advisory system and to establish an Indian Ocean Tsunami Warning and Mitigation System (IOTWAS).

http://ioc3.unesco.org/indotsunami

Marine biodiversity: preserving the richness of the oceans

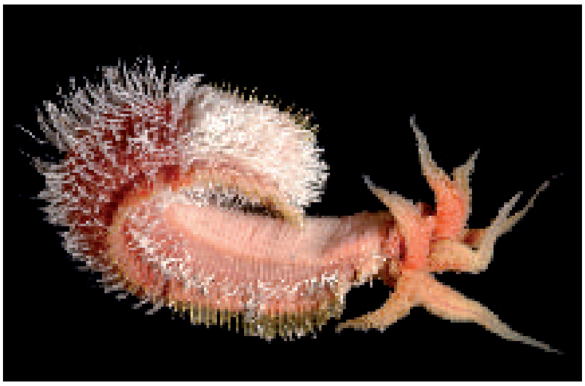
3.15. Quantifying and understanding biodiversity is among the most challenging scientific puzzles facing mankind today. While the pressures on biodiversity and associated species richness are global, many of its drivers are local (Boxes 41 & 42). As a result, potential solutions to address biodiversity loss often require detailed local or regional knowledge. Despite the fact that the oceans provide the habitat for over 90% of known global species (the gene pool of marine flora and fauna exceeds that of terrestrial flora and fauna), it is estimated that less than 5% of marine biodiversity is known, and several hundreds of new marine species are discovered each year. Diverse and original ecosystems are continuously being discovered in the ocean, including those in the deep ocean and in extreme environments. There is an urgent need for a global baseline assessment of marine biodiversity, including plankton. Such a baseline is necessary to provide a benchmark against which future changes can be measured and interpreted. **Support towards exploring and describing ocean biodiversity must be reinforced. This should be included within the frame of the Census of Marine Life (CoML; Box 43) initiative. There should be increased international effort to apply the most recent gene sequencing technologies to differentiate the range and inter-relationships of marine species.**



A live Actinian at 630 m depth on the West Rockall Bank

3.16. Marine biodiversity is increasingly impacted by dredging, pollution, over-fishing, hydrocarbon exploration and drilling, coastal development, climate change, etc. Little is known about the triggers of events such as spawning, diapause, migration, etc. for most species. Some triggers are temperature dependent, while others are light dependent, and several may be impacted on by climate change. To make reliable predictions of changes in ecosystem behaviour in response to external factors, knowledge of species-specific triggering mechanisms is essential. **For large-scale monitoring of biodiversity changes in Europe, marine biologists should focus on identifying and agreeing on sets of key indicator species (at different taxonomic levels), their niches and functional roles. Large-scale biogeographic distribution and biodiversity gradients should be mapped spatially and temporally in relation to oceanographic and geological parameters.** Areas identified as being of both high species diversity and genetic diversity should be the focus for conservation and management efforts, as should areas supporting key populations of rare species. In particular, a substantial effort in deterministic modelling of benthic habitats and species has to be elaborated. Research is necessary to identify the optimal designation of Marine Protected Areas (MPAs) and exclusion zones in shallow and deep waters. Particular attention should be afforded to establishing the functional biodiversity associated with extreme environments *(see also 5.1).*

3.17. Maintenance of large-scale European initiatives in marine biodiversity should be supported. Taxonomic keys require updating and links should be developed between numerical taxonomy, expert systems and genomic techniques. As retiring taxonomists are not replaced, and yet taxonomy is vital to research on all aspects of marine biology, there is a requirement to continue investment in taxonomic education, training and research and to establish effective career paths for taxonomists. The application



Alvinella pompejana, a deep sea species

of new biological identification technologies to a range of marine organisms will greatly improve the ability to identify taxa, resolve population structures and provide estimates of population sizes, and thus their status and evolution. Integration of genetic databases with predictive modelling is required to estimate the potential impacts of environmental risks, climate change and exploitation on marine biodiversity.

3.18. Europe's classical taxonomic archives, specimen and culture collections and genetic databases are still scattered and require support to enhance coordination. This is all the more critical since most such data are collected on small local scales, within the frame of short-lived projects. The European Register of Marine Species (ERMS) and EurOBIS (the European component of the CoML Ocean Biogeographic Information System) should be used to integrate these data.

Box 41: The Convention on Biological Diversity

United Nations Convention

The UN Convention on Biological Diversity commits governments to slow the decline in the richness of living systems by 2010. The Global Biodiversity Outlook (GBO), a report published under the UN Convention on Biological Diversity, states that unprecedented efforts will be needed to achieve this aim, and that virtually all indicators of the future diversity of life on Earth are heading in the wrong direction. The report sets out 15 indicators of progress towards the 2010 target, ranging from trends in the extent of wildlife habitats to the build-up of nutrients such as nitrogen which can harm aquatic life.

http://www.biodiv.org/default.shtml

Box 42: IUCN Red List

International initiative

The International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species provides taxonomic, conservation status and distribution information on taxa that have been globally evaluated using the IUCN Red List Categories and Criteria. This system is designed to determine the relative risk of extinction; the main purpose of the Red List is to catalogue and highlight those taxa that are facing a higher risk of global extinction (i.e. those listed as Critically Endangered, Endangered and Vulnerable).

http://www.iucnredlist.org

Box 43: Census of Marine Life (CoML) & European Census of Marine Life (EuroCoML)

International initiative

The Census of Marine Life (CoML) is a global network of researchers from more than 70 nations engaged in a ten-year initiative to assess and explain the diversity, distribution and abundance of marine life in the world's oceans – past, present and future. The emphasis of the programme is field studies, which are to be conducted in poorly known habitats as well as those assumed to be well known. By 2010, CoML field projects will integrate and synthesise their discoveries and conclusions, thereby producing a new global view of the biodiversity of the oceans. The European Census of Marine Life (EuroCoML) is a Regional Implementation Committee for CoML.

http://www.coml.org
http://www.eurocoml.org

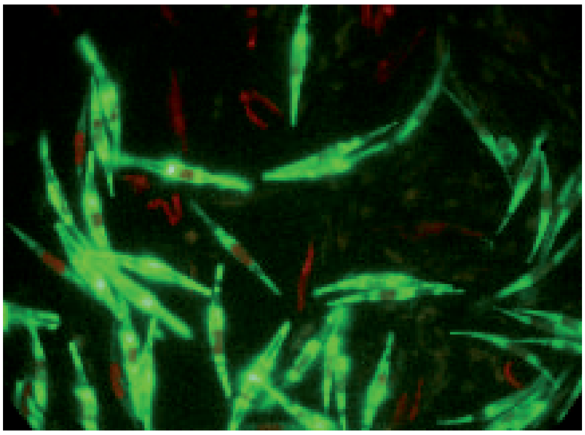
3. Europe's coastal zones, shelf seas, continental margins and biodiversity

Functional role of biodiversity

3.19. Long-term time series data of species and population distributions are critical for climate change studies. Many individual long-term data sets exist and are at risk of dissipation due to low funding priorities and commitment. **Long-term biodiversity data sets should be sourced and compiled as a vital European resource.** An understanding of the role of biodiversity and species composition in ecosystem functioning and community structure is necessary to improve modelling and predict changes in and responses of such communities to external factors including global climate change *(see also 4.6).*

3.20. Investigation into the nature of the links between biodiversity and ecosystem functioning is needed at all levels of organisation. This should be developed within the frame of international projects such as IMBER (Box 44) and existing projects funded by the European Union Sixth Framework Programme (FP6; Box 45). Research by fisheries biologists, ornithologists, mammologists, ecologists and marine conservation scientists should be coordinated to provide a broader ecological perspective and understanding of the seas and marine food webs. **There is a need for improved understanding of the relative importance of top-down regulation of marine food webs versus the traditional approach in which bottom-up control (by nutrients and primary production) is emphasised.** The role of the relatively few key marine vertebrates needs to be understood, as an efficient method of studying how species impact on ecosystem functioning, and as indicators of the status of marine environments. Several sets of definitions of functional groups should be developed, in order to address different issues, and allow further elaboration of ecosystem functioning. For example, impacts of climate change on marine ecosystems (e.g. the migration of plankton in the North Atlantic due to decreasing ice and an increase inflow of melt water) could have a negative impact on Arctic and sub-Arctic marine biodiversity.

3.21. Recent advances in functional genomics and systems biology, such as those developed in biomedicine, should be adapted for application in marine biology. This would include frontier technologies, such as array-based methods for analysis of genome variations, protein detection, nanotechnologies for single cell applications, RNA interference, bioinformatics tools, and numerical simulations *(see also 4.13)*.



The diatom Phaeodactylum tricornatum

Box 44: Ecosystem Research

Integrated Marine Biogeochemistry Ecosystem Research (IMBER)
International Geosphere-Biosphere Programme (IGBP) - Scientific Committee on Oceanic Research (SCOR) project

The goal of the IMBER project is to understand how interactions between marine biogeochemical cycles and ecosystems respond to and force global change. IMBER supports the study of processes within, and interactions between, the euphotic and mesopelagic layers of the ocean, the continental margins, and high-latitude and polar ocean areas.

http://www.imber.info

HERMES – (Hotspot of the Ecosystem Research on the Margins of European Seas)
EU FP6 IP

HERMES (45 partners from 15 European countries) is an international multidisciplinary research programme. HERMES studies hotspot ecosystems: discontinuous environments that are constrained by chemical, physical, topographic and geological factors and which contain a wealth of unknown species that thrive in insular habitats. Determining the distribution as well as the resilience of these ecosystems is important to producing plans for their sustainable management.

http://www.eu-hermes.net

Box 45: Marine Biodiversity projects funded by EU FP6

EUR-OCEANS (EURopean network of excellence for OCean Ecosystems Analysis)
EU FP6 NoE

The EUR-OCEANS network aims to achieve a permanent integration of European research organisations on pelagic marine ecosystems and global change in the relevant scientific disciplines. EUR-OCEANS aims to develop models for assessing and forecasting the impacts of climate and anthropogenic forcing on food-web dynamics (structure, functioning, diversity and stability) of pelagic ecosystems in the open ocean.

http://www.eur-oceans.org

MarBEF - Marine Biodiversity and Ecosystem Functioning
EU FP6 NoE

MarBEF, involving 83 partner organisations, is a platform to integrate and disseminate knowledge and expertise on marine biodiversity, with links to researchers, industry, stakeholders and the general public.

http://www.marbef.org

Other projects include:

ALARM (IP) is assessing the large-scale environmental risks for biodiversity posed by climate change, biological invasions, pollinator loss, environmental chemicals and socio-economic pressure. ALTER-Net (NoE) is building a long-term biodiversity, ecosystem and awareness research network from case studies across seven countries, while EDIT (NoE) is integrating European taxonomic efforts to create a top-class European virtual centre of excellence ia top-level European P6 also supported many smaller Specific Targeted Projects and Coordination Activities in biodiversity.

http://www.alarmproject.net/alarm
http://www.alter-net.info/default.asp
http://www.mnhn.fr/museum/foffice/science/science/Recherche

Microbial biodiversity

3.22. Marine microbes account for a substantial part of primary production in the marine environment, and represent more than 90% of the biomass in the oceans and seas. Almost nothing is known about marine microbial biodiversity (which includes archea, bacteria, fungi, protists, viruses), nor about changes in microbial diversity, either with time, spatially or with climate change. Marine microbes are also responsible for the far greater part of food web processes and the cycling of carbon and nutrients. They govern the biogeochemical cycles (CO_2, CH_4, N, S, Fe, etc.) and thus both impact on climate and are impacted on by climate change. **Microbial biodiversity differs very considerably between the different marine habitats (with varying depth, latitude, salinity, temperature, pressure, etc.), including sub-floor ecosystems. Research on microbial biodiversity is a fertile and very necessary area for prioritising future marine research commitments (see also 4.13, 5.1).**

3.23. Research is required to investigate the role of micro-niches and micro-scale dynamics in sustaining symbiotic consortia of micro-organisms, in the ocean, in marine sediments and in extreme environments. The effect of microbes on biogeochemical cycles, such as alteration of deep-sea basalts, anoxic methane oxidation, CO_2 fixation and carbon storage, have still to be described and quantified. The role of toxins, attractants, biopolymers, etc. in shaping pelagic microbial communities requires further investigation (Box 46). Recently developed techniques include a quantitative DNA analytical method which allows the total microbial biodiversity in a sample to be determined. This opens the possibility to monitor biodiversity and changes therein and to predict future biogeochemical cycles and thus future climate scenarios. **There is a requirement for further development of molecular biology and genomic techniques for *in situ* detection and monitoring of the biodiversity, abundance and activity of micro-organisms.**

3.24. Classification and detection of viral particles, investigating their behaviour in marine ecosystems and their infective impacts (on bacterial and phytoplankton blooms, vertebrates and human health) is of growing interest and should be further developed.

