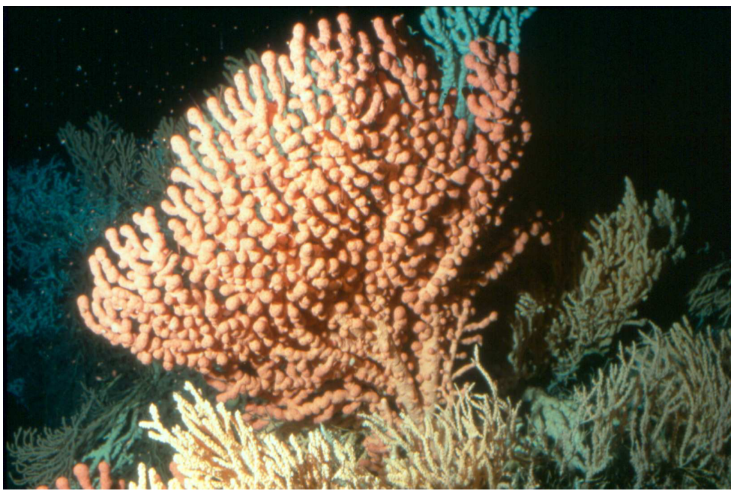
Biodiversity Assessment and Threats Analysis for the WWF Global 200 Ecoregion „North-East Atlantic Shelf"



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ABSTRACT

The North-East Atlantic Shelf Ecoregion (NEASE) is mainly situated on the continental shelf of northwestern Europe, and covers a sea area of about 1.38 million km². The NEASE comprises the North Sea, including the Channel and Skagerrak and Kattegat, and the Celtic-Biscay Shelf including the Celtic Sea, Irish Sea and Malin Sea. At its southern limits, off the French-Spanish border, the shelf is steep and narrow, but widens steadily along the Atlantic coast of France, merging with the broad continental shelf surrounding Ireland and the United Kingdom. The NEASE is one of the most diverse marine regions in the world, with a wide variety of coastal and offshore habitats and ecosystems. Nine States have coastlines bordering the NEASE: Belgium, Denmark, France, Germany, Ireland, the Netherlands, Norway, Sweden, and the United Kingdom.

The influence of advected warm, nutrient rich North Atlantic water coupled with the naturally high productivity of continental shelves, sustains a rich biodiversity of marine plants and animals. Primary production from phytoplankton, seaweeds, seagrass and marshgrass is substantial, but varies considerably with the highest levels occurring in the shallower coastal regions, influenced by land-based inputs of nutrients, or at fronts and upwelling areas close to the shelf edge. These crops of plants support large stocks of zooplankton, pelagic and demersal roundfish, flatfish, benthic animals such as shellfish, seabirds and shorebirds, and seals and whales. The living marine resources exploited in the region include a wide range of animals and plants from seaweeds to shellfish and fish. The commercial fisheries currently land about 4 million tonnes annually of fish and shellfish. All are intensively exploited and the majority of the fish stocks landed for human consumption are overexploited.

Many human activities in the region, on land and at sea, pose serious threats and result in substantial impacts to biodiversity. These activities include tourism and recreation, coastal industries, power generation, agriculture, coastal engineering and land reclamation, sand and gravel extraction, dredging and dumping of materials including litter and garbage, fishing and mariculture, oil and gas exploration and production, shipping, and military activities. In the NEASE, these have resulted in the intensive exploitation of many fish, shellfish and other renewable resources, pollution from hazardous substances (e.g. heavy metals, organic substances) and radioactive substances, inputs of nutrients causing eutrophication effects, the introduction and transfer of non-indigenous organisms, microbial pollution, and diverse forms of disturbances. The effects of climate change also pose a pervasive threat affecting all levels in the ecosystem. The intensive pressures on biodiversity have caused widespread declines in ecological quality, habitat degradation, and changes in trophic and community structure, which in the case of benthos and fish have resulted in a decrease in the abundance of larger individuals and species towards smaller sized ones. Many vulnerable species have become seriously depleted and locally extinct. Depleted stocks of larger piscivorous fish (e.g. cod) have reduced the predation on stocks of small pelagic fish and allowed the expansion of pelagic and industrial fisheries.

In the NEASE, many transboundary and international conventions, agreements, and other instruments provide regulatory and management measures regarding reducing pollution, protecting the marine environment, and conserving living marine resources and their habitats and ecosystems. To be more effective, they require to be implemented fully within the framework of the precautionary principle and the ecosystem approach to management. In order to make the ecosystem approach to management operational, further progress should be made in reforming scientific and governance institutions with a view to better integrating and representing wider groups of disciplines and stakeholders.

1. INTRODUCTION

1.1 Background

The purpose of this report is to review existing information and/or identify gaps in knowledge with regard to the:

1. Occurrence, distribution and role of components of the marine biodiversity; and
2. Threats / human pressures to these components in the ecoregion North East Atlantic Shelf as defined by WWF's Global 200 initiative.

The resulting Biodiversity Assessment Report will be introduced at WWF's Ecoregion Action Programme Workshop (Vilm, Germany, 22-25 September 2002) and serve as the key background for WWF's ecoregional biodiversity vision. It will also form part of the baseline information for further decision making with regard, for example, to a potential review of the ecoregion's delineations, the identification of subsystems to which the ecosystem approach is applicable, the identification of sub-regions in which the future Ecoregion Action Programme (EAP) should be made operational, the ranking of threats, and the root cause analysis for major threats. The specific terms of reference are reproduced in Table 1.

Table 1. Terms of Reference for the Biodiversity Assessment and Threats Analysis

Professor Chris Hopkins / AquaMarine Advisers shall produce a Biodiversity Assessment Report (BAR) - including the analysis of threats and human pressures to the components of biodiversity such as marine habitats – for the ecoregion North-East Atlantic Shelf. The ecoregion (No. 200) has been defined by WWF's Global 200 initiative and identified as a geographic focus for marine conservation work under WWF's Europe/Middle East Programme. Professor Hopkins shall present the main findings and conclusions from the BAR during WWF's initial workshop to develop an Ecoregion Action Programme (EAP) and provide further advice during discussions and decision making at the workshop as appropriate.

Objective and background. The objective of the BAR is to review existing information and/or identify gaps in knowledge with regard to:

- the occurrence, distribution and role of components of the marine biodiversity; and
- threats / human pressures to these components in the ecoregion North East Atlantic Shelf.

The point of departure and basic reference for the review is provided by the OSPAR Quality Status Report 2000 for OSPAR Regions II (Greater North Sea), III (Celtic Seas) and part of IV (as far as the Bay of Biscay is concerned). Biodiversity assessment, human impact analysis and conclusions from the QSR shall be reviewed in the light of other sources of such information.

Target audience and utilisation of the report. The BAR will be distributed to marine programme staff and conservation directors of WWF national organisations (NOs) concerned. It will be introduced and discussed at WWF's Ecoregion Action Programme Workshop (Vilm, Germany, 22-25 September 2002) with NO experts, representatives from partner NGOs and key stakeholders, and evt. IGOs involved.

In this context, the BAR serves two major purposes: it will

1. be the key pre-requisite for WWF's ecoregional biodiversity vision.
2. form part of the baseline information required by WWF to take major decisions about the format and focus of the EAP, such as the

- potential review of the ecoregion's delineations;
- identification of subsystems to which the ecosystem approach is applicable;

- identification of subregions in which the future EAP should be made operational;
- ranking of threats, and the root cause analysis for major threats. and
- review of management recommendations from the OSPAR QSRs with a view to making regional management consistent and operational under the EAP.

Outline of report structure. The BAR should include the following units / be structured along the following tasks:

- Describe the main forcing factors (e.g. currents, climate drivers) and characteristics of the (large marine) ecosystems in the NE Atlantic Shelf Ecoregion. (= Setting the Scene)
- Identify the degree of cohesion between geographic compartments included in (OSPAR regions II, III, part of IV) and/or boundaries determined for the ecoregion. Identify and describe subsystems according to topographic, oceanographic and bio-geographic characteristics.
- Provide an overview of existing measures and management systems related to marine biodiversity in the ecoregion – from transboundary to regional agreements and mechanisms
- Identify threats and/or human pressures to components of biodiversity, including habitats.
- Identify gaps in knowledge and correlate them with failures in current monitoring and assessment regimes.
- Emphasize the importance of the ecosystem approach to management, and identify how progress is being made to achieving such aims in this region as well as the underlying impediments to progress.

Delivery dates. For draft BA Report: 23 August 2002. For final BA Report: 30 August 2002. For presentation of results: during workshop from 22-25 September 2002. The final report as produced in May 2003 includes revisions made on the basis of comments received from the workshop participants.

1.2 Definition of biodiversity

The definition of biodiversity has broadened over the last few decades, and in the Convention on Biological Diversity the term means *"the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems"* (CBD 1992). Thus, biological diversity is now understood to include the levels of species and their genes, as well as ecosystems. This definition will be used hereafter in this document.

This broad definition of biological diversity has implications for plans to conserve and manage biological diversity, as information on biological diversity on a gene or ecosystem level is generally limited, placing the focus of most biodiversity action plans on the species and habitats levels.

2. THE GLOBAL 200 ECOREGION NORTH-EAST ATLANTIC SHELF

The Global 200 is a science-based global ranking of the Earth's most biologically outstanding terrestrial, freshwater and marine habitats. It provides a critical blueprint for biodiversity conservation at a global scale. Developed by WWF scientists in collaboration with regional experts around the world, the Global 200 is the first comparative analysis of biodiversity to cover every major habitat type, spanning five continents and all the world's oceans. The aim of the Global 200 analysis is to ensure that the full range of ecosystems is represented within regional conservation and development strategies, so that conservation efforts around the world contribute to a global biodiversity strategy.

The Global 200 reflects three major innovations:

1. It is comprehensive in its scope - it encompasses all major habitat types including freshwater and marine systems as well as land-based habitats. It ranges from arctic tundra to tropical reefs, from mangroves to deserts, to include species from every major habitat type on Earth;

2. It is representative in its final selection. The most outstanding examples of each major habitat type are included from every continent and ocean basin. Thus, it includes, for example, the most important tropical and temperate forests from each continent, and the most important coral reefs from each ocean;
3. It uses ecoregions as the unit of scale for comparison and analysis. Ecoregions are large areas of relatively uniform climate that harbour a characteristic set of species and ecological communities. Biophysical features—such as topography, ocean currents, and climate—are used to help delineate ecoregions because they greatly influence the distribution of plant and animal communities. By focusing on large, biologically distinct areas of land and water, the Global 200 sets the stage for conserving biodiversity.

Global 200 marine ecoregions have been defined as areas encompassing similar biological communities and over which key ecological processes occur. Marine ecoregions delineated under the Global 200 analysis are nested within a biogeographically based framework (e.g. Sherman 1994; Longhurst 1998). The identified ecoregions represent the most distinct examples of biodiversity for each habitat type, based on the concept of Large Marine Ecosystems (see section 2.3.4). The fluid nature of water and ocean currents, and the dispersal patterns of many plants and animals, results in the patterns of biodiversity being 'transboundary' and not conforming to national waters and exclusive economic zones (EEZs). Thus, conservation at an ecoregional scale and other large-scale approaches are essential for the successful management of the marine environment including its biodiversity. Accordingly, ecoregional conservation provides a framework to align conservation priorities identified at a community scale with global and regional conservation priorities, and to apply the 'ecosystem approach' (see section 2.3.2) at a variety of scales.
Further information concerning Global 200 is found in the WWF publication 'The Global 200 Ecoregions - A User's Guide' and at:

The North-East Atlantic Shelf Ecoregion (NEASE) and its associated WWF North-East Atlantic Programme *"aims to protect and, where necessary, restore biodiversity and maintain the natural productivity and status of the North-East Atlantic marine environment. Its special focus is on the land-sea interface, land-based activities in the catchment area and commonly shared resources"*.

A map of the WWF NE Atlantic Shelf Ecoregion (NEASE), currently in use by WWF, is provided in Figure 1. The degree of equivalency between the extension of the NEASE and other assessment regions is described in sections 2.2 and 2.3.5. It should be noted that the geographic delineation of the NEASE as reproduced in the above-mentioned figure is rather vague and ambiguous with respect to its boundaries. For example, it is apparently now understood by the well informed that the NEASE does not include the Baltic Sea but on the other hand there is uncertainty as to where the 'outer' seawards boundary is situated with respect to being positioned either on the shelf-break or at some currently undefined distance in deeper water (i.e. > 200 m depth). The issue of the 'outer' boundary for the NEASE will be further examined later in this report.

