6. Sustainable use of deep-sea resources

Economics

The important life support functions of marine ecosystems are increasingly recognised as part of the global ecosystem, while deep-sea ecosystems goods and services are of growing economic significance. The potentially vast reservoir of renewable and non-renewable resources present in European and international deep waters have received renewed attention in the past decade. Established industries such as fisheries and hydrocarbon extraction have moved rapidly and steadily downslope as shallower and more accessible resources become depleted. Deep-sea fisheries and oil and gas exploration now occur in depths below 2000m, while emerging industries such as blue biotechnology – obtaining useful products through the exploitation of deep-sea genetic biodiversity – are not limited by depth.

New deep-water fisheries may still be developing on a global scale, but in the North Atlantic some have been exploited for a century or more, or developed over the last 30-40 years. Scope for further growth appears to be limited as it is clear that the life history characteristics of deep-sea fish are unsuited to industrial harvest. Deep-water trawling is particularly problematic as it leaves a large environmental footprint, especially where fishing occurs in areas of vulnerable habitat such as cold-water coral reefs.

In contrast, extraction of energy from the oceans will rise dramatically in the coming decades. Oil and gas exploitation in deep waters will continue to increase over the next 20 years as higher prices make deeper exploitation economically viable. Gas hydrate deposits may provide a new source of energy and research into renewable ocean energies, such as wave, geothermal and ocean-thermal sources, is gaining importance. In tandem with the exploitation of new reserves comes increased pressure to actively remove fossil fuel-derived greenhouse gases from the atmosphere. In the future the deep sea may be used as a reservoir for the sequestration of CO_2, thus providing capital in the potentially lucrative carbon trading market.

The number of existing and planned large deep-sea infrastructure projects is set to expand in the near future due to an increase in the installation of submarine cables, oil and gas pipelines, sub-sea production platforms and cabled ocean observatories. This will create opportunities for innovation as the major technological and engineering challenges are met and overcome. These developments can be drivers of new surveys, maintenance, monitoring and reduced environmental impact engineering products and methodologies. The provision of information and communication technology (ICT) infrastructure for cabled observatories and sub-sea platforms will similarly drive innovation in mass data storage and processing, sensors and autonomous platform technologies.

The Lisbon Agenda sets out the European Union's strategy for competitiveness, growth and employment. Therefore, a key driver of research and development in the deep sea over the next 5 to 10 years will be to fulfill the vision, in the marine context, that the European Union will become, '*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*'. The recent Green Paper 'Towards a Maritime Policy for the European Union' clearly articulates that any future European Maritime Policy will fully contribute to the Lisbon Agenda by exploiting the economic potential of the oceans and seas in harmony with the marine environment. This requires research to better understand the effects of climate change, improve the competitiveness of European maritime industry, and improve the groundwork for the implementation of an ecosystem-based management approach that will ensure environmentally sustainable economic development on a regional basis. Research underpinning the development of new sustainable management policies and practices, experience of sustainable exploitation of offshore resources, and the knowledge capital these represent, will create opportunities for Europe to provide leadership in the global economy.

Environment

The current and anticipated economic activity in deep-sea areas of European and international waters described above does not come without a price. Already there is much evidence of damage to fragile deep-water corals and other vulnerable habitats by trawling. It is likely that the multiplicity of anticipated future activities will lead to user conflicts requiring the development of new decision-making processes. To address these issues, data must be integrated from different sources, including oceanographic, geophysical, geological, sedimentary, hydrological, biological, microbiological, social, economic and legal studies. Assessments of the impact of different management strategies on the resource base, the environment, and on socio-economics will be needed. This will require the development of new dynamic ecosystem management scenario models and indicator frameworks.

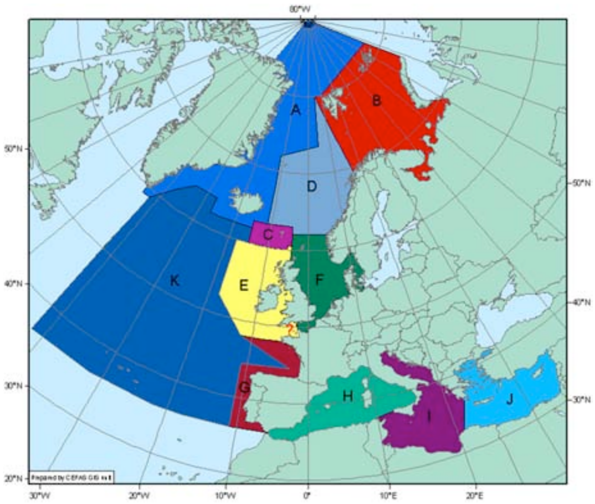


Figure 6.1: Map showing proposed eco-regions for implementation of an ecosystem approach in European waters (Source: 'ICES response to EC request for information and advice about appropriate ecoregions for the implementation of an ecosystem approach in European waters'. ICES Advisory Paper, pp. 1-27.)