3.25. Research on the impacts of climate change on micro-organisms should include assessment of those species that: (i) are important in shaping the marine food web; (ii) control ocean biogeochemistry; (iii) have potential for bioprospecting and biotechnology; and (iv) have a potential human health impact (e.g. HABs) *(see also 4.6).*

Box 46: BIODEEP: Deep-sea brine interface

EU FP5 project

Research through BIODEEP (Biotechnologies from the Deep) has discovered flourishing diverse communities containing novel microbes in the brine lakewater column transition zone. The discrete stratified habitats of the brine lake interfaces constitute exceptional conditions in which novel organisms have evolved. Their phylogenetic diversity reflects their functional diversity. Exploration of these and other extreme environments, and characterisation of the biological properties of new organisms found, will lead to important discoveries about life processes and interesting new biotechnological applications.

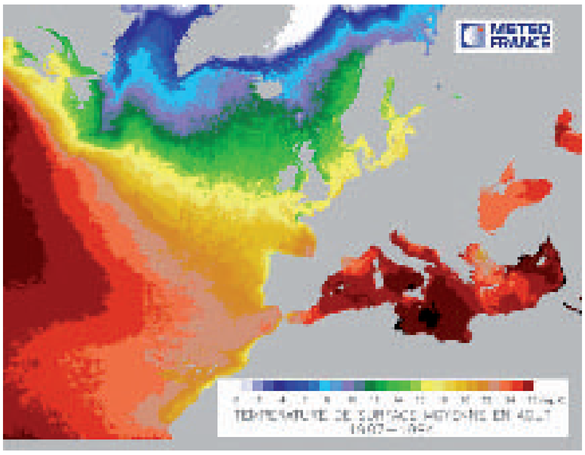
http://www.geo.unimib.it/BioDeep/Project.html

4. Ocean climate interactions and feedback

Climate change

4.1. The ocean is a crucial component of the Earth's climate system. It is the driver of many important climate processes on a range of time scales. Although there can be no certainty regarding the precise nature and rates of change in the marine environment due to alterations in climate, in the absence of policies and measures to prepare for these changes, even the more moderate of the predicted scenarios indicate major social and economic impacts. The 2001 Report of the Intergovernmental Panel on Climate Change (IPCC; Box 47) states that "*global climate change will affect the physical, biological and biogeochemical characteristics of the oceans and coasts, modifying their ecological structure, their functions and the goods and services that the oceans provide*". The Stern Review on the Economics of Climate Change (2006 Report to the UK Government) further reiterates this prediction, stating that climate change will have serious impacts on growth and development, and that the failure to address global warming will cost the global economy 3.68 trillion pounds sterling (5,500 billion euros) by 2050, triggering a catastrophic recession, unless it is tackled within a decade. Thus it is estimated that the effects of climate change would cost the world between 5% and 20% of GDP. Increasing dialogue between scientists and policy makers is necessary to allow assessment of whether there is sufficient sound scientific evidence on which to base new policies. Specialist workshops are required to address not only the environmental challenges that the scientists and policy makers face, but also the inevitable socio-economic repercussions associated with rising temperatures. To support the development of knowledge-based policies, there is a requirement for validated methods to turn data into information, in the form of integrated assessments and indicators, and for improved methods to assimilate data into climate models. This would improve reanalysis of climate variability in climate evolution over past decades. **The global nature and scale of the environmental and economic impacts of climate change emphasise the need for European research programmes to coordinate and integrate with the climate component of international research programmes, including CLIVAR, GLOBEC and IMBER (Boxes 44, 47, 48, 49 & 50).**

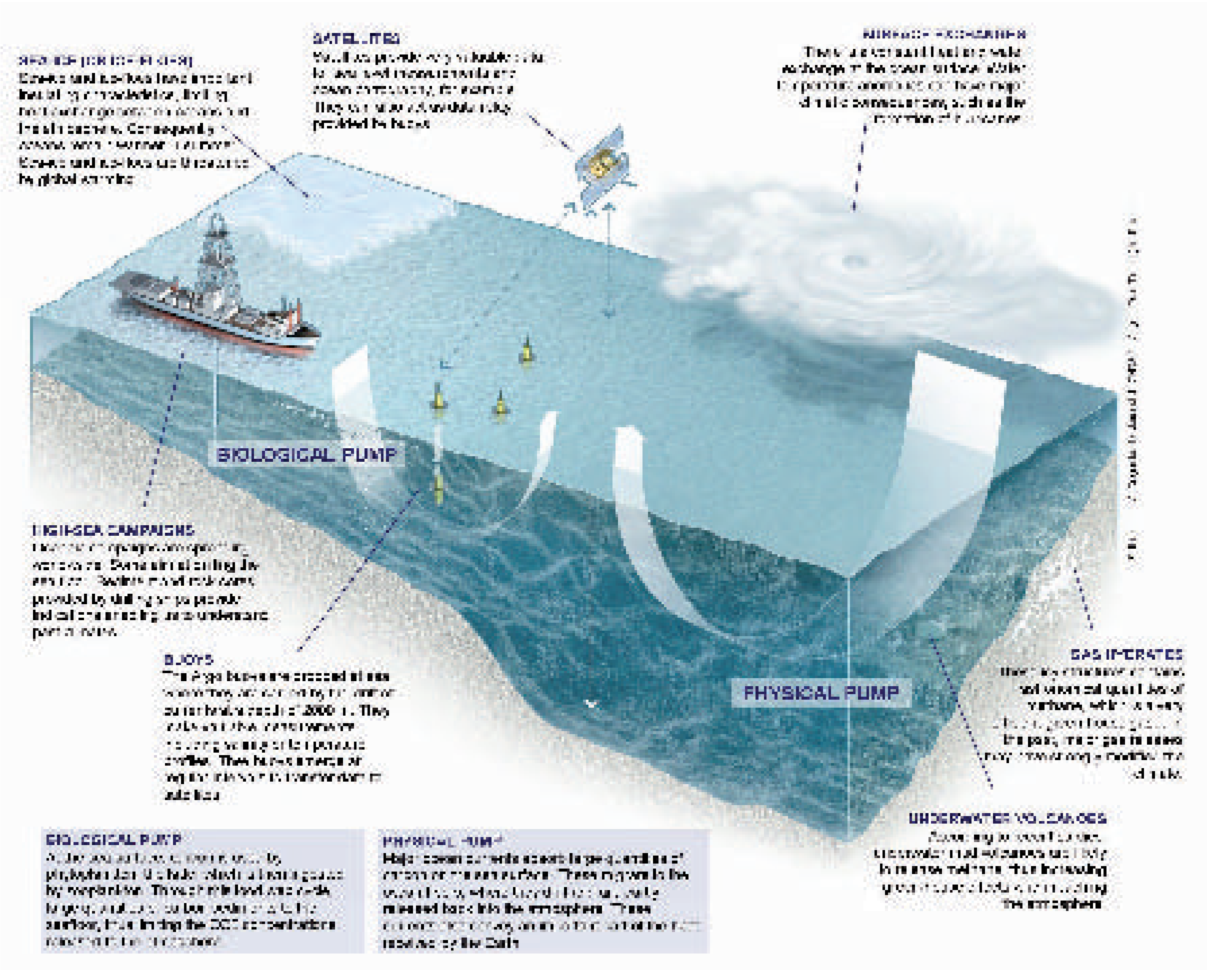
4.2. Palaeoclimate records provide an important tool for analysing the response of the climate system to internal and external forcing (e.g. greenhouse gases, volcanic activity and solar energy), and for understanding the physical, chemical and biological processes responsible for the changes. **Gathering the vast amount of palaeoclimate records into databases and their spatial and temporal analysis is necessary. In order to place the present status of the Earth's climate within an historic perspective of climate variability, the ability to develop numerical models of past climatic events requires further improvement and refinement. The combined use of palaeoclimate data and palaeoclimate models with fine spatial and temporal resolution will facilitate the recreation of past ocean climate scenarios, which will advance the understanding of the mechanisms of climate change. Research is required to improve the temporal resolution in the reconstruction of climate history of the ocean in scales from tens to hundreds of years. Continuous development of geochemical proxies is required for reconstruction of past surface CO_2 content, temperature, salinity, pH values and nutrients.**



August mean sea surface temperature 1987-1994

4.3. One of the potential effects of climate change is the change in intensity, frequency and location of extreme events, such as storms, tidal surges and extreme wave heights**. Improved definition of extreme events, their statistical analysis, definition of proxies for past events, identification of processes at play in their generation, and the identification of their variability and trends, all need to be developed. Observing networks provide crucial contributions to monitoring and forecasting extreme events, and require further development.**

4.4. As well as the development of improved simulation models of climate variability and its effects, there is a requirement for the development of long-term capabilities for climate observation. **Detecting the actual phenomena, understanding in more detail the processes at play, such as the Pacific El Niño Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO) and their**



Ocean climate interactions

potential change in frequency and intensity, is critical. To support climate change research, new observational and measurement sensors and systems need to be designed, including sensors for air-sea interactions of specific substances. With observation networks in place, there will be a requirement for new methods to assimilate data into Atlantic and Mediterranean circulation and climate impact models.

4.5. There is a need to improve the use of existing data on physical, chemical and biological status in the field of operational oceanography modelling tools**. To support development of climate change models, an open data policy is needed, with timely and improved access to data.** Data access should include near real-time, high frequency sea-level data from tide gauges, satellite missions, and *in situ* observation systems, including pictures of changes in plankton assemblage compositions and ocean colour data. Efforts in data archaeology, to retrieve and make accessible historical sea-level records, should also be supported.