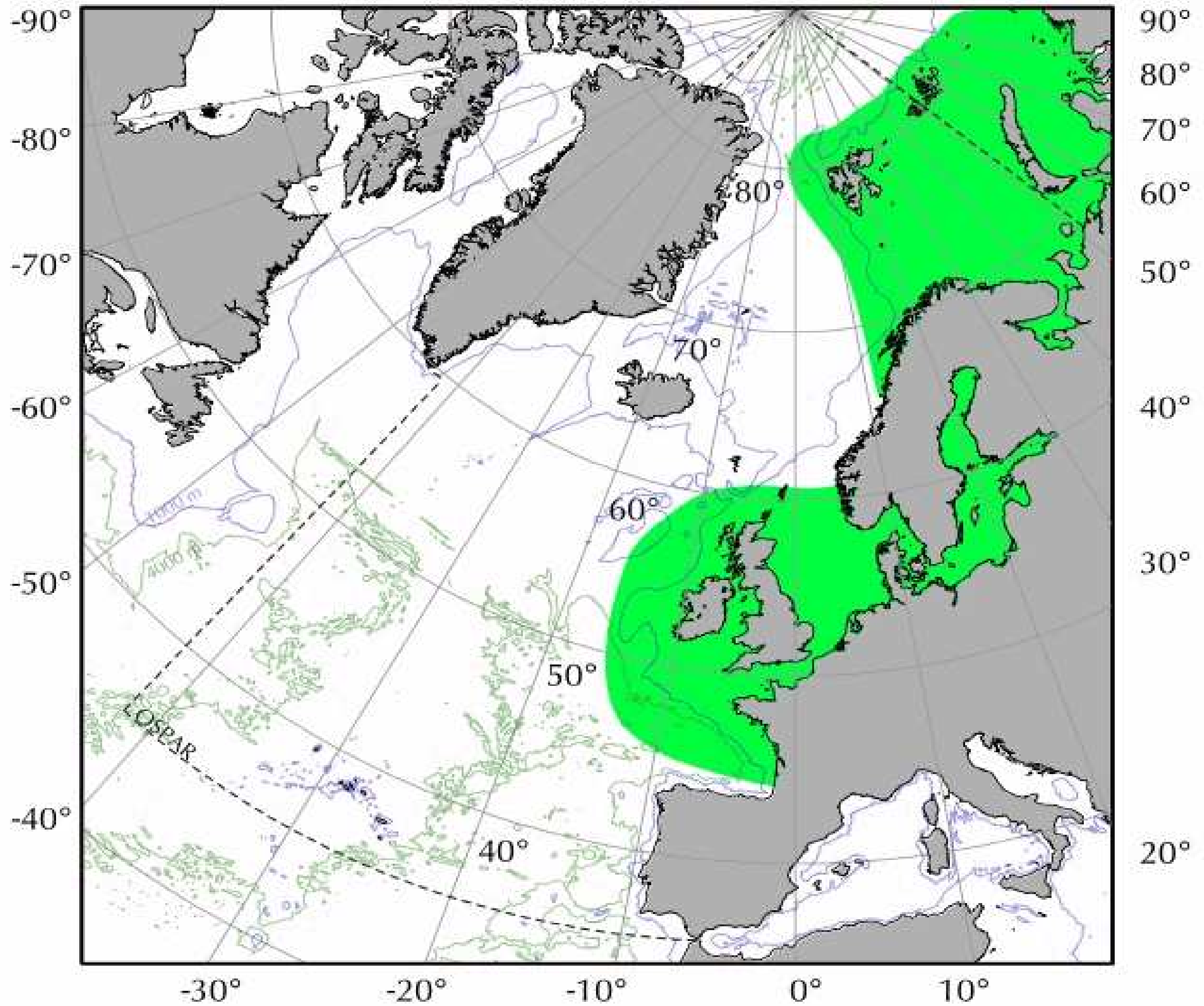

Figure 1. WWF Global 200 Ecoregions in the North-East Atlantic (Barents Sea & NEASE).

2.1 Geography, hydrography, and climate

Geography and topography of the NEASE

The NEASE coincides with the European continental shelf and slope from about 62° N, northeast of the Shetland Islands in the north, to about 43° 30' N, in the south (Figure 2). The region comprises the North Sea including the Channel and Skagerrak, and the Celtic Seas - including from south to north the sub components of the Celtic Sea, the Irish Sea, and the Malin Sea - bordered by the western shelf stretching from northwestern Scotland around Ireland and turning southeastwards along the Atlantic coast bordering the Bay of Biscay. At the northeastern periphery of the region is found the Norwegian Trench that has a maximum depth of about 700 m in the Skagerrak. The total sea area of this sea region, as roughly defined above, covers approximately 1.38 million km^2.

On the continental shelf, classically defined as being less than 200 m depth, substantial areas shallower than 50 m mainly occur in the southern North Sea and stretch along the southern and northern margins of the Channel, and along the eastern side of the Celtic Sea and Irish Sea (e.g. Cardigan Bay and Liverpool Bay). Many submerged sandbanks, often less than about 25 m in depth, are frequently found in both coastal and offshore areas, while submerged reefs rarely occur on the shelf, being more frequently found on the continental slope at depths down to 2,000 m or more (WWF 2001a)

The most common offshore substrates on the continental shelf are soft sediments comprising mud and sandy mud, and sand (Eisma 1981; OSPAR QSR 2000). The distribution of different sediment types is largely a function of the tidal streams and current flows: where they are strongest only gravelly sediment persists, and where they are weakest mud and silt accumulates. In the latter areas deposition of organic material occurs, originating from sedimenting phytoplankton and riverine run-off. The finest muddy sediments are deposited in depressions (e.g. Oyster Ground, Elbe Rinne, Devil's Hole, Norwegian Trench), in areas associated with estuaries and deltas (e.g. the Wadden Sea), and all along the margins of the shelf (McGlade 2002) High accumulation rates of fine material are also a feature of elevations occurring at the Fladen Ground and the Dogger-Fisher Bank, due to the concentrating effects of hydrographic features such as gyres. These areas of sediment deposition also often act as sinks for concentrations of contaminants (Eisma & Irion 1988). The Dogger Bank, in particular, is known for high concentrations of several contaminants. Mainly coarse sand and gravel deposits occur in the shallower areas of the North Sea, nearly all of the Channel, and most of the Celtic Seas. In the latter, limited muddy areas occur in deeper areas in the middle of the Celtic Sea and the Irish Sea as well as in the vicinity of major estuaries.

The coastlines of nine States occupy the NEASE: Belgium, Denmark, France, Germany, Ireland, the Netherlands, Norway, Sweden, and the United Kingdom. With the exception of Norway, they are all members of the European Union. The coastlines display a large variety of landscapes. Generally, the western margins are rocky indented with fjords and estuaries, and in the north mountains dominate the coast. Around the North Sea and the Celtic Sea, the coast shows a range of features, including cliffs of varying height and rock types, bays and estuaries, sandy and shingle beaches, dunes and island archipelagoes. Along the Channel, low cliffs and flooded river valleys, maritime plains and estuaries, are interspersed along the coast to the rocky shore of Brittany. Farther south, the French coast of the Bay of Biscay is low-lying with marshes and lagoons. The coastline of many areas, such as the Southern Bight of the North Sea, have been substantially changed by human intervention, including urban and harbour development, land reclamation, coastal protection structures, as well as ports and industries at river mouths and estuaries.

The region has many notable rivers and estuaries, (e.g. Scheldt, Rhine, Meuse, Weser, Elbe, Shannon, Liffey, Humber, Thames, Mersey, Bristol Channel, Seine, Loire, Gironde, Adour), discharging large amounts of sediments and freshwater, forming in some areas tidal bays and inlets such as in the Wadden Sea and the Wash. As the main rivers are generally regulated, fine particulate material is the main material that reaches the estuaries and adjacent coastal areas. Tidal flats, estuaries, and wetlands are habitats for many marine and brackish-water organisms, and nursery and feeding grounds for many fish, birds and seals. However, these habitats are prone to act as sinks for the accumulation of contaminants due to net sedimentation of particles from upstream sources (OSPAR QSR 2000).

Hydrometeorology and climate

The climate of the NEASE is dependent on the balance between warm and cold hydrometeorological forcing events, mainly occurring out in the North Atlantic Ocean (Figure 2). The distribution and circulation of the water masses are of utmost importance for the biological productivity, distribution and abundance of species, including commercial fish, and the transport and concentration of non-living matter including nutrients and contaminants (Mann & Lazier 1991; Bakun 1996; Dintner 2001).

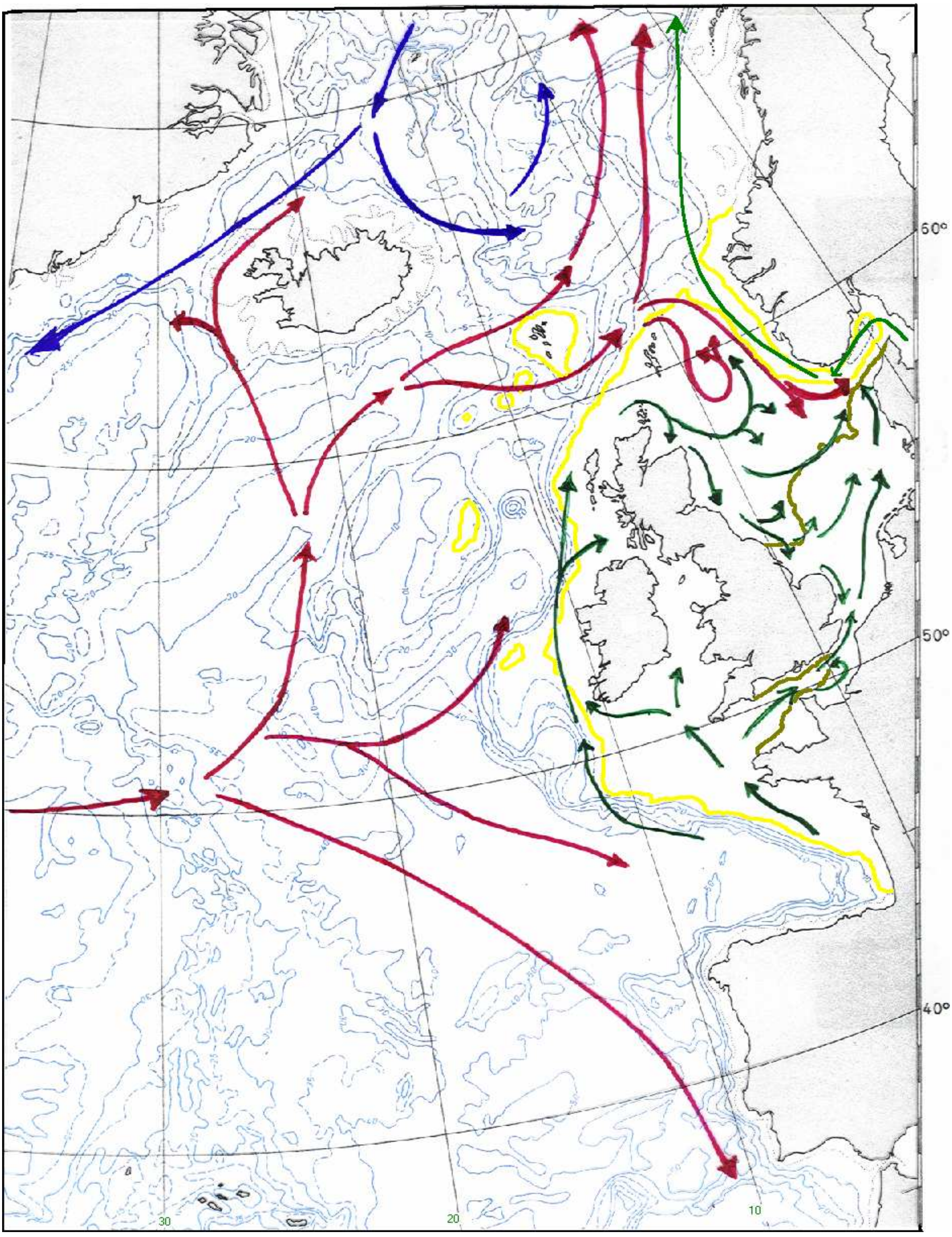

Figure 2. The NEASE showing the main surface currents and bathymetry.
Cold water currents (East Greenland Current): blue; warm North Atlantic currents: red; shelf and coastal currents: green. Continental shelf (< 200 m): yellow. Shallow areas (< 50 m) of the southern North Sea and Channel: brown.

Warm, high salinity Atlantic surface water, as an extension of the Gulf Stream, flows in a northwesterly direction towards the Norwegian Sea as the North Atlantic Current (NAC). A southeasterly flowing branch of the NAC, the Azores Current (AzC), carries warm water into the Bay of Biscay and Iberian area. Other southeasterly flowing branches transport Atlantic water into the northern North Sea.

The northwards flow of warm surface waters into the Greenland, Iceland and Norwegian (GIN) Sea is balanced by a southwards flow of intermediate and deep water of boreal and arctic origin, taking place in the Denmark Strait between Iceland and Greenland, and from the Faroe-Shetland Channel and the Labrador Sea.

The NAC and the AzC - in conjunction with the effects of the predominantly westerly winds, seawater density gradients, and the Coriolis effect - force oceanic water against the European coast to generate a northwards flowing Eastern Boundary Current (EBC) of lower salinity due to freshwater run-off from the land. The EBC flows along the margin of the continental shelf from southern Portugal to northern Norway.