Some of this work is already underway in the deep sea where, for the first time, large integrated projects such as HERMES are beginning to build the foundation for a better understanding of continental margin and deep-sea ecosystems at the European scale. This is being achieved through the fledgling integration of natural and social sciences and the development of broadly applicable prototypic management tools such as the HERMES Geographic Information System.

The recently published European Commission 'Thematic Strategy on the Protection and Conservation of the Marine Environment' is one of seven thematic strategies resulting from the Sixth Environmental Action Programme. The objective of the Strategy is '*to protect and restore Europe's oceans and seas and ensure that human activities are carried out in a sustainable manner so that current and future generations enjoy and benefit from biologically diverse and dynamic oceans and seas that are safe, clean, healthy and productive*'. The Marine Strategy will constitute the environmental pillar of the future European Maritime Policy.

The Marine Strategy sets out the broad objective of achieving good environmental status in the marine domain by 2021 via a number of intermediate milestones. Implementation of the Marine Strategy will require regional environment quality assessment and the definition of 'good' environmental status. Environmental targets and indicators to attain and maintain good environmental status need to be set, and regional monitoring and assessment programmes implemented. This will require selection of new indicators and repeated observations at long-term reference sites with sufficient geographic spread to separate natural and/or climatic changes from local anthropogenic effects.

The application of the Marine Strategy is intended to go beyond Europe's ocean and seas, as indicated by the statement that '*while the Strategy is primarily focused on the protection of the regional seas bordered by EU countries, it also takes into account the international dimension in recognition of the importance of reducing the EU's footprint in marine areas in other parts of the world, including the High Seas*'. In addition to fishing in international waters, it is likely that a number of EC Member States will become increasingly involved in deep-sea mineral mining and bio-prospecting in the High Seas.

Socio-economic, sustainable management and governance issues

The Marine Strategy acknowledges the deteriorating state of Europe's marine environment, the inadequacy of the present institutional framework for the management of the seas, and the insufficiency of the knowledge base. It stresses that '*a new approach to marine monitoring and assessment and the use of scientific information is required across the different levels of governance which should identify and fill knowledge gaps, reduce duplicated data collection and research, and promote the harmonisation, broad dissemination and use of marine science and data*'.

Despite some progress in projects such as HERMES, most of the advances in our understanding of the deep ocean come from the natural sciences, and socio-economic research is lagging behind. To better grasp the societal and economic implications of human interactions with deep-sea ecosystems and achieve sustainable use and conservation of deep sea biodiversity, more research on socio-economic and governance issues related to ecosystems needs to be carried out and integrated with the natural sciences.

This has an equally important international dimension. In February 2006, the UN's 'Ad Hoc Open-ended Informal Working Group' studying issues related to the conservation and sustainable use of marine biological diversity beyond areas of national jurisdiction' stressed that '*achieving sustainable use and exploitation of marine resources called for further studies and greater* *understanding of conservation, use and impacts*'. They proposed that '*the value of marine ecosystems and resources be further studied and taken into account in policy and decision making*', and noted '*that the economic benefits derived from the protection and use of marine biological diversity in areas beyond national jurisdiction needed further study*'. This fits well with the goals of the Marine Strategy.

Development of an integrated European ocean management strategy in support of the Maritime Policy and implementation of the Marine Strategy will require, amongst others, the following advances:

- a better understanding of the physical character of margin processes;
- an overview of margin processes;
- preparation of margin-wide resource inventories (GIS);
- socio-economic studies examining the multiple use of offshore resources;
- assessment of climate change related economic stress factors and new opportunities;
- a review of policy options for integration of European maritime governance;
- planning of projects and funds to meet operational and basic research programme requirements;
- development of integrated enforcement and compliance capabilities;
- establishment of monitoring and evaluation programmes;
- increased public awareness of the value of offshore resources and the need for integrated management.

Deep-water fisheries

Europe's fishing production amounted to 8% of world production in 2004. Deep-water fisheries on upper continental slopes, in deep shelf troughs, and on seamounts, ridges and island slopes in the open ocean amount to a relatively small portion of this total. In continental slope waters, these fisheries exploit resources from about 400m depth and beyond, but few fisheries operate deeper than about 2000m. Most deep-water fish species are long-lived, slow-growing, have a low reproductive capacity and are adapted to live in an ecosystem of low energy turnover in which major environmental changes occur infrequently. Deep-water fishery resources are, therefore, highly vulnerable to exploitation. Deep-water habitats are also sensitive and in need of protection.