4.6. The impacts of climate change on functional biodiversity are unknown. Developing the capability to predict the response and feedbacks of marine biota to climate change is required. Research is needed to assess how marine ecosystems' structure (e.g. foodwebs, population size and distribution) and functioning (e.g. biomass, production, decomposition) will change under current predictions of climate change. **Experimental and numerical studies using climate-simulating mesocosms are required to unravel the basic biogeochemical links and responses of climate-critical plankton species (e.g. diatoms, coccolithophorids, N_2 fixers, DMS producers, bacteria, viruses, archaea) to physical and chemical drivers of climate change (e.g. temperature, pH, CO_2, solar radiation) and the associated biogeographic consequences.**

Box 47: International Framework Initiatives on Climate Change

International Geosphere-Biosphere Programme (IGBP)
IGBP is an international scientific research programme which studies the interactions between biological, chemical and physical processes and human systems. IGBP collaborates with other programmes to develop and impact the understanding necessary to respond to global change.

http://www.igbp.kva.se

Intergovernmental Panel on Climate Change (IPCC)
The World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) in 1988 to address potential global climate change. IPCC is open to all members of the UN and WMO.
The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. The IPCC does not carry out research nor does it monitor climate related data or other relevant parameters. It bases its assessment mainly on peer reviewed and published scientific/technical literature.

http://www.ipcc.ch

The World Climate Research Programme (WCRP)
The World Climate Research Programme, sponsored by the International Council for Science (ICSU), the World Meteorological Organisation (WMO) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO, is positioned to draw on the totality of climate-related systems, facilities and intellectual capabilities of more than 185 countries. The two overarching objectives of the WCRP are to determine the predictability of climate and to determine the effect of human activities on climate.

http://wcrp.wmo.int

Box 48: GLOBEC - Global Ocean Ecosystem Dynamics

GLOBEC was initiated in 1991 to understand how global change affects the abundance, diversity and productivity of marine populations representing a major component of oceanic ecosystems.
As part of the International Geosphere-Biosphere Programme (IGBP), the aim of GLOBEC is to improve the understanding of the structure and functioning of the global ocean ecosystem, its major subsystems, and its response to physical forcing so that a capability can be developed to forecast the responses of the marine ecosystem to global change.

http://www.globec.org

Box 49: CLIVAR

World Climate Research Programme (WCRP) 1995-2010

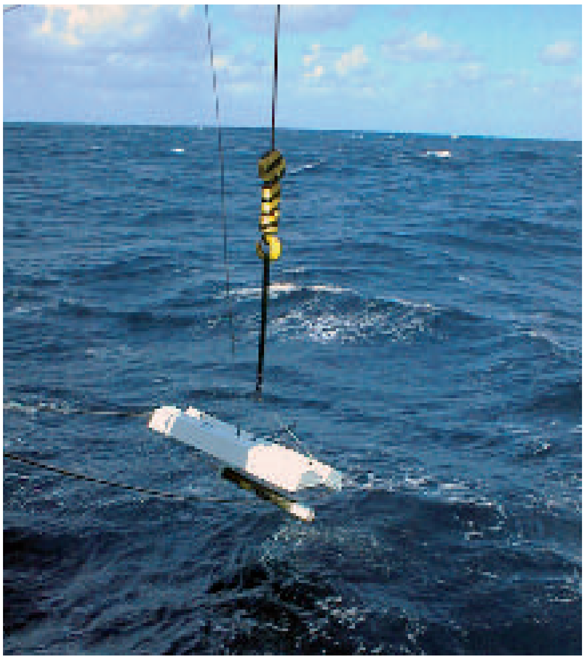
CLIVAR (Climate Variability and Predictability) is an international research programme investigating climate variability and predictability on timescales ranging from months to decades and the response of the climate system to anthropogenic forcing.
CLIVAR aims to:
1. Describe and understand the physical processes responsible for climate variability and predictability on seasonal, interannual, decadal, and centennial time-scales, through the collection and analysis of observations and the development and application of models of the coupled climate system, in cooperation with other relevant climate-research and observing programmes;
2. Extend the record of climate variability over the time-scales of interest through the assembly of quality-controlled paleoclimatic and instrumental data sets;
3. Extend the range and accuracy of seasonal to interannual climate prediction through the development of global coupled predictive models;
4. Understand and predict the response of the climate system to increases of radiatively active gases and aerosols and to compare these predictions to the observed climate record in order to detect the anthropogenic modification of the natural climate signal.

http://www.clivar.org

Ocean-atmosphere coupling and the ocean thermohaline circulation

4.7. The ocean circulation in the North Atlantic plays a fundamental role in the coupled ocean-atmosphere system which results in the present temperate climate of Western Europe. The Atlantic Thermohaline Circulation (THC), or North Atlantic Current (one of the strongest ocean currents in the world), refers to a key regional heat engine mechanism partly responsible for allowing some areas of Europe to experience a climate 10°C higher than areas at similar latitudes (Box 50). There are indications that this system can change dramatically on a time scale of one to two decades, with far-reaching consequences. Observations of decadal changes in the THC, and of the subsurface heat fluxes in the North Atlantic, have been described. Models and recent observations suggest that the THC may be weakening in response to greenhouse forcing. It has already been shown that the circulation of the North Atlantic Current has slowed by 30% over the last 12 years, and that part of this current came to a 10 day halt during November 2004, the most abrupt change on record. **Prototype observational experiments should be transformed into multidisciplinary long-term observational networks to monitor the evolving dynamics of the system. Research effort is required to focus on key Arctic and sub-Arctic deep water formations, gateways and pathways for the out-flows of cold dense water, and return flows of warm surface currents in the world ocean (see also 5.7).**

4.8. Over the last two decades climate models have predicted that the impact of global warming caused by elevated atmospheric CO_2 would be stronger and faster in the Arctic. Climate simulation models currently show that with a doubling of atmospheric CO_2 (predicted to happen by 2080) Arctic sea-ice could disappear in the summer months. During the winter months, the reduction in sea-ice may be up to 20%, resulting in the opening of the now seasonally ice-covered Barents Sea to shipping. Climate change will thus induce dramatic changes to the economy of the areas bordering on regional seas, impacting on local communities, fishing practices, maritime transport and oil exploitation. **Efforts should be directed towards research on impacts of climate change on regional seas (e.g. the Artic, Nordic, Baltic and the Mediterranean Seas) as these are areas where the effects of climate change would impact most immediately on Europe. Global models of ocean-climate coupling and the THC should be downscaled to incorporate: (i) flux-critical processes of subduction, convection, overflows and boundary currents; (ii) teleconnections between the Pacific El Niño and the NAO, and between the NAO-IO (North Atlantic Oscillation - Indian Ocean) dipole and Mediterranean climate; and (iii) greenhouse forcing: the responses of European seas, and its local and regional impacts.** As the Mediterranean Sea is a region in between the Atlantic and the Indian climate regions, capturing the specific modes of climate variability in this region is necessary. The impact of outflow of Mediterranean waters into the Atlantic and their behaviour in the Atlantic Iberian region requires particular attention.



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Float deployment

4.9. The ARGO experiment (Box 37), with its *in situ* global array of profiling floats recording oceanographic data, demonstrates the feasibility of providing a world-scale near real-time tri-dimensional observation of ocean hydrographic parameters. **Through EURO-ARGO Europe should actively contribute to the global ARGO experiment to provide hydrographic observations in the long term, both for operational oceanography and for monitoring climate change.** The development of more cost-effective profilers would help to extend the ARGO array of profiling floats and to implement the ARGO system.

Box 50: Rapid climate change (RAPID joint initiative)

UK, Norway, Netherlands joint initiative

Funding agencies from the Netherlands (NWO), Norway (RCN) and UK (NERC) have established a joint initiative for funding research related to the ThermoHaline Circulation (THC) and rapid climate change in the North Atlantic region, which is linked to the UK programme RAPID. The RAPID programme aims at assessing the variability of this system and its sensitivity for changes in external forcing such as wind, temperature, atmospheric pressure, inflow of fresh water.

http://www.noc.soton.ac.uk/rapid/index.php

Box 51: Marine carbon sources and sinks assessment: CARBOOCEAN

EU FP6 IP

The aim of CARBOOCEAN (47 partners) is to determine the ocean's quantitative role for uptake of CO_2. The resultant knowledge is essential to provide a quantitative evaluation on the expected consequences of rising atmospheric CO_2 concentrations. Increased ocean acidification also affects the ability of cold water corals, shellfish, starfish and sea urchins to make their calcium carbonate exoskeletons and shells, and reduces the amount of dissolved oxygen available, impacting on activity of invertebrates and fish. The outcome of the project will guide the development of appropriate mitigation actions, such as the global management of CO_2 emission reductions within a global context.

http://www.carboocean.org

Ocean biogeochemical impacts and feedbacks in a greenhouse ocean

4.10. Estimates of current absorption of anthropogenic CO_2 into the ocean are still uncertain and have recently been re-evaluated; the ocean is the dominant sink for anthropogenic CO_2, as it has taken up 50% of anthropogenic CO_2. Greenhouse scenarios predict a globally warmer, more stratified and more acidic upper-ocean that could significantly reduce both convective and biogeochemical export sinks of atmospheric CO_2 into the deep ocean. This would accelerate accumulation of CO_2 in the atmosphere, with an associated risk of accelerated greenhouse warming. Increasing CO_2 levels are leading to a decline in seawater pH to levels that have not existed in at least 20 million years, so the oceans are becoming increasingly acidic. Ocean acidification not only changes the distribution of dissolved carbon species but also impacts on plankton, which could affect carbon uptake by primary production. Plankton absorb CO_2 from the atmosphere, and in so doing help to counter global warming. With a decrease in plankton diversity and population density, the oceans will absorb less CO_2 from the Earth's atmosphere. Research to profile status of phytoplankton assemblages is required. **To reliably predict future CO_2 levels, research is necessary to further elucidate these mechanisms, and to estimate absorption limits and oceanic budgets for anthropogenic CO_2 under greenhouse scenarios (Box 51).**

4.11. The United States, Japan, UK and Norway are developing experiments to assess whether deep ocean disposal of liquefied CO2 (carbon sequestration) and iron fertilisation, can be used for large scale removal of CO2 into the deep ocean. **Europe should conduct independent studies and evaluations, so that there can be an objective debate on the environmental feasibility, usefulness, ethics and impacts of ocean carbon sequestration.** Interactions between decision makers, scientists, environmental NGOs and the public should be promoted to facilitate the development of the most appropriate approaches towards such sensitive issues.

Ventilation of marine biogases and fertilisation feedbacks

4.12. Research is needed on current air-sea fluxes of climatically critical biogases (CO_2, DMS, N_2O, CH_4), particularly on their regional and seasonal variability, to enable a global assessment of their role in climate change. **The biogenic sources, distributions and pathways responsible for production, transformation and flux of climatically reactive marine biogas compounds should be investigated and modelled under present and future climate conditions.** This effort should be developed as a contribution to the SOLAS international programme (Box 52).

4.13. There is a requirement to further develop coupled physical biogeochemical ocean climate models that incorporate carbon speciation and nutrient dynamics. This would allow prediction of changes and feedbacks in global and regional ocean productivity under various greenhouse scenarios. In particular, in view of the importance of medium- and small-scale phenomena for primary productivity, it is necessary to assess how their inclusion in climate models could be made.

4.14. Single-celled marine organisms (archaea, bacteria, phytoplankton, etc.) are abundant, diverse and productive and are the principal drivers of marine and global biogeochemistry. **Support should be directed towards adapting biogeochemical gene probes, coupled with phylogenetic probes, to enable the application of high-throughput bioanalytic technologies (e.g. analytical flow cytometry, microarrays) for use onboard ship during large-scale oceanographic expeditions for exploration of microbial biodiversity, and assessment of food web dynamics and biogeochemical feedbacks in diverse oceanic environments** *(see also 3.23, 5.4)*.