On the continental shelf, the transport is dominated by tidal and wind generated currents, with buoyancy important off major rivers during periods of high freshwater run-off. In shallower areas, these affect mixing throughout the water column down to the bottom sediments. In the North Sea, the residual circulation is anticyclonic (i.e. anticlockwise), passing out northwards along the Norwegian coast as the Norwegian Coastal Current after mixing with the low salinity outflow from the Baltic Sea.

The influence of oceanic Atlantic water is important for the general circulation in the NEASE. This water causes inflow into the northern North Sea and the Skagerrak, as well as a general northwards flow entering the Celtic Sea, passing from south to north through the Irish Sea and emerging into the Malin Sea to exit either into the North Atlantic or after flowing around the north of Scotland into the North Sea. The inflow of water from the Atlantic into the Celtic Seas and the northern and central North Sea replenishes the nutrients necessary for the growth of plankton, which ultimately supports the productive fisheries and provides the resources for many other types of organisms. The input of Atlantic water via the Channel into the North Sea is much less.

In major parts of the northern and central North Sea, the Celtic Sea and the open areas of the outer continental shelf, the water becomes stratified in summer, with relatively warm water near the surface and a sudden drop in temperature at a thermocline around 30-40 m. The temperatures in the deeper parts of the shelf show relatively little seasonal variation compared with the more shallow parts.

North Atlantic Oscillation and Gulf Stream North Wall

Climatic variability on the European continental shelf is dominated by events over the North Atlantic, and in particular by the North Atlantic Oscillation (NAO) (Dickson *et al.* 1996). The NAO index (a measure of the NAO's variability) is the difference in atmospheric pressure at sea level between subtropical high surface pressures centered over the Azores and sub-polar low surface pressures centered over Iceland, and describes the strength and position of westerly airflows across the North Atlantic. Decadal variations in the NAO give rise to changes in the circulation of the North Atlantic, and strongly influences ocean circulation, precipitation, temperature, wind patterns, and is a proxy for effects seen in both terrestrial and marine ecosystems (Ottersen *et al.* 2001). A high NAO index increases the degree of westerly winds, and consequently mild temperatures, over northern Europe. A low NAO index is usually associated with weaker westerly winds, allowing colder winds from the north to dominate over northern Europe.

A measure of the westerly-directed circulation is the latitude of the north wall of the Gulf Stream, which exhibits annual variability reflecting changes in its flow across the North Atlantic. Periods of a high index for the latitude of the northern boundary (i.e. a northwards position of the north wall) of the Gulf Stream (GSI) are associated with increased amounts of warm Gulf Stream and North Atlantic Drift waters flowing into the

North-Eastern Atlantic and penetrating all the way into the Arctic in a strong eastern margin current. Under these conditions, warm water inflow to the North Sea also increases with associated increases in the abundance of advected plankton (Taylor & Stephens 1980; Joyce *et al.* 2000; Taylor 2002).

The latitude of the Gulf Stream North Wall has been predicted by models based on changes in the strength of the NAO index, indicating that from about 1970 until 2001 there has been a generally increasing intensity of the NAO and Gulf Stream indices although there is a decadal periodicity of peaks and troughs (Taylor 2002). The increased intensity of the indices is symptomatic of the increased encroachment of warmer conditions to the NEASE that has taken place over the last 20-30 years (Figure 3) (Rodwell *et al.* 1999). Climate variability associated with changes in the NAO index has substantial implications for the productivity and community structure of marine ecosystems including those in the NEASE (Drinkwater *et al.* 2002).

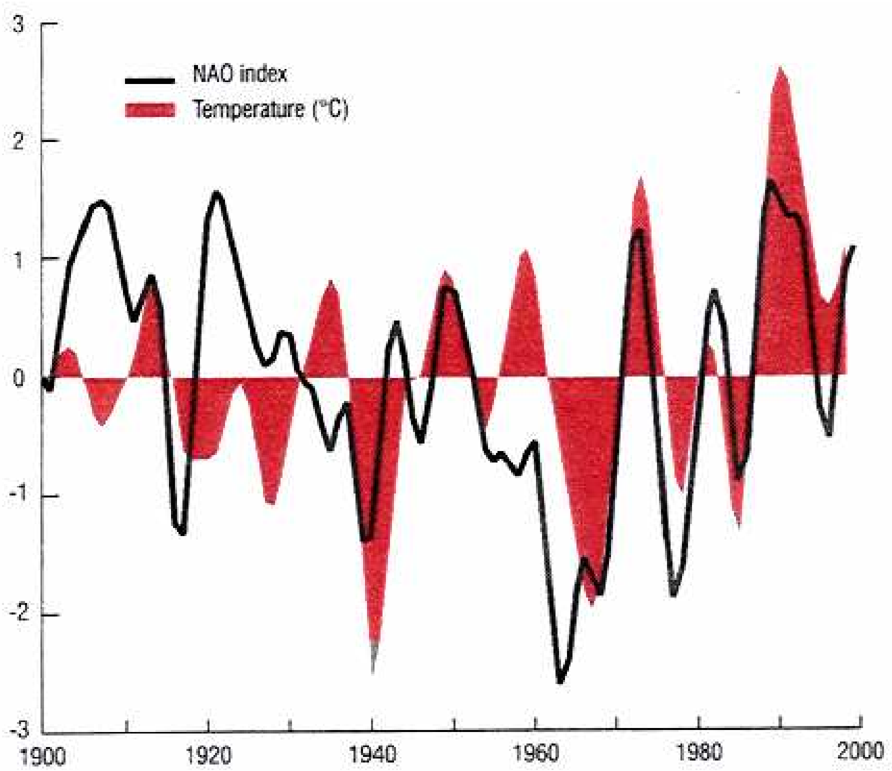

Figure 3. Comparison between the observed NAO index and the observed North European land/sea surface temperatures averaged over the box 5-50° E and 50-70° N, from 1900 to 1999 (Source OSPAR QSR 2000 modified after Rodwell et al. 1999).

Fronts

Frontal zones are formed when water masses of distinctly different properties (e.g. temperature, salinity) meet at a sharp boundary, and fronts tend to be areas of enhanced biological production (Mann & Lazier 1991). In the NEASE these are primarily shelf-break fronts, upwelling fronts, and shallow sea fronts commonly found at the boundaries between shallow, mixed, inshore waters and stratified, deeper, offshore waters. The common feature is that they are all at the boundary between a well-mixed nutrient rich water mass on the one hand and a stratified, relatively nutrient poor, water mass on the other hand. The resulting boundary area is characterized by high phytoplankton productivity, an associated high abundance of zooplankton, attracting foraging concentrations of fish, seabirds, and marine mammals. The most prominent larger scale fronts in the NEASE include the system of fronts in the North Sea demarcating the shallower and deeper waters, the Irish Shelf Front near the west of Ireland, the Celtic Sea Front where the Irish Sea meets the Celtic Sea, the Ushant Front at the western end of the Channel between Cornwall and Brittany, upwelling fronts situated around the continental shelf break, and numerous fronts near the mouths of larger rivers and estuaries throughout the region.

2.2 Relevant assessments in the NEASE and approach used in the current assessment

Monitoring of the various components of the environment and its living resources forms the basis for carrying out assessments of the changing status and trends of the ecosystem related to human induced pressures and natural variability (ICES 2000a). Integrated management measures can then be formulated for the implicated human activities in order to maintain or achieve desired ecological quality objectives, e.g. reduced levels of pollution, more viable utilization of living resources within sustainable ecosystems, conservation of vulnerable species and habitats.

The main sources of information for conducting a biodiversity assessment, including a threats analysis resulting from the affects of human impacts, for the NEASE are the reports arising from the OSPAR Commission and the North Sea Conference Process. These are mainly based on scientific information and advice provided by the International Council for the Exploration of the Sea (ICES). Thus, for the sake of biodiversity assessment purposes, the NEASE may be considered to approximately comprise parts or the whole of the following areas/regions:

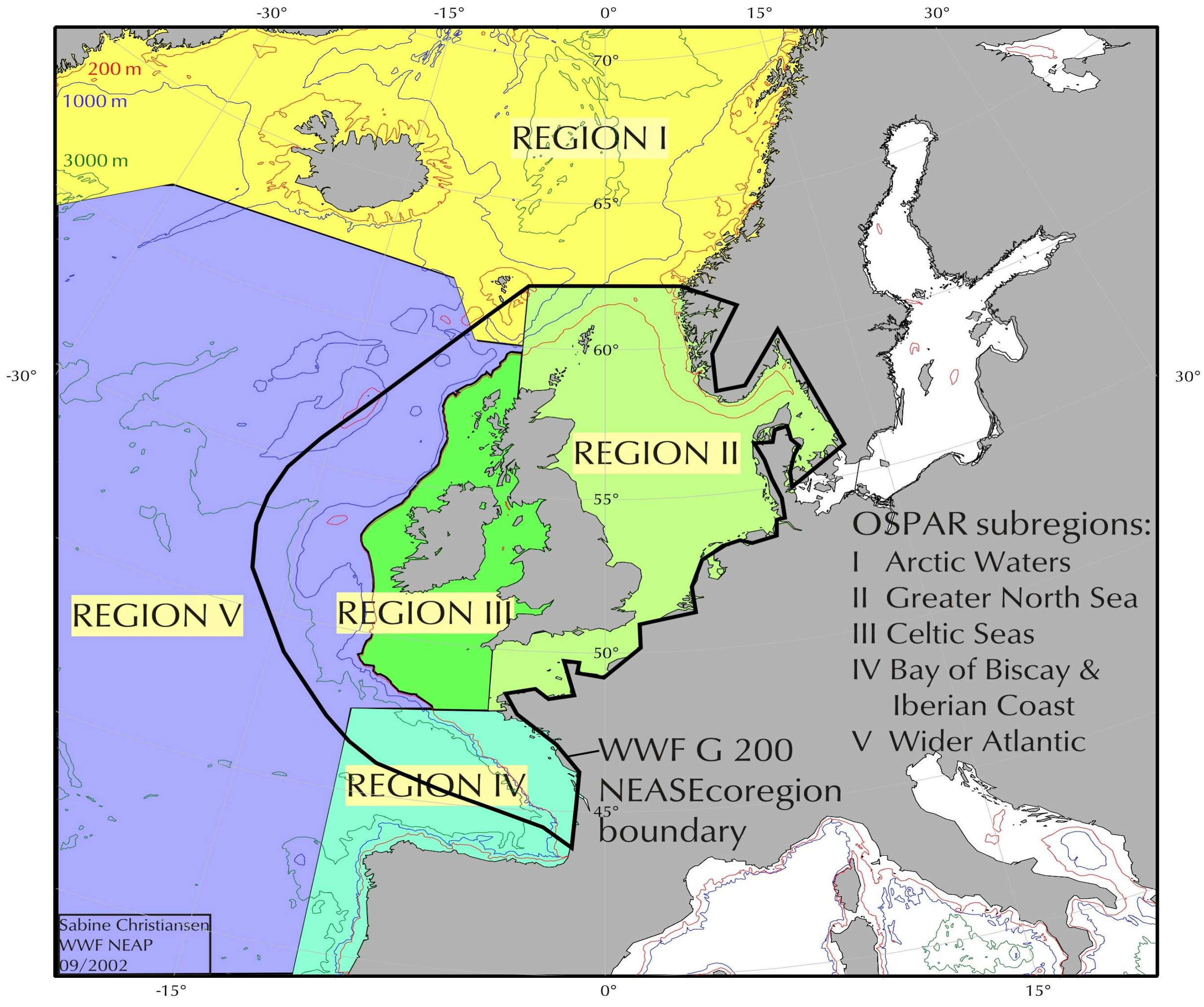

Figure 4. The OSPAR maritime area with special reference to its sub-regions and the boundary for the WWF Global 200 Ecoregion 'North-East Atlantic Shelf' (NEASE) as proposed by the current report.

OSPAR Regions (Figure 4):

- The OSPAR Region II – Greater North Sea – is bound by the coastlines of England, Scotland, Norway, Sweden, Denmark, Germany, Netherlands, Belgium, and France, and by imaginary lines deliminating the western approaches to the Channel (5° W), the northern Atlantic between Scotland and Norway (62° N 5° W), and the Baltic in the Danish Straits.
- The OSPAR Region III – Celtic Seas – extends between 60° N and 48° N and between 5° W and the British west coast to the 200 m depth contour to the west of 6° W.
- The OSPAR Region IV – Bay of Biscay and Iberian Coast – extends from 48° N to 36° N and from 11° W to the coastlines of France, Portugal, and Spain. The Global 2000 NEASE encompassed within this area covers the northern portion of the Bay of Biscay with the shallow continental shelf descending to the deep Biscayan Abyssal Plain with depths of more than 4,000 m off France.