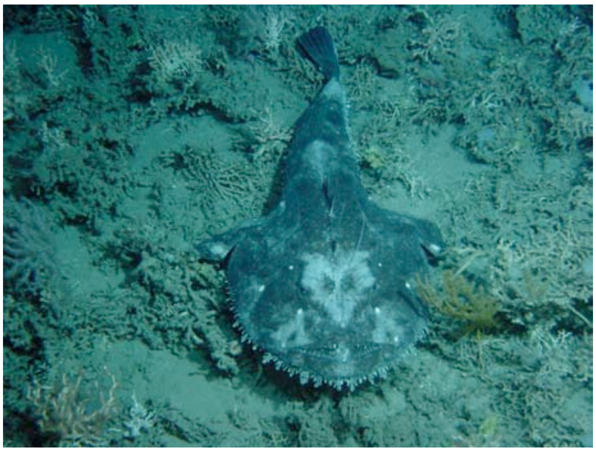


Figure 6.2: The commercially-exploited monk fish, Lophius *sp., pictured amongst coral in water depths of 800m off the west coast of Ireland. Image courtesy Ifremer.*

Experience in the South Pacific and elsewhere has shown that some deep-water fish stocks can be depleted quickly and recovery can be very slow. In most cases, reliable information on stock identity, status and fisheries production potential has considerably lagged behind exploitation. In the NE Atlantic this concern has been exacerbated by the fact that until 2003 most fisheries were completely unregulated. As far back as 1998, the International Council for the Exploration of the Sea (ICES) considered most deepwater species as 'outside safe biological limits' - in other words, showing signs of being heavily exploited or overexploited.

The historical analyses of trends in catch, landings and fishing effort is hampered by the lack of basic data from many areas, and most data are not available on a geographic and temporal scale appropriate for detailed studies. Traditional stock assessment techniques cannot readily be applied, and there are few alternatives to using very simple fisheries-based analyses. It has also proven difficult to document the true scale of impacts by fisheries on vulnerable invertebrate communities such as corals and sponge beds.

Despite incomplete knowledge, national and international management authorities have now recognised the need for action and various measures have been implemented by the EC, countries outside the EU, NEAFC and OSPAR. The 2006 United Nations General Assembly A61/L38 addressing sustainable fisheries called upon fisheries management organisations to i) access the degree to which bottom fishing activities significantly impact vulnerable marine ecosystems, ii) identify vulnerable ecosystems and where they occur through improved scientific research and data collection, and iii) close such areas to bottom fishing unless conservation and management measures have been established to prevent significant adverse impacts on the ecosystems.

The science community is faced with the challenge of analysing the effects of factors such as landings, quota systems, area closures, effort and gear regulations, often without sufficient information to carry out these assessments and give well-founded advice in support of ecosystem based-management of fisheries. In addition, the term ‘ecosystem based’ is ill-defined. What is implied is that the implementation of any management system should not only manage fisheries and the target resources, but also avoid lasting destruction of the biotic and abiotic environment in which the resources live.

Oil and gas exploration

Despite the challenges of offshore ocean exploration, exploitation and monitoring, some 35% of global oil production and 27% of gas production is from offshore areas. Since fossil hydrocarbon resources are predicted to last for at least another fifty years, the industry will continue to invest in infrastructure and new techniques for optimised exploitation, leading to more and enhanced underwater facilities. In the future, it is likely that the huge fixed rigs used today will be increasingly replaced by floating production platforms and smaller-scale sub-sea production technology deployed directly on the seabed, similar to those already in existence on the Norwegian margin and in the Gulf of Mexico.

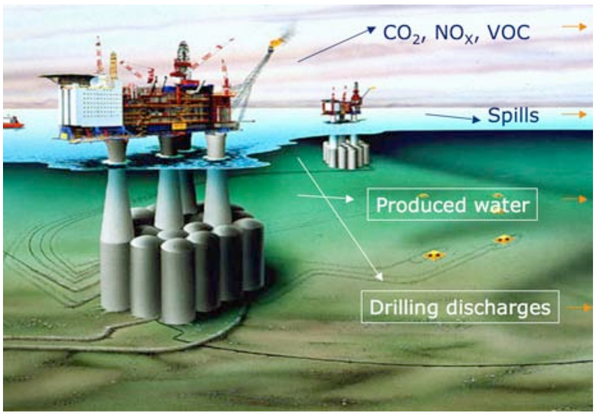


Figure 6.3: Deep-water oil and gas production platform and infrastructure (image courtesy Statoil).