Box 52: Surface Ocean-Lower Atmosphere Study (SOLAS)

International programme

SOLAS (Surface Ocean-Lower Atmosphere Study) is an international initiative to carry out research at the interface between the oceans and the atmosphere. SOLAS is focused on processes at the air-sea interface and includes a natural emphasis on the atmospheric and upper ocean boundary layers, while recognising that some of the processes to be studied are linked to significantly greater depth scales.

http://www.uea.ac.uk/env/solas

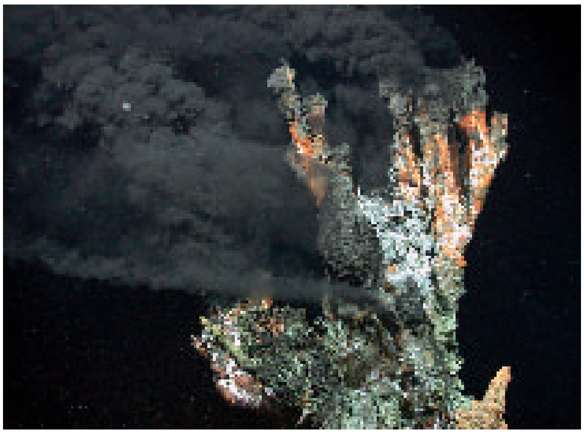
5. New frontiers in marine science

Life in extreme marine environments

5.1. Increasing Types of marine ecosystems are being discovered in the extreme environments of the ocean, including areas characterised by very cold or very hot water temperatures, absence of light, extreme chemical conditions (e.g. anoxic waters, methane- or hydrosulphide-rich water, salt brines, trace metals) and extreme property gradients. Examples of ecosystems supported by such environments include those associated with sea-ice, hydrothermal vents, cold seeps, carbonate mounds, deep cold-water coral reefs, deep sediments, mud volcanoes and gas hydrates. The presence of life and the diversity of living organisms in extreme environments raise a number of fascinating questions regarding the origins of biodiversity and community associations, the structure of food webs, physiological and genetic adaptations of species, and the establishment and dynamics of ecosystems with changing environmental conditions. **Research on microbial, invertebrate, vertebrate and other populations supported by these extreme habitats should be supported, and should be carried out in an interdisciplinary manner, concurrent with geological and oceanographic surveys.**

5.2. Exploration of extreme environments, and characterisation of the biological properties of the new organisms found therein will lead to important discoveries about life processes, with potential for interesting new biotechnological applications. Investigating specific adaptations of organisms to a range of extreme conditions found in ocean habitats is very relevant in terms of societal benefits as some properties of these organisms have clear potential for industrial applications (e.g. pharmaceutical, cosmetics, textile, agro-alimentary or industrial processes). Researching ecosystems supported by extreme environments is also of relevance towards improving our understanding of the evolution of life on geological time scales and predicting biodiversity and biogeographical changes induced by climate change *(see also 2.10, 2.13, 3.6, 4.6*).

5.3. The establishment of *in situ* observatories is required to elaborate baseline studies, supporting the implementation of an ecosystem approach to the management of deep ocean resources. Improved long-term observations of key biomarkers and xenobiotics at specific deep ocean locations will increase understanding of how the flux of material from land, or the alteration of surface ocean processes, ultimately affects deep-sea ecosystems. Such information will be necessary to guide the identification and management regimes for deep-sea Marine Protected Areas (MPAs).



©MARUM / University of Bremen

Black smoker from the Logatchev Hydrothermal Vent field, Mid Atlantic Ocean

5.4. It is necessary to develop new technologies for observation, sampling and experimentation in the ecosystems of the deep ocean (including advanced genomics and molecular biology technological capabilities), as well as techniques for cultivation of organisms from extreme habitats. **Deep ocean vehicles and observatories should be continuously developed and deployed with new sensors, *in situ* experimental and monitoring capabilities and two-way telemetry for remote exploration, experimentation and monitoring of extreme ecosystems and their response to climatic and episodic events.** In parallel, because of the difficulty in accessing these environments, and the associated high costs incurred, it is important to invest in laboratory simulation techniques and facilities.

Deep ocean geophysical and biological processes: the deep-sea frontier

5.5. The deep oceans, with an average depth of 3.7 km and millions of square kilometres of abyssal plains, represent the largest set of environments on Earth. At the same time, the deep oceans are by far the least studied part of our planet. They play a crucial role in the biogeochemical cycling of carbon and nutrients, they represent areas of high species biodiversity and contain important biological, mineral and chemical resources (Box 53). The ocean floor, as the interface between the biosphere and geosphere, represents a niche of important biogeochemical processes. The slow growth, long life span and late maturity of many deep ocean eukaryotic species make the system extremely vulnerable to impacts of human activities (e.g. deep-sea fishing). **The investigation of the (micro)biological processes in the oceans (including particle transfer and their exchange with water) and sediment/water interface requires the development and implementation of new suites of instruments.**

5.6. Understanding hydrothermal phenomena along mid-ocean ridges requires quantification of the transport of material and energy in hydrothermal systems and improved modelling of fluid convection systems in the oceanic crust. Distinction between fluids originating from heated sea water and those released by fractional crystallisation of underlying magma is required. It is necessary to understand and quantify the influence of fluids on seawater composition. Research towards understanding primary generation of hydrocarbons at mid-ocean ridges and considering the volumetric importance of oceanic serpentines, the associated catalytic reactions and the resulting fluxes, requires attention.

5.7. The thermal structure and fluid regimes in areas of colliding plates should be further investigated. **Quantification of the contribution of cold vents to the geochemical balance of various elements with fluids is required (i.e. how much carbon, sulphur, water and halogens are introduced into the ocean). Transport paths in the sediments and the respective contributions of focused and diffuse dewatering are still poorly understood and require further research, as do: (i) biological mediation of precipitations at fluid flow sites; (ii) periodicity and transient effects; (iii) integrating early diagenetic material fluxes in models of ocean circulation; and (iv) the relationship between flow, tectonics and earthquakes.**

Box 53: Deep-sea research

EU FP5 and EU FP6

Research funded through the EU Framework Programme seeks to enhance the understanding of the interaction between deep-water circulation, the biosphere and the geosphere, with a view to assessing the role of deep ocean margin ecosystem processes in global change and to develop concepts and strategies for the sustainable use of the deep offshore resources. Initiatives include:

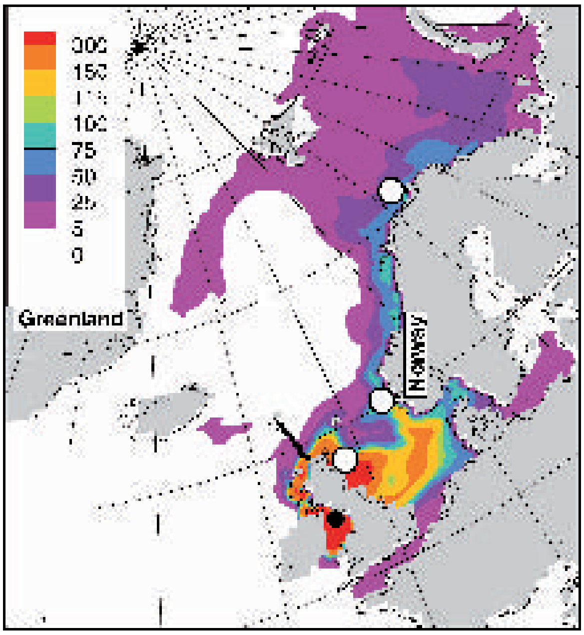
- **ESONET** FP5 (the European Seafloor Observatory Network, EU FP 5 project) established the basis for a network of long-term, seafloor and multidisciplinary observatories at key locations on the European margin;
- **ESONIM** (European Seafloor Observatory Network Implementation Model, EU FP6 SSA project) suggests the appropriate legal structures to establish a seafloor observatory that conforms to the model defined within the ESONET thematic network;
- **ESONET** FP6 (European Seas for Observatories NETwork, EU FP6 NoE) seeks to establish a European underwater ocean observatory system, extending into deep water capable of monitoring biological, geo-chemical, geological, geophysical and physical processes occurring throughout the water column, the seafloor interface and the solid earth below. ESONET will contribute towards the sub-sea segment of the **Group on Earth Observation** (GEO) initiative and it would also provide research data for the Global Monitoring for Environment and Security (GMES) system;
- **Deep-Seafloor Frontier** (Deep-SF), which has arisen from ECORD, aims to integrate European research on ocean margins and their ecosystems, ocean drilling science and seafloor observations and monitoring. It promotes common use of infrastructures in international, national and European initiatives including: **ECORD**, **ESO**, **EuroMARGINS**, national margins programmes and **HERMES**;
- **European Multi-disciplinary Seafloor Observatory** (EMSO) identified by ESFRI as a candidate research infrastructure.

http://www.ifremer.fr/esonet
http://www.oceanlab.abdn.ac.uk/esonet/esonim.shtml
http://www.ecord.org/enet/deepsea-frontier

Arctic seas and the International Polar Year (2007-2008)

5.8. The Arctic is a unique region, a critical area for the formation of oceanic deep water, a key region for regulating European climate, and fundamental to our understanding of the global climate system and climate variability. The Arctic seas support large fish stocks, and are affected by pollution which originates from the European landmass, including airborne pollution from Europe and radioactive Caesium originating from discharges into the Irish Sea. Arctic geophysics is one of the least known on Earth, while specific ecosystems with major paleo-evolutions are found in Arctic seas. Arctic climate and ecosystems are evidently changing with the diminishing extent and thickness of sea-ice, and with changes in seasonal inputs of freshwater from Siberian rivers. Arctic regions are remote and inhospitable, and remain insufficiently studied, yet they are an integral component of the Earth' system. Operationally, the Arctic is an extreme environment; the ice cover prohibits the use of many conventional instruments, data transfer methods and calibration schemes. Thus, research in Arctic seas represents a real frontier for marine research. **Increased effort is required to adapt and transfer for use in the Arctic those technologies devised for deployment elsewhere. Improved understanding and preservation of the Arctic ecosystem is of high priority in Europe.**

5.9. Arctic sea-ice plays an important role in regulating climate change through feedback mechanisms (Box 54). Sea-ice cover in Arctic regions has decreased by 3% per decade since 1978, while multi-year sea-ice cover has decreased by 7% per decade. The melting Greenland ice sheet represents a possible increase of 60% freshwater flow into Arctic and Atlantic seas, with resultant impacts on species biogeography (including phytoplankton and their capacity to absorb CO_2) and Atlantic THC. At a particularly sensitive time in the Earth's history, due to the emergence of global warming, International Polar Year (IPY; Box 55) intends to develop an internationally coordinated research campaign. **Europe should make a concerted effort to develop research in Arctic seas in partnership with many other countries, in particular the Russian Federation. Arctic studies should be further elaborated within the frame of the International Polar Year in 2007-2008.**



© Gao et al., 2004

Spreading of radioactive Caesium discharge from Sella field, UK


© Lars Horn / Marine Board-ESF

Research Vessel en route to Svalbard, the Arctic

Box 54: Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies (DAMOCLES)

EU FP6 IP

DAMOCLES (45 European research institutions and 8 SMEs from 12 European countries including Russia, in association with the USA, Canada and Japan) aims at reducing the uncertainties in understanding climate change in the Arctic and the associated impacts. DAMOCLES is specifically concerned with the potential impacts that a significantly reduced sea-ice cover may have on the environment and on human activities, both regionally and globally.