ICES fisheries statistical areas (Figure 5):

- III a, IVa, IVb, IVc, Vb1, Vb2, VIa, VIb, VIIa, VIIb, VIIc, VIId, VIIe, VIIf, VIIg, VIIh, VIIj, VIIk, VIIIa, VIIId, and VIIIe;

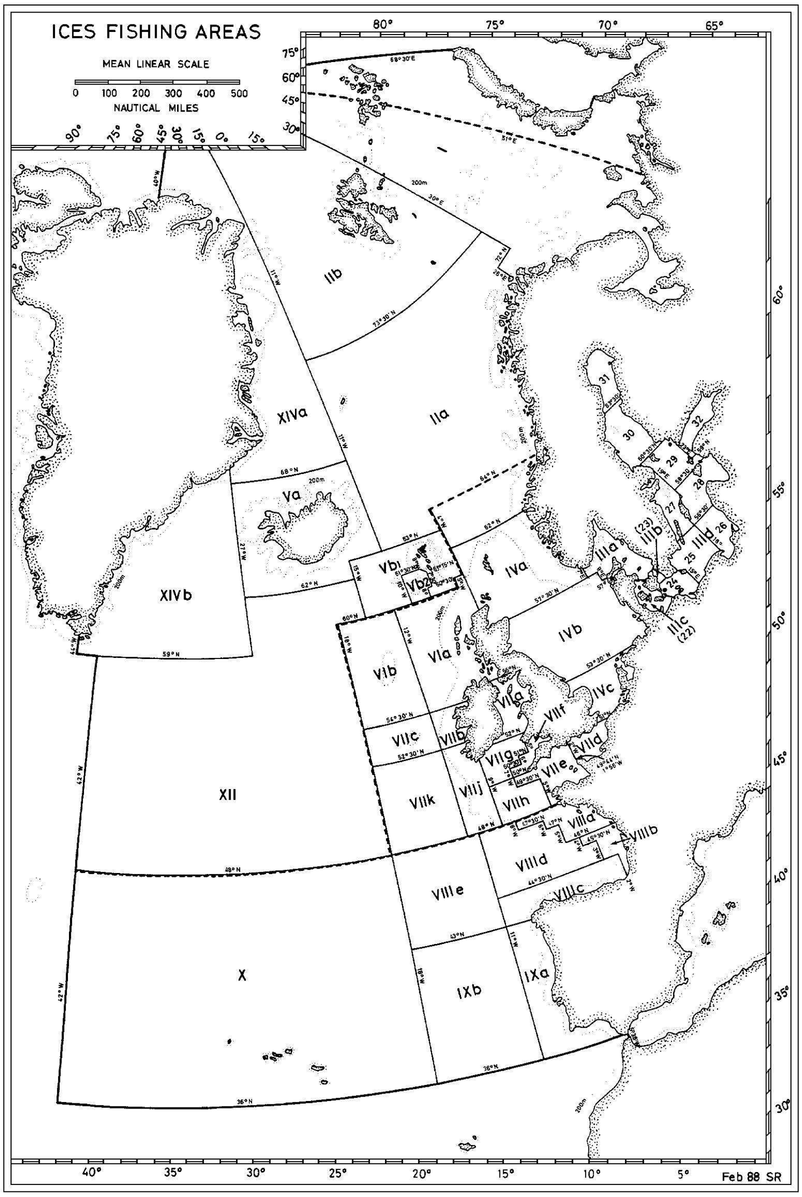

Figure 5. ICES Fisheries Statistical Areas

Further consideration of the identity and degree of cohesion between the ecoregion and other relevant boundaries is provided in section 2.3.5.

The main sources of compiled information forming the background for the assessment of the status and trends of biodiversity in the NEASE in the current report are:

1. The OSPAR Quality Status Report 2000 for the overall OSPAR Maritime Area (OSPAR QSR 2000), with emphasis on OSPAR Regions II, III, and IV (OSPAR rQSR II 2000; OSPAR rQSR III 2000; OSPAR rQSR IV 2000).
2. Declarations and supporting reports from the North Sea Conference process, especially:
    a. The Ministerial Declaration from the 1997 Intermediate Ministerial Meeting on the Integration of Fisheries and Environmental Issues and its supporting Assessment Report on Fisheries and Fisheries Related Species and Habitats Issues (IMM97; Svelle *et al.* 1997);
    b. The 2002 Bergen Declaration from the Fifth International Conference on the Protection of the North Sea and its supporting Progress Report (NSC 2002; Nilsen *et al.* 2002); and to a lesser extent:

3. The North Sea Quality Status Report 1993 (NSTF 1993).

Together with the individual quality status reports (OSPAR rQSRs) for the OSPAR regions II, III, and IV, the QSR report for the overall OSPAR Maritime Area (OSPAR QSR 2000) forms the basis for a holistic and integrated summary of the quality status of the appropriate OSPAR Maritime Area. These various reports describe the physical, chemical and biological characteristics of the coastal and marine ecosystems and examine the impact of human activities. Attention is also drawn to the recent reviews of human impacts in the Bay of Biscay (Valdés & Lavin 2002) and the North Sea (McGlade 2002).

The main sections of the current report consist of the Biodiversity Assessment (section 3), the Threats Analysis (section 4), and the Overall Assessment and Gaps Analysis (section 5). Further information on the specific approaches used in their organization and production is given in the particular sections.

Literature references have been kept to a minimum in the current report in order not to incessantly refer to the above-mentioned sources and to limit the size of the reference list. Additional references to the basic sources are cited mainly with regard to subjects and issues that have either not been noted in the above-mentioned documents or are deemed by the author's judgement to have been insufficiently emphasized. Beyond this, information concerning various habitats and biota has been extracted from the author's own working knowledge in order to amplify areas where these documents are considered to be deficient in substance.

2.3 Transboundary and regional management systems related to biodiversity

The following sub-sections provide an overview of the main operative and developing management systems contributing to the protection of biodiversity in the NEASE. These systems have the *potential* to redress the root causes of overexploitation, pollution and habitat degradation. These systems include various international conventions, agreements and other instruments, as well as the important precautionary principle and the ecosystem approach to management. The intention is to focus on international initiatives rather than those falling under the auspices of a single coastal State, in order to both limit the review to a convenient size and to focus on transboundary collaboration. A substantial proportion of the regional instruments are related to the European Community (EC), of which eight of the nine coastal States are members, and by extension to the EC the European Economic Area (EEA) agreement to which Norway has recently acceded.

2.3.1 Conventions, agreements, and other instruments

The framework of several conventions, agreements and instruments contribute to the protection of the biodiversity of the ecoregion. These include the Convention on Wetlands of International Importance, especially as Waterfowl Habitat (Ramsar Convention), the Convention on the Conservation of European Wildlife (Bern Convention), the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) and its subsidiary Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), the Convention on Biological Diversity (CBD), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention on the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention), and the European Community instruments.

An important new Annex V to the OSPAR Convention, relating to 'The Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area' was adopted in 1998.

The Netherlands, Germany and Denmark, since 1978, have coordinated their activities and measures under the Trilateral Cooperation on the Protection of the Wadden Sea.

As part of the implementation of the CBD, work is being conducted by the coastal States of the area at identifying and mapping the species and habitats that are threatened and declining in their own territories. In several cases, Biodiversity Action Plans have been drawn up for the conservation and/or enhancement of priority species or groups of species and their habitats. The implementation of these plans and the success of marine nature conservation measures are being evaluated in several States with a view to making improvements.

Numerous European Community (EC) Directives apply to the EC Member States and EEA States regarding the protection of the marine environment and its biodiversity. The new Water Framework Directive (WFD) adopted in 2000 (2002/60/EC) must be incorporated into the national legislation of all States in the NEASE by the end of 2003. This influential Directive will promote the integrated management of all water-related operations in fresh and marine waters, including coastal waters extending to one nautical mile outside the baseline. By 2013, several of the components of EC Water Legislation will be streamlined and subsumed within the WFD.

In the NEASE, the Common Fisheries Policy (CFP) was adopted in 1983 as a 20-year programme to regulate the fisheries of the EC States. A mid-term review was conducted in 1992, and a full review is due by 2003. In Norway, a body of legislative and administrative instruments, the most important being the Saltwater Fisheries Act, regulates the fisheries management system.

An overview of the main legally binding international instruments applicable to protection of biodiversity and the environment in the NEASE is provided in Table 2. The list is not intended to be complete due to the total number of candidate instruments being too numerous to include[1].

[1] However, readers are invited to inform the author of important omissions from the list for possible future amendment.

Table 2. The main legally binding international instruments concerning protection of the environment and biodiversity in the NEASE.

Instrument	Purpose
Ramsar Convention 1971	Protect internationally important wetlands
London Convention 1972	Prohibits dumping at sea, and bans disposal of radioactive waste at sea
MARPOL 73/78 – IMO Convention on Marine Pollution from Ships	Limits operational discharges of oil, noxious liquids, and ship generated garbage. From 1999, North Sea waters designated Special Area for oil discharges
Bonn Convention 1979	Conservation of migratory species of wild animals, including ASCOBANS 1991 to protect and conserve small cetaceans in North Sea and Baltic Sea.
Bern Convention 1979	Conservation of European wildlife (fauna and flora) and natural habitats
UN Convention on the Law of the Sea (UNCLOS) 1982	Establishes rights and duties of States regarding resource management and protection of the marine environment
Convention on Biological Diversity 1992	Establishes three main goals: the conservation of biological diversity: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources
OSPAR Convention 1992	Sets comprehensive framework for all Contracting Parties to protect marine environment of the North-East Atlantic
EC Amsterdam Treaty 1997	Sets environmental policy objectives
EC Directive on Bathing Water (76/160/EEC)	Sets cleanliness standards for bathing water
EC Directive on Dangerous Substances (76/464/EEC)	Eliminate or reduce pollution from chemicals
EC Directive on the Conservation of Wild Birds (79/409/EEC)	Special conservation measures to protect habitats of rare or vulnerable species, and migratory birds
EC Directive on Shellfish Growing Waters (79/923/EEC)	Ensure a suitable environment for shellfish growth
EC Environmental Impact Directive (85/337/EEC superseded by 97/11/EC)	Requires developer to provide information to competent authority about likely significant environmental effects
EC Directive on Aquaculture Animals and Products (91/67/EEC)	Increase productivity, introduce health rules, and limit the spread of infections or contagious diseases
EC Urban Wastewater Treatment Directive (91/271/EEC)	Limits the discharge of urban waste water and biodegradable waste water from the food processing industry through the establishment of waste water collection systems and provision of treatment
EC Nitrates Directive (91/676/EEC)	Protect waters against pollution caused by nitrates from agricultural sources
EC Directive on the Conservation of Natural Habitats and Wild Fauna and Flora (92/43/EEC)	Designate and implement conservation measures for Special Areas of Conservation
EC Integrated Pollution and Control Directive (96/61/EEC)	Control emissions from industrial processes to air, water and land
EC Water Framework Directive (2000/60/EC)	Establishes a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater that *inter alia* prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems.

In addition to the agreements noted above, the North Sea States have held five Ministerial Conferences on the Protection of the North Sea, supported by Intermediate Ministerial Meetings, at three to five year intervals since 1984. The Parties have also included the European Commission. These conferences have led to several legally binding agreements making valuable contributions to improving the status of the marine environment and its biodiversity.

2.3.2 The precautionary principle and the ecosystem approach

The precautionary principle

Mankind's rights to rationally utilize living resources – subject to responsible conservation and protection of species, habitats, and the environment – has been established as a principle through several international treaties and instruments (*e.g.* Rio Declaration, UNCED 1992). The precautionary principle, as set out in the Rio Declaration, states that *'where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.'* In particular, Article 7.5 of the FAO Code of Conduct on Responsible Fisheries (FAO 1995) states that:

"States should apply the precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment. The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation or management measures. In implementing the precautionary approach, States should take into account, inter alia, uncertainties relating to the size and productivity of the stocks, reference points, stock condition in relation to such reference points, levels and distribution of fishing mortality and the impact of fishing activities, including discards on non-target and associated and dependent species as well as environmental and socio-economic conditions. States and subregional or regional fisheries management organizations and arrangements should, on the basis of the best scientific evidence available, inter alia, determine stock specific limit reference points and, at the same time, the action to be taken if they are exceeded."

The ecosystem approach

At the 1997 Intermediate Ministerial Meeting on the Integration of Fisheries and Environmental Issues in the North Sea, the desirability of an *ecosystem approach* was recognized (IMM97). The aim of the ecosystem approach is to ensure that fisheries and environmental protection, conservation and management measures are consistent with maintaining the characteristics, structure and functioning, productivity and biological diversity of ecosystems, and a higher level of protection—consistent with the needs of food production—of species and their habitats (Hopkins 1999; Nilsen *et al.* 2002)

The ecosystem approach is the primary framework for action under the Convention on Biological Diversity (CBD 1992), in which the 12 'Malawi Principles' emphasize that humans are integral components of ecosystems and points out the consequences of this for sustainable use of biodiversity and related management (CBD 1998). The Jakarta Mandate (CBD 1995) focuses specifically on marine and coastal biodiversity, and calls for the adoption of the precautionary and ecosystem approaches for the conservation of biodiversity. Thus, the ecosystem approach is a holistic process, building on the precautionary principle, for integrating and delivering in a balanced way the three objectives of the CBD: conservation and sustainable use of biodiversity and the equitable sharing of the benefits. The ecosystem approach requires adaptive management to deal with the complex and dynamic nature of ecosystems and the absence of complete knowledge or understanding of their functioning.