Underwater platforms, wells, and pipelines will be equipped with sensors providing continuous data transmission describing operational status. This should lead to a reduced need for large ships and manpower at sea and a concomitant reduction in the pollution risk and hazards relating to large platform operation. The control and operation of the facilities will be possible from land as demonstrated by a number of existing and near-operational systems. These integrated systems are currently a hot topic in the petroleum industry. Most operators have built onshore operation support centers for real-time optimisation of drilling operations and production. Real-time onshore monitoring and control of wells and offshore processing are likely ingredients of the subsea-to-shore concepts in the future. Increasing the number of such platforms will lead to the creation of new power and data cable networks along continental margins.

These developments will open up new possibilities for cooperation between the petroleum industry and ecological research. It may be possible to integrate hydrocarbon field development with cabled seafloor observatories. As the petroleum industry moves to deeper waters and higher latitudes, online monitoring around underwater platforms and pipelines using state-of-the-art sensor and instrument systems is possible. This can be achieved through close collaboration between the petroleum industry and the European science community.

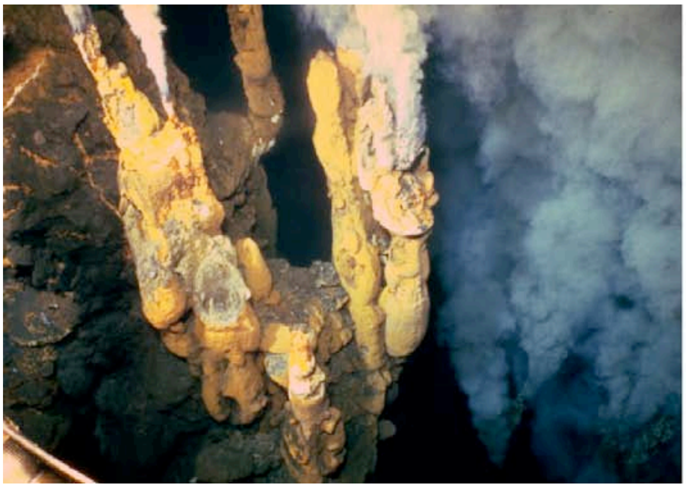
Of course, with this expansion of offshore exploration and development comes increased opportunities for conflict with other resource users, as well as environmental concerns related to potential oil spills and other pollution. It is up to resource managers to balance these conflicting uses with conservation priorities. The oil and gas industry are eager to improve the science and methodologies used in regional strategic (SEA) and local environmental impact (EIA) risk assessments. The industry may also have a role to play in regional monitoring initiatives developed to underpin the Marine Strategy.

Seafloor mining

The ocean covers 71% of the surface of the earth and 60% of the floor of the ocean lies deeper than 2000 m. This huge area remains relatively unexplored. Scientific investigations during the last 30 years have revealed various types of mineral concentrations that are only now becoming the focus of economic interest. Seafloor mineral resources may one day be critical for society to meet its future needs as many of the large, easy to find and highly concentrated mineral reserves on land have already been mined out. An example is copper ore, where the average grade mined on land has decreased from 3 to 0.5 % in less than a century. An immediate consequence of this reduction in ore quality is an increase in extractive energy costs and the environmental footprint required to extract the metal. In contrast, marine seafloor deposits such as polymetallic sulphides, are extremely rich in metals. Thus, even though deposits may be so small that they would never be mined on land, the expense associated with moving from one deposit to another at sea using ship-based operations would be much less than on land.

Ocean mining of various mineral resources therefore has enormous economic potential. Equally, there is considerable potential for environmental impact. A number of European countries are involved in the fledgling development of the industry and the establishment of environmental best practice. As most of the potentially exploitable resources lie within the EEZ of non-European countries or in international waters, a key issue is the development of legislation to regulate the industry. The International Seabed Authority (ISA) has started to develop specific regulations for exploiting polymetallic sulphides in the High Seas, and in 2001 the International Marine Mineral Society produced a 'Code for Environmental Management for Marine Mining'.

Our known supply of minerals will be exhausted early in the third millennium. We are now reaching the limits of reserves for many minerals. Unsustainable consumption rates, human population growth and the rapid industrialisation of highly populated countries (e.g., China, India and Brazil) result in the depletion of available resources at increasing rates. The higher demand for metal has impacted metal prices - for example, the prices of steel, copper and zinc have increased by several hundred percent in the last three years. Marine mining will become a reality this century. The oceans in this context are a major resource for mankind, which are yet to be explored and exploited to their full potential.