http://www.damocles-eu.org

Box 55: International Polar Year 2007-2008

International Initiative

The 2007-2008 International Polar Year (IPY) is planned as the biggest internationally coordinated research effort of the past 50 years, involving thousands of scientists from 60 countries focussing their attention on the polar regions. IPY, co-sponsored by the International Council for Science (ICSU) and the World Meteorological Organisation (WMO), is endorsed by 31 national and more than 16 scientific bodies and organisations. It will build on the success of International Geophysical Year (1957), which resulted in initiatives such as the Antarctic Treaty and discovery of the thickness of ice sheets. IPY will focus on the science of the polar regions and on the human dimension of polar change. Topics will range from the ecology of polar oceans to the dynamics of massive ice sheets and their effect on global sea level, and the impact of space weather on global communications.
The six major research themes for IPY are :

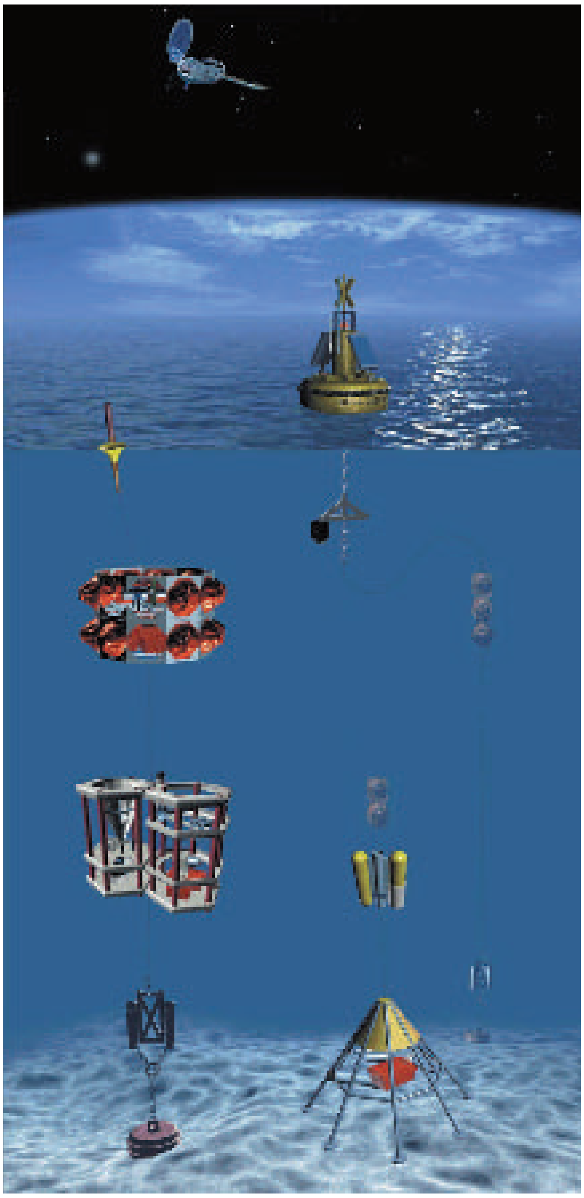
4. Status: to determine the present environmental status of the polar regions
5. Change: to better quantify and understand past and present natural environmental and social change in the polar regions, and to improve projections of future change
6. Global Linkages: to advance understanding of the links and interactions between the polar regions and the rest of the globe, and the processes controlling these
7. New Frontiers: to investigate the frontiers of science in the polar regions
8. Vantage Point: to use the unique vantage point of the polar regions to develop observatories from the interior of the Earth to the Sun and the cosmos beyond
9. Human Dimension: to investigate the cultural, historical and social processes that shape sustainability of circumpolar human societies, and to identify their unique contributions to global cultural diversity and citizenship.

http://www.ipy.org

6. Critical technologies

6.1. Marine research and oceanography are critically dependent on advanced technologies to observe and understand ocean ecosystem dynamics and processes. **Research on marine technology should be supported to: (i) further assess, convert and apply novel miniature sensors arising from developments in physics, bioanalytics, and nanotechnology** (these would be particularly useful for *in situ* measurements of chemical and biological parameters); **(ii) transfer new developments from advanced material science to marine technologies** (notably to address issues such as biofouling, material corrosion or material ageing); **(iii) develop long-lived, easy to use and cost-effective in situ instruments, including novel sampling devices such as micro-sampling devices; (iv) standardise interfaces of system components, including two-way communication; and (v) network national calibration facilities** *(see also 2.3, 2.4, 2.11, 2.13, 3.7, 3.12, 3.21, 4.2, 5.3, 5.4)*.

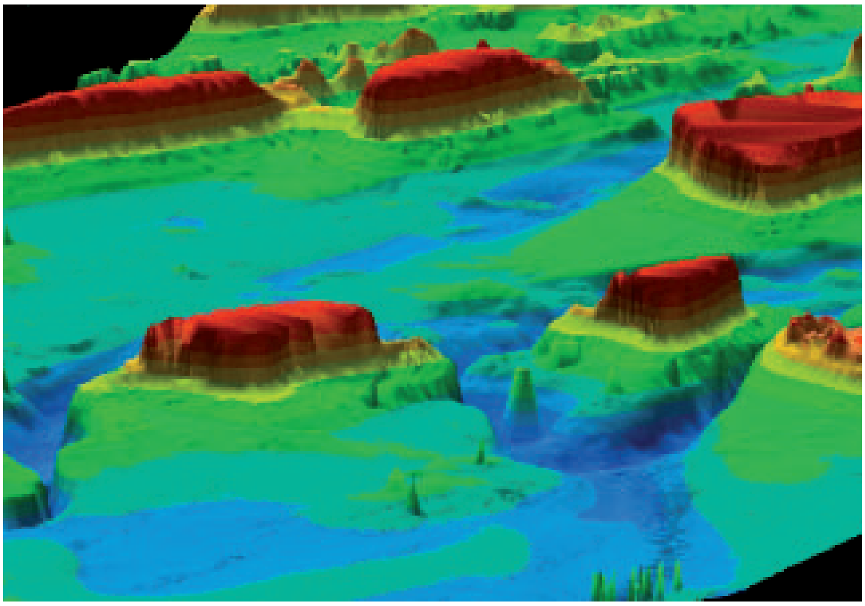
6.2. The level of monitoring of the ocean is insufficient, as operational limitations of conventional ocean observing platforms restrict monitoring at adequate spatial and temporal resolutions. **The development and operation of multi-parametric ocean observatories and monitoring systems is required to: (i) monitor the oceans and regional seas in the context of climate change; (ii) study marine ecosystem functioning; (iii) implement warning systems related to geo-hazards; and (iv) assess the sustainable use of marine resources, including in the frame of the ecosystem approach to fisheries.** Observing capacity should involve both *in situ* and shore-based aspects, and include the water column as well as seafloor processes. **All these *in situ* observing systems should become components of the GEOSS initiative** (Box 20). A special effort should be made to ensure a visible and effective technology contribution by Europe to enhanced monitoring capability, as well as the implementation of observatory networks aiming to include a large variety of *in situ* sensors to reduce human intervention, allowing remote control, and real-time data availability. In this context, special attention should be given to bio-logging technologies *(see also 2.3, 2.11, 2.22, 2.24, 3.7, 3.8, 3.13, 3.16, 3.19, 4.4, 4.7, 5.3, 5.4, 5.5)*.



The DOMEST system for observing material transport at the sea bed includes traps, video, profiling CTD and other sensors, with acoustic and satellite retrieval of data using bi-directional communication

6.3. Remotely Operated Vehicles (ROVs) as well as Autonomous Underwater Vehicles (AUVs) (Box 56) represent important ocean observing tools which have great potential for further development. The trend is towards developing more capable, autonomous and sophisticated instruments (with increased precision and multi-tasking applications), with the ability to collect large amounts of data (in near real-time) at increased depths. Current developments are aimed at units which can travel to full ocean depth and be deployed onto specific locations. Ultimately, research vessels should have a set of instruments, so that they can deploy more than one instrument during any given cruise, thereby increasing the productivity of that particular research exercise. The use and maintenance of such equipment imply increasing investment, as

Deployment of Isis deep ocean ROV



Seabed mapping using airborne lidar – Clew Bay

does the associated requirement for highly skilled and trained operators and technicians. Associated technologies include those involved in determining potential energy sources and efficiency, motorisation, robotics, cabled networks as well as a panoply of instruments and sensors. It is important to note that increasing capability and autonomy of these vehicles is also of interest to the maritime industry for operational purposes (including inspection of pipelines and cables, etc). New technological developments in the design of gliders (autonomous ocean observing platforms which are steered remotely and carry out continuous ocean measurements at high spatial and temporal resolution) open up new opportunities for research and for the development of ocean and coastal services.

6.4. Software technologies must be continuously adapted to meet the needs of marine science. This includes embedded intelligence for instruments and observatories, new data processing and management techniques, as well as new algorithms and methods for numerical modelling, data assimilation and presentation (e.g. 3D and hologram technology). In particular, elaboration of ecosystem models are required for many applications and need to be developed further *(see also 2.1, 2.3, 2.22, 3.4, 3.7, 3.13, 3.17, 4.4, 4.8, 4.13)*.

6.5. Improved effectiveness in industrial partnerships would accelerate the development of new technologies, as would the use of appropriate marine instruments and software and their availability to marine scientists. Improved knowledge and use of technological capabilities developed in other fields of science and industry (for example in the fields of robotics) would be beneficial to the marine science community. Opportunities exist for the development of diagnostics and biosensors for use in quality assessment of the marine environment and of its products. The research community should enlarge its partnership in such a way that observing and monitoring systems should be conceived and planned in association with private sector commercial interests. Interactions and synergies should be deepened so that marine infrastructures could be available to a range of users (fisheries, defence, and environment), increasing efficiency and cost effectiveness.

Box 56: Marine engineering: recent developments

Autonomous Underwater Vehicles (AUVs) are playing an increasing role in oceanography: they have been built to range extensively through waters nearer to the surface. One advantage of AUVs is that they can survey remote environments that are inaccessible to Remote Operated Vehicles (ROVs) and other submersibles. In polar sciences for instance, the main way to obtain a detailed and widespread view of conditions and processes beneath ice shelves is to use an AUV (e.g Autosub [NERC-NOC]). AUVs can collect physical, chemical, biological and geophysical data from the ocean surface to the seabed using a suite of sensors and sampling devices tailored to individual mission requirements.