In 1998, an Annex V to the OSPAR Convention was adopted, applicable to the North-East Atlantic area including the NEASE, entitled 'The Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area' that entered into force in 2001. The accompanying Strategy for Annex V is the vehicle for developing programmes and measures to implement *inter alia* an ecosystem approach.

The requirement for an ecosystem approach has implanted itself into the environmental policy and legislation of the EC and the EEA Agreement, e.g. in the important EC Water Framework Directive (2000/60/EC).

The *ecosystem approach* to management has been defined as *'Integrated management of human activities based on knowledge of ecosystem dynamics to achieve sustainable use of ecosystem goods and services, and maintenance of ecosystem integrity'* (ICES 2000a). This definition underlines the need for a comprehensive and holistic approach to understanding and anticipating ecological change, assessing the full range of consequences, and developing appropriate responses. Ecosystem approach to management, ecosystem management, and ecosystem-based management are all synonymous terms for an integrated or holistic approach to management of human activities. Implementing an ecosystem approach is a tool in a process to help systematically redress the root causes of human impacts.

Healthy ecosystems provide numerous essential functions in the form of goods and services to humanity, in which 'goods' refers to items given monetary value in the market place, whereas 'services' from ecosystems are valued but rarely bought or sold. For example, goods are food, medicinal materials, raw materials, and wild genes, while services are maintaining hydrological cycles and composition of the atmosphere, regulating climate, storing and cycling essential nutrients, and absorbing and detoxifying pollutants (Lubchenko 1994).

The sustainability concept depends on both sustainable use by mankind and the sustainability of ecological resources and their ecosystem: the use of ecological resources by mankind can only be achieved if these resources and their associated ecosystems are themselves sustainable. Thus, the ecosystem approach to management involves, *inter alia*, a paradigm shift from managing commodities towards sustaining the production potential for both ecosystem goods and services ('natural capital') (Lubchenko 1994; Costanza *et al.* 1997).

As a follow-up to the IMM97, a Workshop on the Ecosystem Approach to the Management and Protection of the North Sea was held in Oslo in June 1998. A conceptual framework for an ecosystem approach was established, with four elements supporting policy decisions and management actions: a) objectives, b) scientific knowledge, c) assessment, and d) scientific advice. The workshop also recognized the importance of involvement of stakeholders, along with scientists, managers and politicians, in the process to promote openness, transparency, and responsibility.

The *framework* for an ecosystem approach to management starts with the action to generate information from the ecosystem and interacting human activities (ICES 2000a). This is achieved by monitoring to assess the state of the system and through research, giving insight into relationships, interactions, and processes guiding the ecosystem. Together, this information feeds the central line and dominating part of the framework, the integrated assessment. The integrated assessment is subject to the objectives that are stated for the marine ecosystem at stake. Comparison of the outcome of the integrated assessment with the objectives will result in scientific advice to the management regarding what measures should be considered to achieve the objectives set. Using this advice, managers and policymakers are expected to set up a management regime for the coming period. The effect of this new management regime is measured through monitoring, and the process is repeated over again. In the real world, there are many interactions between the various parties involved, with such communication forming a vital aspect of the ecosystem approach.

To support integrated assessments, monitoring programmes provide updated information on status and trends. There is a need to move towards integrated monitoring in an ecosystem context. Thus, all elements in existing national and international monitoring programmes in a given ecosystem should be reviewed with the aim to incorporate them into an integrated ecosystem-based monitoring programme following appropriate adjustments. There is a considerable potential for a more comprehensive and efficient utilization of monitoring results in integrated assessments.

The integrated assessment is a major factor that forces other elements of the framework to deal with integrated issues, and is an important scientific element of an ecosystem approach. There is, for example, a need to move from the present assessments of fish stocks and environmental conditions to more holistic and integrated ecosystem assessments. For research and monitoring, this can be interpreted as multidisciplinary research and integrated monitoring where, at least, data exchange and quality assurance between different fields of work is common practice. The process to define operationally specific objectives for the management of marine ecosystems is a major challenge before an ecosystem approach can be fully operational. This developing process involves the interaction between scientific knowledge, socioeconomic forces, and national and international agreements ending up in a political decision-making process.

Each of the basic elements hides a complex world underneath. Ecosystem management needs the right building blocks (e.g. scientific information and advice, and management objectives), but it should also concern all the relevant stakeholders. There is a growing belief that the concept of an ecosystem approach should be applied to all management regimes in a marine ecosystem.

The attention for socioeconomics and the strong urge to involve stakeholders in the decision process underlines that humans and their activities form an inherent component of ecosystem management. Ecosystem management can only be effective by the regulation of human activities, which is a good justification for including the users in the ecosystem management concept. Communication and cooperation between scientists and user groups, including NGOs, is essential to reach any new objective.

In summary, in order to maintain the quality of marine ecosystems, there is a need to formulate clear objectives for the management of human activities in the ecosystem both at the general level, as overall or integrated objectives, and at the specific level, as more detailed and operational objectives. Scientific knowledge is needed in order to assess whether objectives are being met and whether additional measures are required. Monitoring provides updated information on the state of the ecosystem components, while research provides insight into the mechanisms and relationships among the components. Regular assessments of the status of the marine environment, its ecosystem, and the degree of human induced impacts on the ecosystem, form the foundation for scientific advice to managers for action.

The need for ecological objectives was recognized in 1990 at the Third North Sea Conference in Den Haag, The Netherlands. Since then a concept and methodology has been developed for *Ecological Quality* (EcoQ) and *Ecological Quality Objectives* (EcoQOs)[2]. EcoQOs are an important contribution to the development of operational objectives as part of an ecosystem approach to management.

The OSPAR Commission decided to develop EcoQOs for the North Sea as a test case for the general concept and methodology. A set of 10 *issues* has been identified as a basis for the development of specific EcoQOs:

- Reference points for commercial fish species;
- Threatened or declining species;
- Sea mammals;
- Seabirds;
- Fish communities;
- Benthic communities;
- Plankton communities;
- Habitats;
- Nutrient budget and production;
- Oxygen consumption.

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[2] Ecological Quality (EcoQ) has been defined as an 'Overall expression of the structure and function of the ecological system taking into account natural physiographic, geographic and climatic factors as well as biological, physical and chemical conditions including those resulting from human activities'; Ecological Quality Objective (EcoQO) is *'the desired level of the Ecological Quality relative to the reference level'*. The EcoQ reference level has been defined as the level of EcoQ where the anthropogenic influence on the ecological system is minimal.

These issues relate to both structural and functional aspects of the ecosystem, and divide the ecosystem into broad compartments for which specific EcoQOs can be developed. While developing EcoQOs, a two-track approach is proposed: one focusing on the ecosystem and identifying the crucial components and processes, and one focusing on the human activities and how they affect the ecosystem. Thus, the set of EcoQOs should be a holistic entity, taking into account the linkages in the ecosystem and the total impact by human activities. Each EcoQO should represent linkage between ecosystem features and one or more human activities. Management objectives should then be formulated for these activities. Since EcoQ and management actions are dynamic, the development of operational EcoQOs must be an iterative and adaptive process.

The detailed selection of variables and quantitative expressions of present state, reference levels, and proposed objectives are being developed as part of an ongoing process. Criteria have been promoted for selecting good ecological quality metrics. The proposed EcoQOs for the 10 issues are currently in different stages of development. However, the North Sea Ministers at the 5NSC (NSC 2002) agreed that these should be developed and applied by 2004 in the form of a number of selected ecological quality elements within the framework of OSPAR. This will be coordinated with the development of marine indicators for environmental health in the European Environment Agency and environmental objectives in the EC Water Framework Directive.

OSPAR is seeking possibilities to apply the ecosystem approach in other sub-regions, besides the North Sea, of the OSPAR Maritime Area. It is emphasized that the development of an ecosystem approach also entails the application of a 'toolbox' of various measures for nature conservation in accord with Annex V of the OSPAR Convention. These measures include, in addition to the development of EcoQOs, the assessment of threatened and declining species and habitats with a view to the establishment and management of marine protected areas and undisturbed areas (e.g. in connection with the EC Habitats Directive and the Birds Directive) in coastal and offshore areas, in order to protect against detrimental human impacts.

Progress and impediments towards implementing the ecosystem approach to management

As explained in the previous sub-sections, substantial progress towards achieving the aims of the ecosystem approach has been made in a short space of time. However, several impediments to making further steps forward in the NEASE require attention. These include:

1. The ecosystem approach to management involves, *inter alia*, a paradigm shift from managing commodities towards sustaining the production potential for both ecosystem goods and services. The value of ecosystems and biodiversity needs to be more widely and practically appreciated by stakeholders in a positive socioeconomic context, particularly via 'outreach' programmes and by further developing the discipline of 'ecological economics'.
2. The ecosystem approach to management must more effectively link the scientifically developed monitoring and assessment programme with 'real life' politics and socioeconomic pressures. To do this, greater integration with bio- and socioeconomics is needed and a greater inclusion of interested parties from all walks of life.
3. The regular emphasis on the need for greater or more focused scientific knowledge on key links in the ecosystem is frequently associated with postponement of appropriate management action to redress the root causes of human pressures in the absence of complete knowledge. This gives the impression of a lack of will to take concerted action. Furthermore, in order to gain confidence from the wider community and stakeholders, science and management need to be made more simple, understandable and focused, and not made increasingly expensive and complex.
4. Sectoral organization and adherence provides a hindrance at most levels from science to management as well as stakeholder representation. The consequences of new strategic movements, like the ecosystem approach, are frequently viewed

skeptically by the implicated sectors, especially the involved primary industries such as fisheries. The ecosystem approach depends on holistic, integrative and representational (i.e. inclusive) ways to tackle science and decision-making. Unless integrative and collaborative forums or arenas are established at both the national and international levels (e.g. 'fisheries' and 'environmental' Ministries and Commissions), progress leading to dialogue, understanding, consensus and joint action will not be facilitated. Institutional reform and reorganization (e.g. amendments to rules and constitutions) need to take place in order to enable wider representation and confidence building. As a vital part of this process, there is a need to increase the level of transparency, coherence, understanding and accountability in all parts of the system, especially regarding the information and data connected with the reporting, assessment and management processes.

5. The ecosystem approach is still primarily in the phase of 'good intent' (i.e. theoretical and intellectual) and has not progressed into a phase that is operational for management and that takes into account the needs to closely link science, management, politics and socioeconomics. Thus, decisions and mechanisms must be established to actually apply the ecosystem approach (i.e. when and where) in integrative management, with inclusive representation of the various stakeholders, at the appropriate regional and local scales. Many of the current management areas are too large and not sufficiently devolved, and are not logically connected with the component ecological sub-systems. It is notable that the ecosystem approach is making substantial progress to becoming operational in several developing regions or areas of economic transition by applying the Large Marine Ecosystem (LME) approach (see section 2.3.4), supported financially, scientifically and organizationally via the Global Environment Facility (GEF) (c.f. Sherman & Duda 1999). There are lessons to be learnt from the LME approach in the WWF's NEASE and in implementing the ecosystem approach in the OSPAR Maritime Region: their interests are clearly highly similar.
6. The ecosystem approach will only be successfully applied when scientific, management and stakeholder responsibilities occur at smaller geographical scales. Thus, it is very important that progress be made towards the geographical devolution of the ecosystem approach, including applying it at the levels of the North Sea and Irish Sea and/or their sub-regional levels.
7. Politicians must dare to establish and fully implement frameworks and measures for advisory, management and regulatory bodies for ecosystems that cross-cut sectoral organization and lobbyists activities aimed at counteracting changes to the current sectoral *status quo*.

Gaps in knowledge and management systems of relevance to the ecosystem approach are further considered in section 5.4.

2.3.3 The Large Marine Ecosystem and Biogeochemical Provinces concepts

The Large Marine Ecosystem (LME) concept for the assessment and management of international coastal waters was conceived in the 1980s, and has been developed and further refined as a complementary instrument for achieving an ecosystem approach to management (Sherman 1994; Sherman & Duda 1999). A major area of its operational application is in international development cooperation aided by the Global Environment Facility (GEF).

LMEs are regions of the ocean encompassing coastal areas from river basins and estuaries out to the seaward boundary of continental shelves, enclosed and semi-enclosed seas, and the outer margins of the major current systems. They are relatively large regions of the order of 200 thousand km^2 or more, characterized by distinct bathymetry, hydrography, productivity, and trophically dependent populations of plankton, benthos, fish, seabirds and marine mammals Within a total of 63 LMEs currently identified, about 95% of the usable annual global biomass yield of exploitable fish and shellfish is produced. However, within their waters most of the global marine pollution, overexploitation of living resources, and coastal habitat degradation occurs. Information for monitoring, assessing, and managing

LMEs is organized according to five interrelated modules focused on: 1) ecosystem productivity, related to carrying capacity; 2) fish and fisheries; 3) pollution and ecosystem health; 4) socioeconomic conditions; and 5) governance protocols.