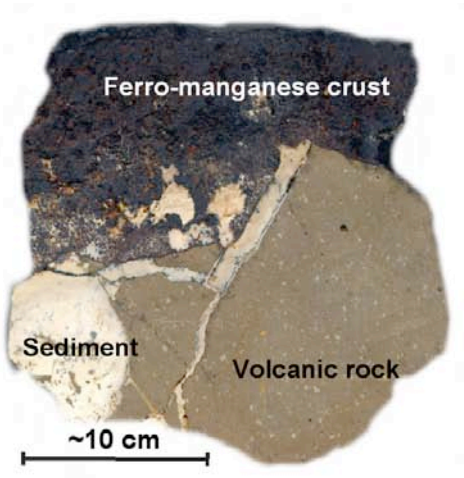


Figure 6.4. Left: Active smokers in the Lau Basin SW Pacific. Chimneys on the left are primarily made zinc and copper sulfides with high gold concentration. Right: Ferromanganese crusts dredged from the French Polynesia area (Images courtesy IFREMER).

Type	Location	Commodity	Depth	Mining status	Economic interest
Salt	Coastal	Salt	Shore	Operational	Moderate
Sand and gravels	Beach, shallow water	Aggregates	Shallow	Operational	High
Marine placer	Beach, shallow water	Tin, gold, chromium, zirconium, Rare Earth Elements, titanium	Shallow	Operational	Moderate
Diamonds	Coastal	Diamonds	< 250 m	Operational	High
Phosphates	Shallow water and seamounts	Phosphate	Shallow to medium depth	Non operational	Low
Nodules	Deep Ocean	Copper, cobalt, nickel	4500m to 5500 m	Potential resources	Moderate
Manganese crust	Intraplate seamounts	Cobalt, copper, platinum	1000m to 2500m	Potential resources	Moderate
Deep-sea sulphides	Volcanic ridges	Copper, zinc, silver, gold, cobalt, lead	1000 to 4000m	Potential resources	High

Table 6.1: Summary of the principal types of mineral resources in the oceans. Compositions vary greatly depending on the geological setting. Most operational mining is in shallow water. Recent advances in industrial capability have increased the potential economic interest of deep-sea mineralisation.

Key scientific questions

- What is the socio-economic importance of deep sea biodiversity and the impact of human activities on it?
- What are the key economic and valuation issues, and what are the socio-economic drivers of change?
- What are the governance principles that are key in decision-making, and can we develop better policy instruments and appropriate management tools? How can we assess their effectiveness?
- Can we provide the scientific knowledge necessary to underpin the development of tools supporting an ecosystem-based management strategy?
- How can we improve the science-policy interface?

Key recommendations

- Assess deep-sea ecosystem goods and services, including provisioning services (food, raw material, fuel etc.), regulating services (climate regulation, disease regulation etc.), cultural services (recreational, aesthetic, spiritual etc.), supporting services (nutrient cycling, primary production etc.).
- Catalogue the human activities having a direct or indirect impact on marine biodiversity, in particular in sensitive habitats such as deep-water corals, seamounts, hydrothermal vents and cold seeps.
- Carry out monetary and non-monetary socio-economic valuations addressing non-market and non-use values. Assess costs and benefits (including restoration costs) and addressing the issue of discounting (long term benefits vs. short term costs). Assess the loss of value due to biodiversity loss, and develop multicriteria analyses to underpin strategies for the conservation and sustainable use of deep-sea biodiversity.
- Strengthen European expertise in socio-economics and governance research on the deep sea.
- Provide support for democratic decision making underpinning marine spatial planning.
- Improve data sharing through integrated and long-term management of industry, government and margin research and environmental databases in line with the INSPIRE directive. Further develop Geographic Information System tools, standardise metadata cataloguing and improve data visualisation methods to improve data access.
- Study past and present fleet dynamics and behaviour, at the finest possible geographical and temporal scale.
- Develop joint oil and gas industry/research/government approaches to maximise the potential of cabled network on a regional basis.
- Involve industry in long-term ecosystem and environmental monitoring, and at an early stage in Strategic Environmental Assessment exercises. Update industry environmental (risk) assessment and monitoring protocols.
- Develop a European deep-sea mining strategy to ensure future autonomy of metal supply. Close the technological gap existing between Europe and countries such as USA, Japan and Russia.
- Co-ordinate at a European level, Member State science and exploration in international waters in relation to mineral exploitation and assessment of environmental impact.
- Develop the support infrastructure (e.g., ships) and technologies necessary to recover metal deposits from the seafloor on a commercial scale. Encourage the development of specific technologies that have minimal environmental impact when mining ore deposits in the deep ocean.