Gliders are autonomous submarine vehicles designed to observe for long time periods the interior of vast ocean areas at a lower cost than oceanographic ships and moorings. Gliders could provide a network of small, intelligent and cheap observing platforms to fill the gaps left by the other observing platforms. Changing buoyancy together with the hydrodynamic structure allow gliders to carry out saw-tooth trajectories between the ocean surface and a prescribed depth along prescribed directions. When the glider is at the surface, positions obtained by GPS and the data collected at depth are transmitted to the land base via a two-way satellite communication system. The use of gliders would be particularly appropriate in under-sampled regions, such as the Arctic, and in difficult conditions.

http://www.mersea.eu.org/index.html

Sensors. Reviews and workshops on marine technology invariably conclude that marine chemists and biological oceanographers lack the suitable sensors necessary to advance their area of science: link physical, chemical and biological processes to climate variability. While there are many ongoing projects in the field of wet chemical analysis there is a lack of emphasis on low consumption and rapid sampling which are needed for modern platforms.

http://www.noc.soton.ac.uk/OED/usl_index.php? page=cs

7. Research infrastructures

7.1. Marine science requires a large variety of specialised and expensive infrastructures, including research vessels, satellites, observing networks, data centres, computing and experimental facilities. The specialised infrastructures necessary to support marine research represent an estimated 50% of investment in marine research. The level of infrastructure available to marine research affects its competitiveness and performance; well developed infrastructure supports the acquisition of enhanced knowledge and understanding of the oceans. Marine research infrastructure priorities are currently considered as key elements of the European Strategy Forum on Research Infrastructures (ESFRI; Box 57). Availability of an oceanographic fleet, and associated marine equipment (e.g. underwater platforms), is essential for research at sea. The oceanographic research fleet should include a large range of research vessels of different size classes (e.g. global, ocean, regional), and should be multipurpose. Research vessels require on-going investment to upgrade their capabilities and ensure that they maintain their status as state-of-the-art facilities. The regional fleet (vessel length < 35 m) in particular is ageing rapidly and it is necessary that decisions are made now to ensure the capacity of European regional class vessels in the future. **There is a strategic requirement for scientists to advise national agencies and the European Commission on specifications for new research vessels, in order to maximise vessel use on a pan-European scale, to improve interoperability and reciprocal access.** This effort should include participation in the major international research programmes (e.g. the International Ocean Drilling Programme [IODP]; Box 58). Tools for collaboration and coordination already exist (e.g. the Ocean Facilities Exchange Group [OFEG], which barters access to European ships) and have demonstrated that pooling resources facilitates an improved and more flexible use of specialised infrastructure for the benefit of the scientific community. The OFEG approach could be extended to include more regional and thematic bartering systems.

7.2. Marine infrastructures include experimental facilities of various types, including hydraulic basins for testing and calibration of instruments (for both research and industry) and aquaculture or ecosystem experimental facilities. **A European strategy to optimise the capacity for experimental facilities is necessary; this would include improvements of some existing major facilities, with improved control of their experimental parameters and the use of various new measuring devices, allowing, for example, the determination of ecosystem parameters.** In addition, facilitating open access to European scientists would enhance the benefit from existing specialised infrastructures. To create such a network and develop a dynamic of interactions, the launch of a forum of specialised operators of experimental facilities would be appropriate *(see also 2.2, 2.6, 2.8)*.

© Ifremer

The French research vessel *Pourquoi pas ?*

7.3. Europe's efforts in developing oceanographic monitoring from space should be continued, in particular with regard to research satellites for observing parameters such as sea-ice thickness, sea surface salinity, chlorophyll pigments, and directional wave spectra. In addition, **operational satellites for observing the ocean in the framework of GMES should be implemented, dealing particularly with ocean currents, wind stress, precise sea surface height, temperature and chlorophyll pigments (Box 59).** Satellite observations need to be as continuous as possible, with overlap between successive missions, and coincident with the collection of appropriate *in situ* observations.

7.4. Data centres are essential as an infrastructure facility in support of marine research, particularly in view of the cost and relative rarity of observational data. While marine research requires the deployment of an increased range of observatories to inform our knowledge of the ocean, a wealth of marine environmental data exists, which needs to be harnessed, quality controlled, assessed and made available. **All marine research and observation programmes should include a detailed, long-term and comprehensive data management plan. Progress has been made in networking data centres in Europe, notably through the SeaDataNet project (Box 60) and through EuroGOOS (Box 15).** This effort should be further elaborated and supported in the long-term, in particular to address issues of data control, interoperability and accessibility, and the development and elaboration of products *(see also 2.5)*.

7.5. Inclusion of data and products from GMES into data centres, including real-time observations and output from numerical models, should be implemented. European efforts should be connected to other regional and global initiatives such as those of the GEOSS (Box 18) and the IODE (Box 20) programmes. Since summer 2006, the major European institutes involved in operational oceanography have started a near real-time exchange of *in situ* data from various observing platforms. It is a collaborative effort between the different regional GOOS systems set up in Europe (BOOS, NOOS, IBI-ROOS, MOON, MedGOOS, BlackSea-GOOS). The exchange is carried out through regional and thematic data centres under the coordination of EuroGOOS and constitutes a major step towards the implementation of GOOS as well as an important European contribution to the marine component of GEOSS. Efforts such as these should be further elaborated and supported *(see also 3.17, 3.18, 4.2, 4.9)*.

7.6. To address many of the major ocean research issues, high-end computing facilities (i.e. computers operating at the current highest operational rate possible, coupled with techniques for parallel computing) are required. Such facilities should have associated data storage, processing, visualisation and retrieval systems. **Support for the implementation of high-end computing facilities in Europe for ocean and climate numerical modelling, comparable with those already in existence in Japan and the USA, is required.** Furthermore, facilitating reciprocal access by European scientists to computing facilities outside Europe should be supported.

Box 57: ESFRI

European Strategy Forum on Research Infrastructures

Launched in April 2002, the European Strategy Forum on Research Infrastructures (ESFRI) aims to support a coherent approach to policy-making on research infrastructures in Europe, and to act as an incubator for international negotiations about concrete initiatives.

European Roadmap for research infrastructures Report

After a first list of identified research infrastructures opportunities issued in March 2005 (Towards New Research Infrastructures for Europe: the ESFRI List of Opportunities), ESFRI issued the European Roadmap for Research Infrastructures Report in October 2006. This first European roadmap for new, large-scale Research Infrastructures identifies 35 large scale infrastructure projects, at various stages of development, in seven key research areas including Environmental Sciences; Energy; Materials Sciences; Astrophysics, Astronomy, Particle and Nuclear Physics; Biomedical and Life Sciences; Social Sciences and the Humanities; Computation and data Treatment. Research Infrastructures considered may be single-sited, distributed or virtual. Among these projects, those that refer to marine science include:

- **EURO-ARGO:** as future European component of the ARGO in situ global ocean observing system, EURO-ARGO would result in the development of around 250 buoys per year as well as the operation of the CORIOLIS data centre. First open access foreseen for 2010.
- **AURORA BOREALIS:** AURORA BOREALIS would be a multipurpose research icebreaker with drilling capability in up to 4000 m water depth with seafloor penetration into up to 1 km. First open access foreseen for 2010.
- **European Multidisciplinary Seafloor Observatory - EMSO:** EMSO is intended to be a network of seafloor observatories to be deployed on specific sites offshore European coastline. It would allow long-term monitoring of ocean environmental processes. First open access foreseen for 2011.
- **LIFE WATCH:** LIFE WATCH would construct and bring into operation the facilities, hardware, software and governance structures for research on the protection, management and sustainable use of biodiversity. First open access foreseen for 2014.

http://www.cordis.lu/esfri

Box 58: The Integrated Ocean Drilling Programme (IODP)

International programme

The Integrated Ocean Drilling Programme (IODP) is an international marine research programme that explores the Earth's history and structure as recorded in seafloor sediments and rocks, and monitors sub-seafloor environments. IODP expands the reach of previous programmes by using multiple drilling platforms, including riser, riserless, and mission-specific platforms. IODP focuses on three scientific themes:

- Deep biosphere and the sub-seafloor ocean:, providing comprehensive characterisation of the ocean below the seafloor;
- Environmental change, processes and effects: investigating the relationship among climate extremes, climate change and major pulses in biological evolution;
- Solid earth cycles and geodynamics: using new technologies to sample and monitor regions of the seafloor that currently have the greatest mass and energy transfers, as well as regions where these transfers were largest millions of years ago.

http://www.iodp.org/home

Box 59: Marine Environment and Security for the European Area (MERSEA)

EU FP6 IP

Launched in 2004, MERSEA addresses the development of a European system for operational monitoring and forecasting of ocean physics, biogeochemistry, and ecosystems, on global and regional scales. The strategic objective of MERSEA is to provide an integrated service of global and regional ocean monitoring and forecasting to intermediate users and policy makers in support of safe and efficient offshore activities, environmental management, security, and sustainable use of marine resources. The MEDSLIK oil spill model constitutes one of the oil spill models of MERSEA that is aiming to establish the marine core services of the GMES.

http://www.mersea.eu.org/index.html

Box 60: SeaDataNet

EU FP6 I3 (2006-2010)

SeaDataNet is a pan-European initiative dealing with ocean and marine data management. It will maintain the existing Sea-Search directories and expand their coverage from 30 to 35 countries bordering the North-East Atlantic and its adjacent seas. Moreover, it focuses on inter-connecting the existing oceanographic data centres through the development and adoption of common standards to provide integrated on-line access to the most comprehensive multidisciplinary available sets of *in situ* and remote sensing marine data, meta-data and products.

SeaDataNet aims to provide:

- Support to the present and future marine research programmes and avoid unnecessary redevelopment of new heterogeneous data systems for each new project;
- An efficient pan-European distributed marine data management infrastructure, in agreement with the principles of the execution of international conventions for protection of the seas and the forthcoming European environmental data Directive INSPIRE.

The existing inventories, which are maintained in the SeaDataNet networking activities, include:

- **ROSCOP/CSR** (reporting on cruises or field experiments at sea), **EDMED** (web-based directory of data sets relating to the marine environment), **EDIOS** (new internet-based tool for searching information on observing systems operating repeatedly, regularly and routinely in European waters) are high level entries for describing collected observation data sets (by ships, by laboratories, by continuous observing system).
- **EDMERP** (Directory of Marine Environmental Research Projects) and **EDMO** (Pan-European directory which list the organisation profiles of all [900+] Data Holding Centres, Research Institutes, Monitoring Agencies and Sea-Search Collating Centres) represent common reference tables including present and historical information. Another important common reference table is the ship/platform table maintained by ICES.
- **CDI** are the Common Data Index of the Marine Data Centres providing access to the data, information and products, by data type and/or any other field. The common work on standardisation is unifying the data dictionaries and the granularity of the data indexed in CDI.

http://www.seadatanet.org

Concluding Remarks

© Mick Mackey, 2006

Fulmars in a Force 11 gale, mid Altantic

Marine science and technology have a major role to play in answering Europe's future challenges, which include the development of a knowledge based economy, environmental security for its citizens, the improvement of social and economic conditions across the continent and the governance of Europe's extensive maritime territories. Europe is well positioned to provide a global lead in developing a scientifically informed trans-boundary (inter-state) maritime policy, while also implementing its marine environment strategy, ensuring that marine and maritime strategies are addressed in a holistic and structured way. This is an appropriate strategic position for a Union of Member States, over 50% of whose territory lies under marine waters.

As the European Union aims to become the world's most competitive knowledge based economic region, the role for innovation, research and development assumes even greater importance. Leadership in marine science and technology will support Europe in its global position at the forefront of generating and using new knowledge for economic and social progress, within an innovation driven culture.

In May 2004, the European marine research community, through endorsement of the Galway Declaration (Box 2), affirmed the key role of marine science and technology in developing Europe's maritime economy. With the enlargement of the European Union and through the Europe Union Seventh Framework Programme (2007-2013), it is timely to mobilise support and re-visit the ambitions of the Galway Declaration, and its objectives, towards the sustainable development of marine resources.

As stated by European Commissioner for Fisheries and Maritime Affairs, J. Borg (January 2005) *"The time is right to develop a Europe with a dynamic maritime economy in harmony with the marine environment, supported by sound marine scientific research and technology, which allows human beings to continue to reap the rich harvest from the ocean in a sustainable manner."*

The European marine research community shares the vision of the Commissioner for Fisheries and Maritime Affairs and is ready and able to commit its intellectual and innovative skills to achieve the objective of this vision. *Navigating the Future III* was developed to facilitate the marine research and policy community on this journey through the 21st Century.