Ecosystem-based fisheries assessment, management, marine biodiversity conservation, and other marine fields require appropriate maps of the major natural regions of the oceans and their ecosystems. A classification system (Platt & Sathyendranath 1988, 1999; Longhurst 1998), defined largely by physical parameters, that subdivides the oceans into four 'biomes' and 57 'biogeochemical provinces' (BGCPs), has been combined with the LME concept in order to represent sub-units of the BGCPs (Pauly *et al.* 2000). This arrangement has enhanced and rendered each of these systems mutually compatible. An incorporation of the LMEs into the framework of BGCPs has allowed the scaling-up of LME-specific flow estimates, including fisheries catches, up to basin and ocean scales. The combined mapping has allowed the spatial computation of derived properties such as temperature and primary production, and their analysis in relation to fishery catch data. Furthermore, it facilitates quantification of the EEZs of various countries in terms of the distribution of important ecological features so far not easily associated with different coastal States (e.g. Christensen *et al.* 2001, spatially mapping changes in fish biomass and catches since the 1950s in the North Atlantic).

2.3.4 Concordance of the NEASE with relevant LME, BGCP and OSPAR areas: Sub-regions for applying the ecosystem approach

At present, the WWF has not exactly determined the boundaries to be selected for the NEASE. However, the approximate degree of conformity between the NEASE and the relevant LME, BGCP and OSPAR areas is ascertained by comparing the information provided in Figure 2, Figure 6 and Table 3.

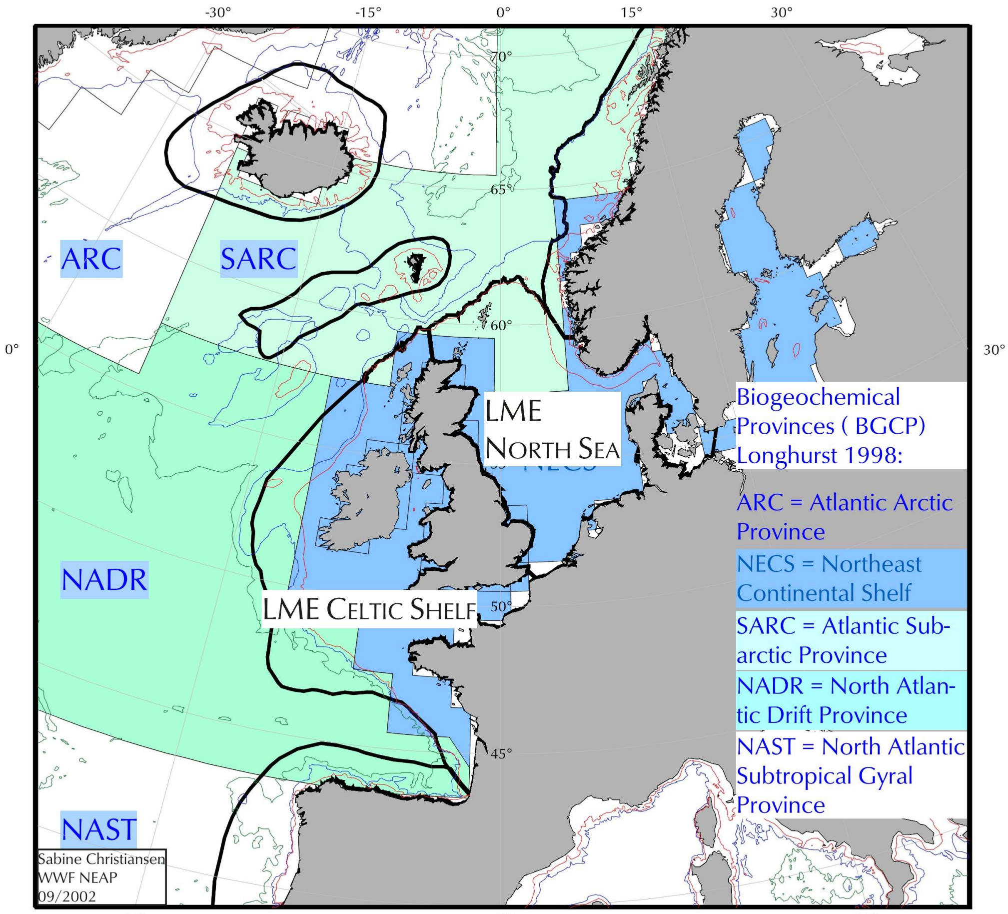
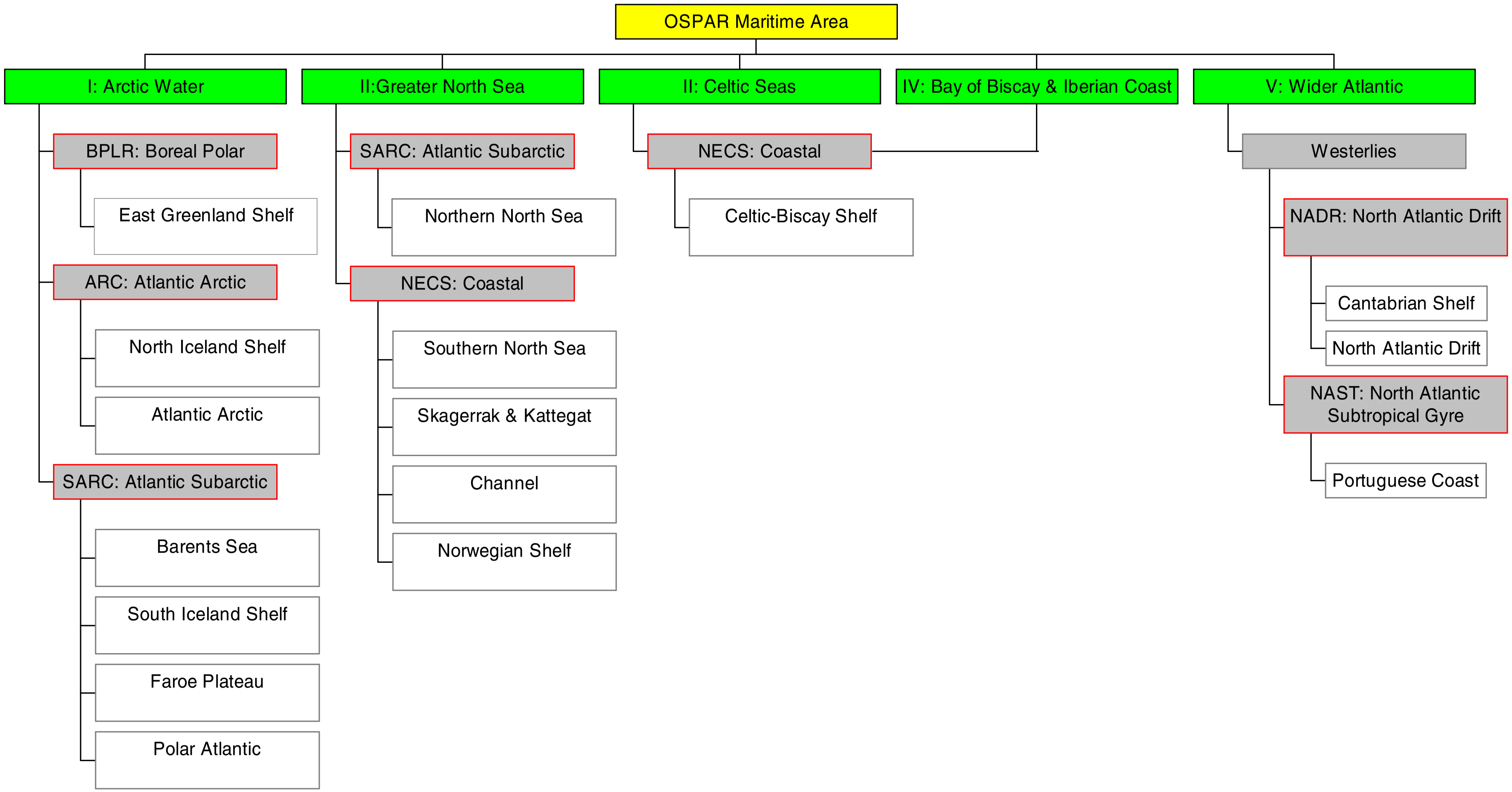


Figure 6. Overview of biogeochemical provines (BGCPs, c.f. Longhurst 1998) and large marine ecosystems (LMEs, c.f. Sherman & Duda 1999) in the North-East Atlantic.

Note the overlap between the North Sea LME and the Celtic-Biscay Shelf LME and the NE Continental Shelves (NECS), Atlantic Subarctic (SARC) and North Atlantic Drift (NADR) provinces of the BGCP classification. See Table 3 for related information on BGCPs. The Icelandic Shelf LME, the Faroe Plateau LME, and parts of the Norwegian Shelf LME and Iberian Coastal LME are also indicated.

Table 3. Allocation of a proposed hierarchy of biogeochemical provinces (BGCPs) to the Regions (I-V) comprising the OSPAR maritime area (After OSPAR Doc. BDC 00/09/01 submitted by WWF based on Pauly et al. 2000).



BGCP units according to Longhurst (1998): Atlantic Polar Biome: BPLR (Boreal Polar province), SARC (Atlantic Subarctic province), ARC (Atlantic Arctic province); Atlantic Coastal Biome: NECS (NE Atlantic Shelves province); Atlantic Westerly Winds Biome: NADR (North Atlantic Drift province), (North Atlantic Subtropical Gyre).

The NEASE essentially:

- Corresponds to a merger of the North Sea LMEs No. 22 (North Sea) and No. 24 (Celtic-Biscay Shelf) according to the current numbering system (Sherman & Duda 1999);
- With regard to the BGCP classification, most of the NEASE is situated in the North-East Atlantic Shelves (NECS) province, with smaller areas falling into the Atlantic Subarctic (SARC) province in the north and the North Atlantic Drift (NADR) province in the western and southwestern parts (Longhurst 1998);
- With regard to the OSPAR maritime area, as already highlighted in section 2.2, most of the NEASE falls within OSPAR Regions II (Greater North Sea), III (Celtic Seas), and part of IV (Bay of Biscay and Iberian Coast).

Delineation of the eventual NEASE boundaries should take into account both scientific considerations as well as the particular policy issues identified for prioritization within WWF's marine strategy for the NEASE. Nevertheless, it is clear that the NEASE should at least generally coincide with the European continental shelf and slope from about 62^{o} N, northeast of the Shetland Islands in the north, to about 43^{o} 30' N, in the south. However, in order to include deep-water issues (e.g. fisheries, oil and gas activities, cold water corals) the boundary could be placed at a strategic distance off the continental shelf beyond the 200 m bathymetric contour. On the basis of these considerations, this report proposes that the NEASE boundary be established as shown in Figure 4.

Within this approximation of the coverage of the NEASE, a number of component sub-regions may represent candidate areas for ecosystem-based management of living resources and the marine environment:

1. The Atlantic Frontier, substantially influenced by Atlantic waters on the western edge of the area including deeper areas outside the continental shelf;
2. The Celtic Sea and Iberian Shelf;
3. The Irish Sea;
4. The North Sea with sub-areas including the northern and southern North Sea, Norwegian Trench, Skagerrak, Kattegat, and Channel.

These may be either combined or further sub-divided as considered appropriate for addressing the spatial scales of particular ecosystem-based issues.

2.4 Socioeconomic importance of the NEASE

The NEASE has a long history of multiple usage by people from many nations. There is a need to safeguard the marine ecosystem and to achieve sustainability in respect of human use. Knowledge of the main human pressures and understanding their impact is essential for the development and implementation of effective measures to achieve sustainable use.

Many human activities occur in the NEASE:

- *Recreation and tourism* in coastal areas and adjacent land is an important social and economic activity with intense development pressure;
- *fishing* for fish and shellfish and, in some coastal areas, the harvesting of seaweeds;
- *mariculture* is undertaken for fish and shellfish;
- *coastal engineering* includes the damming of rivers, but also beach nourishment, diking and land reclamation;
- *power generation* by tidal and wave energy, and windmills ('wind-farms'), are currently limited to a few locations but are anticipated to increase in numbers;
- *mineral extraction* (sand and gravel, calcium carbonate shell aggregates, maërl) takes place in nearshore areas;
- *dumping* of waste or other matter is prohibited by the OSPAR Convention, except *dredged material* (for maintenance dredging, and laying of cables and pipelines), waste from fish processing, inert material of natural origin and vessels or aircraft (until 2004). *Litter* generated by fishing vessels and commercial shipping, and tourism and recreational activities causes substantial problems;

- *shipping* is prominent in the area, with some of Europe's largest ports being situated on the coasts in bays and estuaries;
- *oil and gas* exploration and exploitation has become a major economic activity in the region, particularly in the North Sea since the late 1960s;
- *coastal industries* of various kinds are located along the coasts and estuaries of the region, often requiring large amounts of water for cooling and washing purposes;
- *military use* of the sea, including fishery protection patrols and naval exercises.

The marine environment provides socioeconomic benefits based on biodiversity, and both renewable and non-renewable resources. Recreation and tourism also provide high socioeconomic value, with tourism being placed amongst the most highly valued global industries. The sea and its interactions with the land and the atmosphere have a valuable role in maintaining climate stability and moderating climate change.

2.4.1 Value of nature and ecosystem services

The sea supports a rich coastal and marine wildlife and has a number of important habitats. Although the values of marine ecosystem services[3] are immense, there is a lack of assessments of the value of non-exploited natural capital and services, resulting in reduced priority attached to the maintenance of biodiversity (Nilsen *et al.* 2002). It is important, however, to recognize that the sea and its living resources have an intrinsic value to coastal communities and affect the recreational value of coastal areas. Ecological economists (e.g. Costanza *et al.* 1997) have drawn our attention to the value of '*natural capital*' and *ecological services* provided by global ecosystems. These estimates indicate that the total (i.e. global) value of ocean and coastal ecosystem services (e.g. nutrient cycling, waste treatment in coastal systems) is an impressive USD 21 trillion, equivalent to USD 577 per hectare per year. This is ca. 60% of the value of the estimated global ecosystem services, and 21 times more than the total gross domestic product of marine industries (e.g. fisheries, transport, tourism, oil and gas exploitation, which amount to about one trillion USD. By comparison marine industries account for only about 4% of the global GDP. Thus, the life support system of the globe is connected with the oceans.

The NEASE contains a rich and diverse coastal and marine wildlife with their essential habitats. The region and its wildlife provide a high inherent value to coastal communities and enhance the recreational value of coastal area. Although the value of non-exploited natural goods and services are recognized as immense, these have not been assessed on the regional scale resulting in reduced priority attached to the conservation of whole ecosystems and their biodiversity.

2.4.2 Utilization of renewable and non-renewable resources

The renewable resources comprise capture fisheries aimed at exploiting fish and other living marine resources and the harvesting of seaweeds, mariculture primarily using fish and shellfish, and the harnessing and utilization of wind and tidal energy.

The non-renewable resources comprise oil and natural gas, and marine minerals and aggregates.

3. BIODIVERSITY ASSESSMENT

The marine organisms living in the NEASE belong to a wide range of taxonomic and ecological groups, including bacteria, viruses, plankton, benthos, fish, birds, cephalopods (squids and octopus), mammals and turtles. These organisms are linked through food webs that, together with their environment, comprise the various ecosystems of the region.

The current section provides a general overview of these organisms and some of their important habitats, drawing attention to some of the threats - both human and naturally induced - that substantially affect their

[3] Ecosystem services: The full range of benefits provided to society by ecosystems and their constituent biodiversity, encompassing more than just the capital value of its constituent parts.

productivity and existence. Additional attention is drawn in specific sub-sections to the issues of non-indigenous organisms and the protection of species and habitats. A systematic review of the threats and impacts to the environment and biodiversity caused by various human activities is provided in section 4.

Annex V to the OSPAR Convention, adopted in 1998, aims at protecting species and habitats in the OSPAR area including the whole of the NEASE. The Annex V strategy is to identify species and habitats for which protection measures are to be adopted, including species and habitats under threat or subject to rapid decline.

3.1 Microorganisms

Microorganisms - including bacteria, viruses, yeasts, and fungi - are constituents of the plankton and the benthos as well as being able to act as pathogens and cause diseases (Kirchman 2000).

One of the important functions of marine bacteria is to break down organic matter to inorganic components, utilizing oxygen, nitrate and sulphate as the reduction substrate. A chemical gradient occurs in sediments, in which oxygen using forms live closest to the sediment surface and sulphate-using forms live deeper in the sediments.

Microbial pollution may affect all marine biota ranging from invertebrates to seals. However, the most significant concerns have been connected with human health in the form of the quality of bathing water and the quality of seafood, e.g. shellfish.

Although the dumping of sewage sludge in the NEASE has been prohibited, treated and untreated sewage continues to be discharged from land-based sources into the marine environment throughout the coastal areas (OSPAR QSR 2000). Bacteria and viruses associated with sewage and agricultural run-off can affect water quality (e.g. bathing water) and can accumulate in filter-feeding shellfish (e.g. bivalves such a mussels).

In the past, bacteria and organic matter such as sewage and agricultural run-off, polluted bathing water at many coastal beaches. Bathing water quality has improved substantially since about the mid-1990s, primarily due to the use of new or improved treatment plants for waste water and sewage. The majority of bathing waters at designated beaches in the region now conform to the standards set by the EC Bathing Water Directive (76/160/EEC) with regard to hygiene, based on monitoring of biological and physico-chemical parameters. However, a lack of harmonized methodology for evaluation purposes makes it very hard to compare States.

The EC Directives for shellfish water quality (79/923/EEC) and shellfish hygiene (91/492/EEC) set permissible limits for bacteria (*Escherichia coli*) levels in water and shellfish, respectively. The affected States (including Norway in both instances, as well as EC States) must establish appropriate monitoring programmes and classify shellfish growing waters according to the extent that shellfish samples from an area are contaminated by *E. coli* bacteria.

Although important for the protection of public health, the standards for the microbial quality of bathing water and shellfish as established by these Directives are not able to protect all persons against the full range of human pathogens to which they may be exposed through bathing or eating shellfish.

3.2 Plankton

Plankton are organisms that are unable to maintain their distribution against the movement of water masses: included in this group are bacteria and viruses, and plants (phytoplankton) and animals (zooplankton) (Parsons *et al.* 1984). Generally, all plankton are very small and in many cases microscopic. However, larger animals such as jellyfish are also included among the plankton. Animals such as fish, which can maintain their position and move against local currents are called nekton. However, the separation between plankton and nekton is not precise, and pelagic fish eggs and small fish, particularly fish larvae, are usually regarded as part of the plankton community. The forms that live as plankton throughout their whole life cycle are termed holoplankton. In addition to the above, many bottom living (benthic) animals have larval planktonic stages that live on a temporary basis (meroplankton) in the water masses until they settle on the bottom substrate for the rest of their lives.

At the base of the food web, primary productivity from phytoplankton and benthic algae (e.g. seaweeds) provides the initial level of energy production that sustains herbivorous filter-feeding zooplankton in the water column and herbivorous and sediment eating organisms living on the sea bottom. The zooplankton production, in turn, provides the prey resource for larval stages of fish and the principal food source for the production of pelagic fish (e.g. herring and mackerel) in waters of the NEASE. Some of the benthic organisms are in turn eaten by demersal fish (e.g. cod and flatfish) that live on or near the bottom. Thus, the robust condition of the planktonic and benthic components at the base of the food web is vital for maintaining many stocks of commercial fish, as well as seabirds and shorebirds, and marine mammals.

Phytoplankton

About 1,000 species of phytoplankton have been identified in the NEASE (OSPAR QSR 2000). For most of the year diatoms dominate the phytoplankton community, particularly in the most productive areas such as frontal and upwelling zones. Small dinoflagellates and microflagellates tend to dominate warmer stratified areas offshore under low nutrient conditions.

The region undergoes a classical four seasonal climatic cycle that affects the pelagic ecosystem through the interlinked factors of sunlight exposure, heat input, and hydrodynamic forcing due to ambient wind-fields, oceanographic currents and tides. The seasonal cycle of phytoplankton biomass in the NEASE, although exhibiting considerable spatial variation is typical of temperate latitudes, with a spring increase, summer decline, and a second generally less prominent autumn increase before dropping to negligible overwintering levels. The spring phytoplankton bloom generally takes place in March – April, and occurs under conditions of increasing irradiance, and warming and stabilization of the water column, as nutrient levels are still high from winter levels. The spring bloom is mainly due to diatoms, which then decline as concentrations of the accumulated winter nutrients are utilized and grazing pressure by zooplankton increases. During summer stratification, nutrients (e.g. phosphates and nitrates) are depleted by the phytoplankton, phytoplankton biomass decreases to low levels from nutrient limitation and grazing by zooplankton, and dinoflagellates become dominant. In autumn, increasing winds break down stratification of the water column, allowing nutrients to be replenished and an associated secondary bloom of phytoplankton to occur. During winter, water mixing and low irradiance substantially restricts phytoplankton growth despite high nutrient concentrations. It must be emphasized, however, that in areas with distinctive hydrological regimes, such as well-mixed estuaries, fronts and upwelling areas, there is a departure from this general pattern.

Phytoplankton biomass, measured as chlorophyll concentrations in surface waters, varies both with regard to area and season within the NEASE (Figure 7). The mean annual phytoplankton primary productivity of the NEASE, estimated from the so-called SeaWiFS satellite data and the model developed by Behrenfeld & Falkowski (1997), is about 350 g C/m^2/year. However, the range varies from a maximum of about 500 g C/m^2/year in the coastal areas shallower than ca. 50 m in depth, to minimum levels of less than 100 g C/m^2/year in the deeper oceanic waters outside the shelf break and in the deeper and more open northern and central North Sea. In general, the highest phytoplankton production occurs in the shallower, nutrient rich and well-mixed waters of the southern and southwestern North Sea (e.g. German Bight, Wadden Sea), and at numerous frontal zones situated near the edge and over the continental shelf, as well as upwelling areas occurring at the edge of the continental shelf. Nutrient inputs from the Atlantic, rivers and estuaries, and the sediments support areas of high productivity on the shelf.

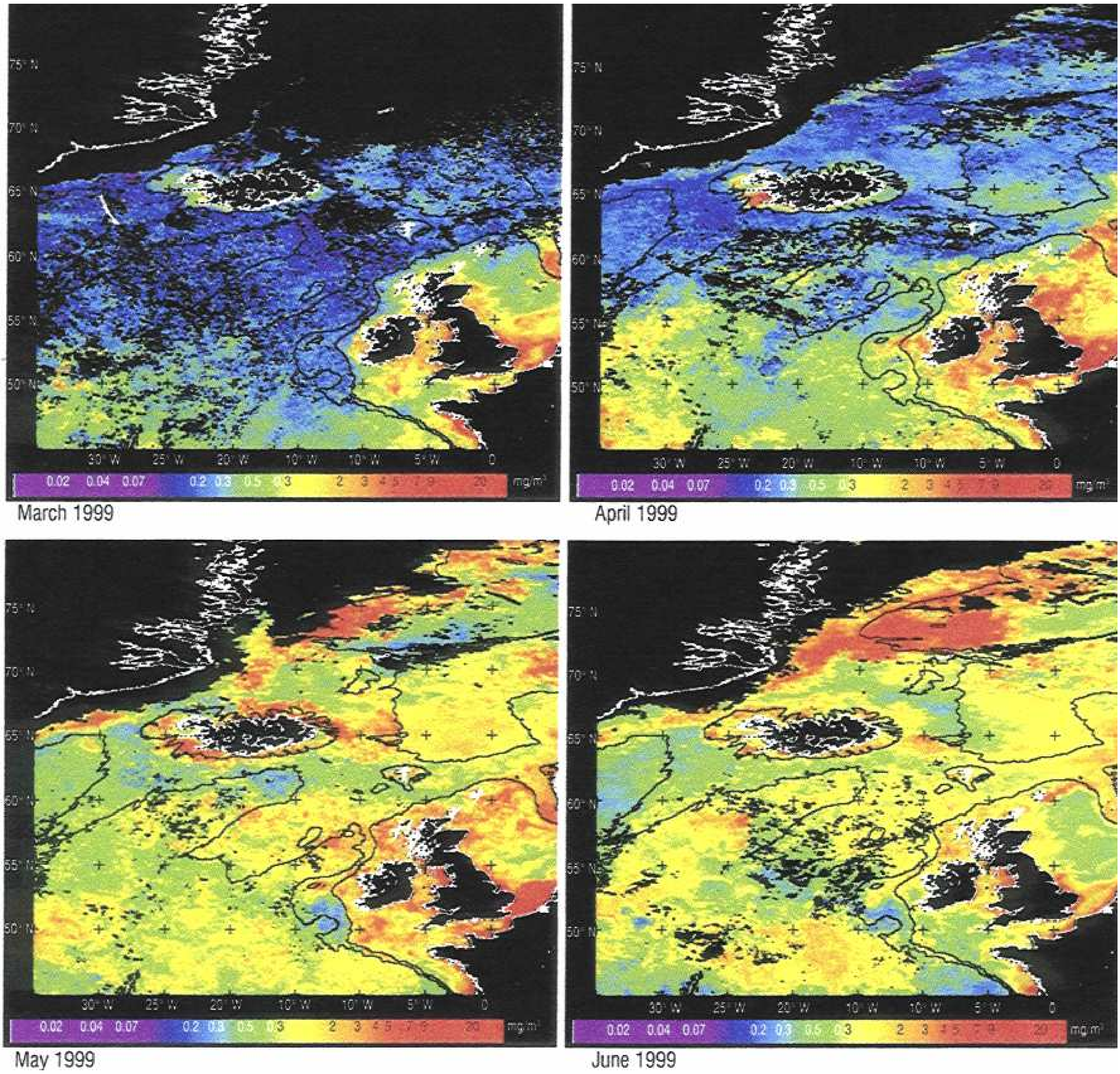


Figure 7. SeaWiFS images of chlorophyll concentrations in the North-East Atlantic (After OSPAR QSR 2000, source CCMS).