To this end, *Navigating the Future III* identifies a number of exciting challenges, including:

- **Climate change and the oceans - impacts and prediction**
- **Continental margins, deep-sea ecosystems and their resources**
- **Marine biodiversity**
- **Coastal ecosystems**
- **Ecosystem approach to resource management**
- **Operational oceanography**
- **Marine technology**, **including *in situ* marine observing**
- **Marine infrastructures**

The Marine Board – ESF has developed *Navigating the Future III* as a compass, rather than a blueprint, to navigate a common and complementary course for national and European research programmes. Support such a common course will strengthen Europe's scientific research capacity and competition globally. The strategies outlined in *Navigating the Future III*, compiled as a result of extensive consultation and expert advice, aim to assist our marine research community to improve their competitiveness through the application of knowledge and technology, thus strengthening existing and building new research capacity. *Navigating the Future III* is intended to provide a first step towards identifying the policy directions that are needed to ensure that marine research in Europe continues to be successful over the next decade. The Marine Board – ESF hopes that this report will, as a reference document, stimulate further debate and discussion on the marine research and policy challenges that face Europe.

Roll on, thou deep and dark blue Ocean – roll!
Ten thousand fleets sweep over thee in vain;
Man marks the Earth with ruin – his control stops
With the shore; upon thy watery plain
The wrecks are all thy deed,

Lord Byron (*Childe Harold's Pilgrimage*, Canto IV, CLXXIX 1818)

Appendix I – ERA-NETs and coordination of national funding programmes

One of the principal aims of the European Union Sixth Framework Programme is to increase coordination of the European Research Area (ERA). The European Union wishes to enhance collaboration among national and regional research finance agencies, and is funding this by investing in ERA-NETs. The long term aim is to create national research funds for international applications. This benefits the quality of research and also results in a concentration of research efforts. At present, almost 70 ERA-NETs have been granted.

Examples of marine related ERA-NETs include:

AMPERA (2005-2009)
AMPERA aims at fostering prevention and best response to marine oil pollution (priorities in transdisciplinary accidental marine pollution research, prevention and mitigation activities, coordination of national and regional research programmes on accidental marine pollution)
http://www.ampera-net.info

BiodivERsA (2004-2008)
BiodivERsA aims at setting up efficient trans-national cooperation in the field of biodiversity research funding. Also contributing to the European Union Biodiversity Strategy, BiodivERsA will allow the funding agencies to collate existing activities, compare future strategies and recommendations of consultative bodies
http://www.eurobiodiversa.org/Home_141.html

BONUS (2004-2007)
BONUS for the Baltic Sea aims to produce an action plan for joint research programmes and courses for researchers concerning the environment and management of the Baltic Sea. The background lies in the serious environmental problems of the Baltic Sea – eutrophication, over fishing and the prevalence of environmental toxins.
http://www.bonusportal.org

CIRCLE (2005-2009)
Climate impact analysis and adaptation response must be informed by a coherent body of research and it is CIRCLE´s prime objective to contribute to such efforts by networking and aligning national research programmes in the 17 CIRCLE partner countries. The implementation of a European Research Area (ERA) for climate change is CIRCLE's final goal.
http://www.circle-era.net

CRUE (2004-2008)
The CRUE network has been set up to consolidate existing European flood research programmes, promote best practice and identify gaps and opportunities for collaboration on future programme content. Its 13 partners come from most European countries that have been particularly badly affected by flooding.
http://www.crue-eranet.net

ECORD-net (2003-2007)
ECORD-net aims at implementing the ECORD structure (European Consortium for Ocean Research Drilling) and to move towards a single research and operational funding structure for science enabled by ocean drilling. This project networks the management and coordination aspects of ECORD with all areas of scientific drilling in the oceans and continents, to marine geophysical surveys which require validation by drilling, and to marine observatories.
http://www.ecord.org/enet/ecord-net.html

EPC (2005-2009)
The European Polar Consortium aims to coordinate European Polar R&D Programmes. It will lead to long-term durable partnerships within Europe and internationally and will also deepen and strengthen the interactions between countries with large polar R&D programmes and nations with evolving polar programmes in central and Southeastern Europe.
http://www.europolar.org

MariFish (2005-2009)
MariFish concerns research on fisheries and fisheries management, with the aim of creating a network of funding agencies for fisheries and fisheries research in Europe. The goal is to bring about greater coordination of research at European and regional level and to issue a joint call for applications for research funds in the final phase of the project.
http://www.marifish.net/default.htm

MarinERA (2004-2008)
MarinERA (15 partners from 13 countries) aims at coordinating national and regional marine R&D activities in Europe. MarinERA takes a pro-active role within the European marine science landscape, a role that goes far beyond the formal aims and objective of the project. Indeed, by catalysing information and know-how exchange between not only other marine-related ERA-NETs, but also Networks of Excellence and the ESF EUROCORES scheme, the MarinERA project operates as a key facilitator and the main European platform to structure marine science in the European Research Area (ERA).
http://www.marinera.net

Appendix II – EUROCORES and collaborative research

EUROCORES, the European Science Foundation Collaborative Research Programmes Scheme, is a funding instrument of the European Science Foundation (ESF). The aim of EUROCORES is to create a critical mass for research excellence within a specific topic in Europe to develop multi-annual funding collaborations. It builds on existing national structures and leaves the funding to the national agencies. The selection of a proposal however is made by an international peer review.

Processes at the Passive Continental Margins (EUROMARGINS – 2003-2007)
EUROMARGINS is financed by 11 funding agencies from 10 European countries. The programme provides the framework for promoting innovative studies that are focused on the imaging, monitoring, reconstruction and modelling of the physical and chemical processes that occur in the passive margin system.

Climate Variability and the (past, present and future) Carbon Cycle (EuroCLIMATE – 2005-2009)
Palaeoclimates offer an essential tool for analysing the response of the climate system to internal and external forcing, such as from greenhouse gases, volcanic activity and solar energy, and for understanding the physical, chemical and biological processes responsible for the changes. EuroCLIMATE is financed by 13 funding agencies from 11 countries. The programme focuses both on reconstructing past climates and on modelling climate and climate variations for a better understanding of the underlying physical, chemical and biological processes involved.

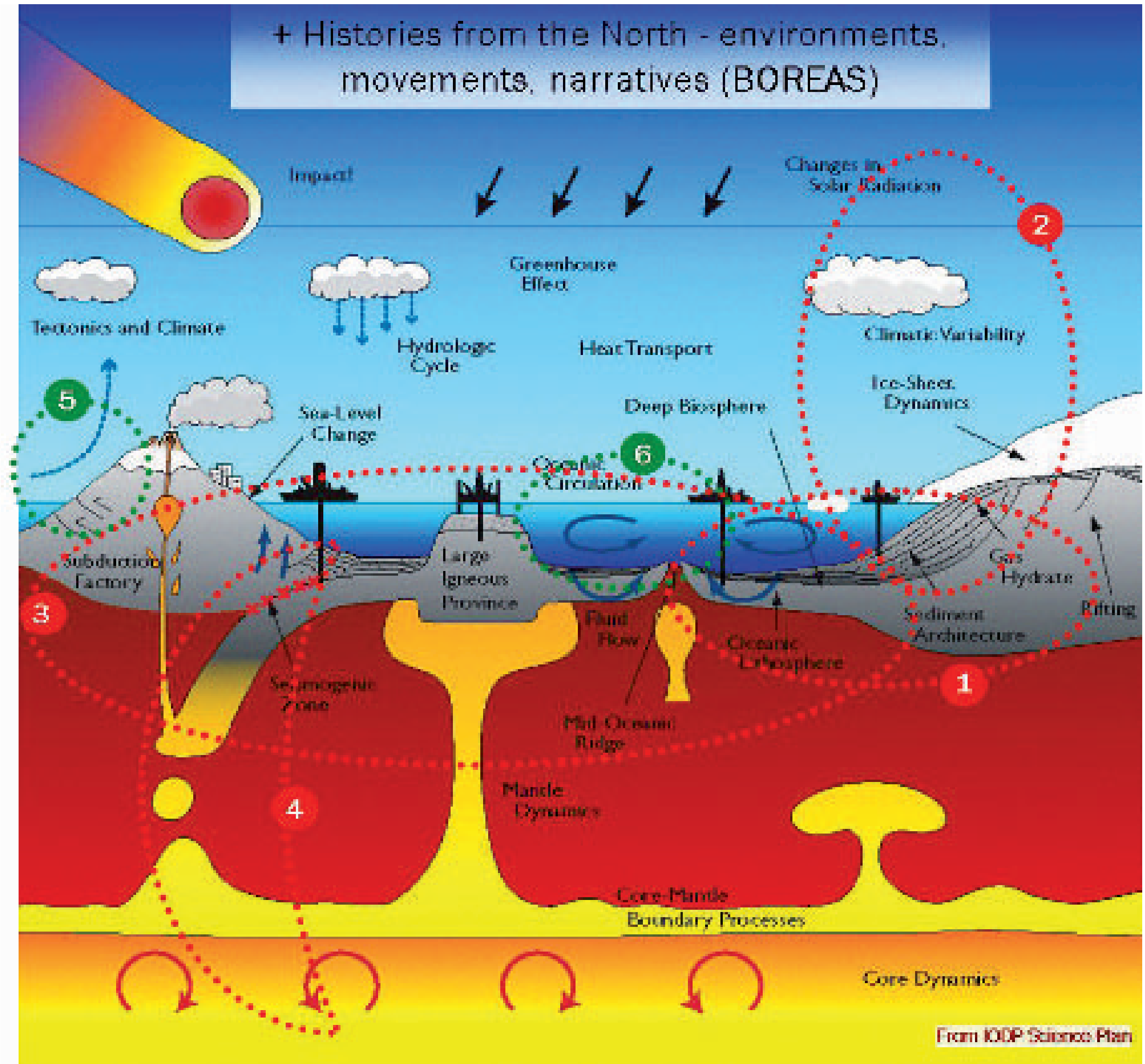
Challenges of Marine Coring Research (EuroMARC – 2007-2011)
EuroMARC is financed by 12 funding agencies from 11 European countries. It is an essential enabling tool to boost European leadership in the planning of international marine coring expeditions and the preparation of European proposals, hence ensuring the effective exploitation of research opportunities. Pre-cruise science should address the fundamental science questions of EuroMARC as well as enable proposals for further research in other programmes, such as the Integrated Ocean Drilling Programme (IODP). Post-cruise science will use the results of coring programmes, such as IODP, to address the EuroMARC topics.

European Mineral Sciences Initiative (EuroMinScI – 2006-2010)
EuroMinScI is financed by 13 funding agencies from 12 countries. The scientific content of the EuroMinScI Programme derives from the fact that the physical and chemical properties of the Earth and terrestrial planets depend on the properties of their constituent minerals. Interactions between the lithosphere and the atmosphere, biosphere or hydrosphere occur across mineral surfaces. The EuroMinScI Programme therefore focuses on the atomistic understanding of structures, properties and processes of minerals.

Challenges of Biodiversity science (EuroDIVERSITY – 2006-2009)
EuroDIVERSITY is financed by 25 funding agencies from 19 countries. The goal of EuroDIVERSITY is to support the emergence of an integrated biodiversity science based on an understanding of the fundamental ecological and social processes that drive biodiversity changes, their impacts on ecosystem functioning and services, and societal responses to these changes. This should result in new tools and strategies for the conservation, restoration and sustainable use of biodiversity.

Ecosystem Functioning and Biodiversity in the Deep-Sea (EuroDEEP – 2007-2010)
EuroDEEP is financed by 11 funding agencies from nine countries. The aim of the EUROCORES programme on “Ecosystem functioning and biodiversity in the deep-sea” is to further explore the deep-sea environment, to further describe the biological species and communities that inhabit it, and to better understand the physical and geochemical processes that shape the environment in which these communities live, in order to describe, explain and predict variations of biodiversity within and between deep-sea habitats, their consequences for deep-sea ecosystem functioning and the interactions of the deep-sea with the global biosphere.

http://www.esf.org/esf_activity_home.php?language=0&domain=0&activity=7



Geosciences, Environmental sciences and EUROCORES
1. Processes at the Passive Continental Margins (EUROMARGINS)
2. Climate Variability and the (past, present and future) Carbon Cycle (EuroCLIMATE)
3. Challenges of Marine Coring Research (EuroMARC)
4. European Mineral Sciences Initiative (EuroMinScI)
5. Challenges of Biodiversity Science (EuroDIVERSITY)
6. Biodiversity and Ecology of Deep-Sea Ecosystems (EuroDEEP)

Appendix III – Acronyms and abbreviations

AFLP
Amplified Fragment Length Polymorphism

ALARM
Assessing large-scale environmental risks with tested methods (Integrated Project)

ALTER-Net
A Long-term Biodiversity, Ecosystem and Awareness Research Network (Network of Excellence)

ALW
Council for Earth and Life Sciences (Aard- en Levenswetenschappen)

AMPERA
European concerted action to foster prevention and best response to accidental marine pollution ERA-NET

ARGO
Global Array of Profiling Floats

AUV
Autonomous Underwater Vehicle

BIODEEP
Deep Sea Brine Interface

BiodivERsA
Research programme for the understanding of European and Overseas biodiversity (ERA-NET)

BONUS
Baltic Sea Research Funding Collaboration (ERA-NET)

BOOS
Baltic Ocean Observing System

BWM
Ballast Water Management

CA
Coordinated Action

CARBOOCEAN
Marine carbon sources and sinks assessment (Integrated Project)

CFP
Common Fisheries Policy

CH_4
Methane

CIESM
Conseil International pour l'Exploration Scientifique de la Méditerranée

CIRCLE
Climate Impact Research Coordination for a Larger Europe (ERA-NET)

CLIVAR
Climate Variability and Predictability (international research programme)

CO_2
Carbon dioxide

CoML
Census of Marine Life

CRUE
European flood risk management (ERA-NET)

CZ
Coastal Zone

DAMOCLES
Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies

DDT
Dichlorodiphenyltrichloroethane

Deep-SF
Deep Seafloor Frontier

DG
Directorate General

DISMAR
Data Integration System for Marine Pollution and Water Quality

DMS
Dimethylsulphide

DSDP
Deep Sea Drilling Project

EAF
Ecosystem Approach to Fisheries

EC
European Community – previous to European Union (EU)

ECORD-net
European Consortium for Ocean Research Drilling ERA-NET

EDIT
European Distributed Institute of Taxonomy (Network of Excellence)

EEA
European Environment Agency

EEZ
Exclusive Economic Zone

EFARO
European Fisheries and Aquaculture Research Organisation

EIT
European Institute of Technology

EMBEF
European Centre for the Study of Marine Biodiversity and Ecosystem Functioning

EMSO
European Multi-disciplinary Seafloor Observatory

ENCORA
European platform for coastal research coordination and action

ENSO
El Niño-Southern Oscillation

ENT
ERA-NET on Transport

EO
Earth Observation

EPC
European Polar Consortium (ERA-NET)

ERA
European Research Area

ERA-NET
European Research Area Network

ERC
European Research Council

ERMS
European Registers of Marine Species

ESF
European Science Foundation

ESFRI
European Strategy Forum on Research Infrastructures

ESONET
European Seas for Observatories NETwork

ESONIM
European Seafloor Observatory Network Implementation Mode

ETP
European Technology Platform

EU
European Union

EURO-ARGO
European contribution to the ARGO global array of profiling floats

EurOBIS
European Ocean Biogeographic Information System

EUR-OCEANS
EURopean network of excellence for OCean Ecosystems ANalysiS

EurOCEAN 2004
Irish EU Presidency Event (10th-13th May 2004)

EuroCLIMATE
Climate Variability and the (past, present and future) Carbon Cycle (EUROCORES)

EuroCoML
European Census of Marine Life

EUROCORES
EUROpean COllaborative RESearch scheme

EuroDEEP
Ecosystem Functioning and Biodiversity in the Deep Sea (EUROCORES)

EuroDIVERSITY
Challenges of Biodiversity science (EUROCORES)

EuroGOOS
European Global Ocean Observing Systems

EuroMARC
Challenges of Marine Coring Research (EUROCORES)

EUROMARGINS
Slope Stability on Europe's Passive Continental Margins (EUROCORES)

EuroMinScI
European Mineral Sciences Initiative (EUROCORES)

FAO
Food and Agriculture Organisation

FP
Framework Programme

G10
Guidelines for approval and oversight of prototype ballast water treatment technology programmes

GBO
Global Biodiversity Outlook

GDP
Gross Domestic Product

GEO
Group on Earth Observations

GEOSS
Global Earth Observations System of Systems

GESAMP
Group of Experts on the Scientific Aspects of Marine Environmental Protection

GLOBEC
Global Ocean Ecosystem Dynamics

GMES
Global Monitoring for Environment and Security

GODAE
Global Ocean Data Assimilation Experiment

GOOS
Global Ocean Observing System

GPS
Global Positioning System

HAB
Harmful Algal Bloom

HELCOM
HELCOM: Helsinki Commission – Baltic Marine Environment Protection Commission

HERMES
Hotspot Ecosystem Research on the Margins of European Seas (Integrated Project)

I3
Integrated Infrastructure Initiative

IBI-ROOS
Iberian-Biscay-Irish Regional Ocean Observation Systems

ICES
International Council for the Exploration of the Sea

Appendix III – Acronyms and abbreviations

ICG
International Crisis Group

ICZM
Integrated Coastal Zone Management

IGBP
International Geosphere-Biosphere Programme

IMBER
Integrated Marine Biogeochemistry and Ecosystem Research

IMO
International Maritime Organisation

IMSE
Integrating Marine Science in Europe (Marine Board publication)

INSPIRE
Directive establishing an infrastructure for spatial information

IOC
Intergovernmental Oceanographic Commission

IODE
International Oceanographic Data and Information Exchange

IODP
International Ocean Drilling Programme

IOTWAS
Indian Ocean Tsunami Warning and Mitigation System

IP
Integrated Project

IPCC
Intergovernmental Panel on Climate Change

IPY
International Polar Year

IT
Information Technology

ITIC
International Tsunami Information Centre

ITSU
International Tsunami Service Unit

IUCN
International Union for Conservation of Nature and Natural Resources

KDM
Konsortium Deutsche Meeresforschung (German Consortium for Marine Research)

MARTEC
ERA-NET on maritime technologies

MAST
Marine Science and Technology

MarBEF
Network of Excellence on Marine Biodiversity and Ecosystem Functioning

MARE FORUM
Conference management, project development and policy marketing

MariFish
ERA-NET on research on fisheries and fisheries management

MarinERA
ERA-NET to facilitate the coordination of national and regional marine RTD programmes in Europe

MB-ESF
Marine Board – European Science Foundation

MEDSLIK
Oil spill model

MedGOOS
Mediterranean Global Ocean Observing System

MEPC
Marine Environment Protection Committee

MERSEA
Marine Environment and Security for the European Area (Integrated Project)

MGE
Marine Genomics Europe (Network of Excellence)

MIF
Maritime Industries Forum

MOON
Mediterranean Operational Oceanography Network

MPA
Marine Protected Area

MTCP
Maritime Transport Coordination Platform

N_2O
Nitrous Oxide

NAO
North Atlantic Oscillation

NAO-IO
North Atlantic-Indian Ocean

Natura 2000
Network of European Natural sites

NERC
Natural Environment Research Council

NGO
Non Governmental Organisation

NoE
Network of Excellence

NOOS
Northwest Shelf Operational Observing System
NWO
Netherlands Organisation for Scientific Research

ODP
Ocean Drilling Programme

OSPAR
Convention for the Protection of the Marine Environment of the North-East Atlantic (Oslo-Paris)

PCB
Polychlorinated biphenyl

pH
Potency of the hydrogen ion in an aqueous solution

POGO
Partnership for Observation of the Global Oceans

PPPs
Public Private Partnerships

QTL
Quantitative Trait Loci

R&D
Research and Development

RAC
Regional Advisory Council

RAPID
Rapid Climate Change Research programme

REACH
Registration, Evaluation and Authorisation of Chemicals (EU Directive)

RNA
Ribonucleic acid

ROV
Remotely Operated Vehicle

RTD
Research and Technological Development

SCOR
Scientific Committee on Oceanic Research

SeaDataNet
Pan-European infrastructure for Ocean and Marine Data management for online integrated data access (I3)

SME
Small and Medium Sized Enterprises

SOLAS
Surface Ocean-Lower Atmosphere Study

SPICOSA
Science and Policy Integration for Coastal System Assessment (IP)

SRA
Strategic Research Agency

STECF
Technical and Economic Committee for Fisheries

THC
Thermohaline Circulation

TWG
Thematical Working Groups

UN
United Nations

UNEP
United Nations Environment Programme

UNESCO
United Nations Educational, Scientific and Cultural Organisation

UNFCCC
United Nation Framework Convention on Climate Change

WB TP
The Waterborne Technology Platform

WCRP
World Climate Research Programme

WFD
Water Framework Directive

WSSTP
Water Supply and Sanitation Technology Platform

European Science Foundation

The European Science Foundation (ESF) was established in 1974 to create a common European platform for cross-border cooperation in all aspects of scientific research.

With its emphasis on a multidisciplinary and pan-European approach, the Foundation provides the leadership necessary to open new frontiers in European science.

Its activities include providing science policy advice (Science Strategy); stimulating co-operation between researchers and organisations to explore new directions (Science Synergy); and the administration of externally funded programmes (Science Management). These take place in the following areas: Physical and engineering sciences; Medical sciences; Life, earth and environmental sciences; Humanities; Social sciences; Polar; Marine; Space; Radio astronomy frequencies; Nuclear physics.

Headquartered in Strasbourg with offices in Brussels, the ESF's membership comprises 78 national funding agencies, research performing agencies and academies from 30 European nations.

The Foundation's independence allows the ESF to objectively represent the priorities of all these members.

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Marine Board - ESF Member Organisations

Academy of Finland

Austrian Academy of Science

CNRS Centre National de la Recherche Scientifique

Consiglio Nazionale delle Ricerche

CSIC

Deutsche Forschungsgemeinschaft
DFG

FCT

FNRS

FWF
Der Wissenschaftsfonds.

FWO

H.C.M.R.

Helmholtz Gemeinschaft

Ifremer

Institute of Marine Research
Havforskningsinstituttet

Marine Institute

National Oceanography Centre, Southampton

Natural Environment Research Council

NWO
Netherlands Organisation for Scientific Research

OGS

PAN

The Research Council of Norway

TÜBITAK

Vetenskapsrådet

European Science Foundation
SETTING SCIENCE AGENDAS FOR EUROPE

MARINE BOARD

1 quai Lezay-Marnésia | BP 90015
67080 Strasbourg cedex | France
Tel: +33 (0)3 88 76 71 00 | Fax: +33 (0)3 88 37 05 32
www.esf.org/marineboard

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