Since the mid-1980s, and particularly in the 1990s, there appears to have been substantial increases in levels of phytoplankton chlorophyll measured, for example, by the Continuous Plankton Recorder Survey (CPR), in the North Sea, the Celtic Seas, Bay of Biscay, and oceanic areas to the west of the NEASE (Reid *et al.* 1998; Edwards *et al.* 2001). After 1990, the spring bloom became much earlier and lasted longer, and a strong late autumn bloom also became evident. The change has resulted in a near doubling in phytoplankton colour, increased sea surface temperature, advection of water into the area, changes in the abundance of some phytoplankton and zooplankton species, elevated biomass of benthos animals, and increases in catches of some southern fish species (e.g. horse mackerel) (Reid & Beaugrand 2002; Beaugrand *et al.* 2002a). This 'regime shift' is connected with a rise in the NAO index and the northwards movement and increased flow of the Gulf Stream and North Atlantic Current linked with greater flow to the Bay of Biscay and southern European shelf edge, the northern European shelf edge and the European shelf seas, including penetration of water into the North Sea.

Harmful algal blooms

Harmful algal blooms are a nuisance and cause severe economic and ecological damage (Smayda 1997). Nutrient inputs from land-based sources (e.g. treated and untreated human sewage, run-off from excessive use of fertilizers in agriculture) may increase nutrient availability and increase the duration and intensity of blooms. Additionally, they may cause unusual blooms, e.g. when the natural ratio between N and P (16:1) in seawater becomes distorted. The occurrence of harmful algal blooms is favoured by several algae being able to form resistant resting spores that sink to the seabed or may survive ballast water transport by shipping. Such resting stages start growth and vegetative reproduction under suitable environmental conditions.

Several unusual or exceptional phytoplankton blooms, characterized by the presence of phytoplankton species and their impacts causing public concern, have occurred in the NEASE. Concern may be caused by water discoloration (*e.g. Noctiluca* spp.), foam production (*e.g. Phaeocystis* spp.), fish and invertebrate mortality (*e.g. Chrysochromulina* spp., *Gyrodinium* spp., *Chattonella* sp.), or toxicity to humans (*e.g. Alexandrium* spp., *Dinophysis* spp.). Some of the involved species are non-indigenous introductions resulting from movements including aquaculture and shipping.

Harmful algal blooms, producing toxins, can result in diarrhetic shellfish poisoning (DSP) paralytic shellfish poisoning (PSP), and amnesic shellfish poisoning (ASP). These are best known from accumulating in bivalve mussels and causing human health problems. However, toxic algal blooms are also known to cause mortality to fish, seabirds, and marine mammals. For example, the toxin fibrocapsine, produced by the alga *Fibrocapsa japonicum*, has been registered in common seals in Germany and has resulted in suspicions that accumulation of this toxin in the food web contributed to large numbers of sick and underfed young seals in the Dutch Wadden Sea in 1998.

Zooplankton

The greater part of the formation of new animal protein from plant food each year in the sea occurs in the zooplankton: the enormous stock of zooplankton in turn forms the direct food of such fishes as herring and mackerel, basking sharks, and baleen whales (Lalli & Parsons 1997).

There are generally two peaks in the annual cycle of zooplankton abundance in the NEASE (OSPAR QSR 2000). These occur in spring and autumn and correspond to, although lagging behind, the peaks of phytoplankton production. However, deviations to this scheme occur in estuaries and shallow coastal areas, where tidal action and winds force water column mixing with almost constant nutrient inputs that maintain a more steady production of both phytoplankton and zooplankton.

The zooplankton community is rich in taxonomic groups and species. Crustaceans - mainly copepods and euphausiids (krill) - are the most important group in terms of species richness, persistence, abundance and ecological significance. Both copepods and krill play a significant role in the pelagic ecosystem as grazers on phytoplankton, and in turn providing food for fish, seabirds, and filter feeding baleen whales. Other plankton taxa include arrow worms (chaetognaths), various forms of 'jelly' plankton (e.g. medusae) and amphipods, most of which are predatory on the small herbivorous forms.

Over 400 species of pelagic copepod have been recorded in the NEASE. However, of these only a few species of calanoid copepods (e.g. *Calanus finmarchicus*, *C. helgolandicus*, and various species of the genera *Metridia*, *Pseudocalanus*, *Paracalanus*, *Acartia*, *Temora*) account for 90% of the total production. A substantial biomass of large copepods (e.g. *C. finmarchicus* and *C. helgolandicus*) overwinter at depth outside the continental shelf in the North Atlantic, and provide the parental generation for eggs spawned in the spring in the surface waters, and subsequent juveniles that are transported with the westerly going currents onto the continental shelf. The advective transport of these copepods and others onto the shelf waters and their maintenance in gyres and frontal systems provide important sources of food for plankton eating fish, seabirds, and whales.

Several biological associations of copepod species/taxa occur in the NEASE and are representative for particular geographic areas (Beaugrand *et al.* 2002 a, b) (Table 4).

Table 4. Main biological associations of calanoid copepods characteristic of the areas in and around the NEASE (after Beaugrand et al. 2002a, b).

Region	Main biological associations	Species composition of core group
III: Bay of Biscay and southern European shelf	*Bay of Biscay and southern European shelf edge association* with warm pseudo-oceanic distribution, generally south of 52° N	*Euchaeta gracilis*, *Euchaeta hebes*, *Ctenocalanus vanus*, *Calanoides carinatus*
IV: Northern European shelf edge	*European Shelf Edge association* connected with the Shelf Edge Current (Eastern Boundary Current), pseudo-oceanic temperate species abundance higher along shelf edges to about 55 ° N	*Rhincalanus nasutus*, *Eucalanus crassus*, *Centropages typicus*, *Candacia armata*, *Calanus helgolandicus*
V: East to the oceanic polar front and above 50° N	*Temperate association* connected transitional/mixed water resulting from the North Atlantic Current and Shelf Edge Current	*Aetidius armatus*, *Pleuromamma robusta*, *Acartia* spp, *Metridia lucens*
VI: European continental shelf	*Shelf Sea association* present in Northern North Sea: influenced by boreal water and warmer water coming from the shelf edge; Southern North Sea and Channel: warm temperate water	*Centropages hamatus*, *Temora longicornis*, *Pseudocalanus* adult, *Para-Pseudocalanus* spp.
VII: Southern North Sea	*Coastal association* of shallow warm temperate water	*Isias clavipes*, *Anomalocera pattersoni*, *Labidocera wollastoni*
VIII: North to Faero Islands and East of Iceland	*Temperate and subarctic associations*	(see V & IX for species)
IX: Subarctic region	*Subarctic association* connected with the subarctic waters of the Norwegian Sea	*Heterorhabdus norvegicus*, *Scolecithricella* spp., *Euchaeta norvegica*, *Calanus finmarchicus*

Biogeographical shifts for these species associations are associated with hydrometeorological and climatic regime shifts (Beaugrand *et al.* 2002 a, b). For example, a major change has occurred since the early 1980s to the southwest of the British Isles and from the mid-1980s in the North Sea whereby the abundance of the associations with their centers in the Bay of Biscay and southern European shelf edge as well as the northern European shelf edge have increased northwards by about 10° of latitude. In contrast, the diversity and abundance of the colder temperate and sub-arctic species have decreased in the north. All the biological associations have shown consistent long-term changes that reflect a movement of the marine ecosystems toward a warmer dynamical equilibrium, in accord with biological modifications expected under climate warming. Such an ecological regime shift is particularly attributed to climate warming, connected with an increase in the NAO and Gulf Stream North Wall indices, together with the northwards flow of the European shelf edge current on the western edge of the Celtic Seas (Reid *et al.* 2001).

In the North Sea itself, inflow of species associated with the warm Atlantic oceanic or mixed inflow has been greater in the 1980s and 1990s than previously (Corten 2001; Lindley & Batten 2002). An increase in species richness, particularly of calanoids, in the northwestern North Sea is attributed to increased inflow. However, the species that are currently increasing are not permanent components of the North Sea plankton but immigrants from warmer oceanic and mixed waters as noted above, and meroplankton (e.g. larvae of echinoderms, bivalves, decapods) constituting temporary components of the plankton, migrating from the benthos to the plankton for the pelagic phase of their life (Lindley & Batten 2002). On the other hand, resident and colder water holoplankton (forms that are planktonic throughout their whole lives) have declined in abundance.

3.3 Benthos

The biota (animals and plants) that live near, on, or in the seabed are called the benthos. A distinction is made between plants (phytobenthos) and animals (zoobenthos). The phytobenthos comprises microalgae and macroalgae. A wide variety of animals belong to the zoobenthos, including crustaceans, molluscs, polychaetes, and echinoderms. Animals living in the sediment are called infauna, the fraction larger than 1 mm being called macrozoobenthos or macrofauna (Gage 2001a). Animals living on the seabed belong to the epifauna. Of the macrozoobenthos, shellfish exploited for human consumption consist of crustaceans such as shrimps, crabs, and lobsters, and various groups of molluscs such as whelks; bivalves including mussels, cockles, scallops, and oysters; and cephalopods including squids and octopus (see section 3.4).

As many pollutants end up or accumulate on the seabed and sediments, benthic species are generally exposed to higher concentrations than most pelagic species. They also provide the clearest indication of the physical effects of material disposed of at sea, dredging of seabed materials, and impaction from fishing gears dragged over the seabed. Despite this, large-scale surveys of benthic communities, including their abundance and geographic distribution have rarely taken place and infrequently been supported by funding agencies.

Benthos biodiversity, productivity, and community distribution patterns vary with the type of bottom substrate they live on or in (e.g. hard/rocky substrates and soft substrates such as sand and mud), the depth of the bottom, hydrodynamics (e.g. current speed and wave action), and food availability (Gage 2002; Callaway *et al.* 2002). Marine benthic communities occur from all depth areas ranging at the upper level from intertidal and splash zones that are exposed to a regular alternation between submergence and emergence, to the deepest bottom areas reaching down to more than 4,000 m. However, phytobenthos communities are limited to the photic zone where light penetration supports photosynthesis. In the deep-sea, the macrobenthos becomes the exclusive domain of heterotrophic life, fuelled by the breakdown of complex organic material, in soft sediments. Deep-sea hydrothermal vents are the exception, where benthic biomass relies on the activity of chemoautrotrophic bacteria exploiting the emissions of reduced sulphur-containing inorganic compounds (Gage 2001a).

Soft bottom communities

In shallow shelf areas, benthic and pelagic processes are closely coupled to make these areas very productive. In particular, sediments show spatially and geochemically important relationships, many of which may be modified by human impact. For example, organic enrichment of muddy sediments leads to an increase in macrobenthic biomass up to a threshold where the sediments and overlying water layers become anoxic when overloaded with organic matter, which in turn causes the death of the macrobenthos and emigration of bottom living fishes.

The benthos of mud and sandy-mud bottoms on the shelf has a high productivity as the sedimenting organic material ensures good food availability to both deposit eaters (e.g. polychaete worms) and filter feeders (e.g. bivalves). On the other hand, the benthos of sandy and gravelly areas is less productive as the associated current flow ensures that little organic material accumulates on the bottom, although some filter feeders live by removing organic particles from the water above and nematode worms have adapted themselves to living amongst the sand grains.

There has only been one comprehensive survey of the soft bottom (i.e. sand, mud and silt) dwelling benthos in the NEASE, the so-called North Sea Benthos Survey (NSBS) in 1986, which resulted *inter alia* in a description of six North Sea macrobenthos communities (Künitzer *et al.* 1992). Six benthos communities are also recognized in the Skagerrak/Kattegat, and five offshore and two shallow water communities in the Channel (Thorson 1979; Holme 1966). In the North Sea, the average number of species per assemblage gradually increases with depth, with the maximum number of species in areas deeper than 70 m. In northern areas, diversity is considerably higher than elsewhere. Diversity also increases from southwest to northeast. Total biomass decreases considerably going north, the highest values being found south of the Dogger Bank in the southern North Sea. The mean weight of a benthos specimen also shows a clear decline with increasing latitude and, in areas to the north, with increasing depth.

Sampling of the macrozoobenthos during the course of the 20th century in the North Sea has shown trends in the community structure in the shallower heavily bottom-trawled and more eutrophic southern and southeastern areas (Svelle *et al.* 1997; Nilsen *et al.* 2002). These trends have favoured shifts selecting for robust fast growing and mobile scavengers, predators, and sediment or suspension feeders such as polychaetes, amphipods, and starfish, rather than slow-growing and longer-lived sessile organisms such as many of the larger, and frequently fragile filter-feeding bivalve species. This trend, due to the same human induced impacts, was particularly well illustrated on the Dogger Bank between the early 1950s and late 1980s.

The soft-bottom nature of the majority of the bottom on the continental shelf and the outlying deeper areas is associated with the susceptibility of its more fragile dwellers, such as larger bivalve molluscs, to physical disturbance and damage arising from extractive human activities including fisheries, dredging, and sand and aggregate extraction (Roberts *et al.* 2000).

Hard bottom communities

Rocky substrates occur most commonly in shallow waters, but are also found in a number of deeper areas on the continental slope, with high water movement and turbulence (Little & Kitching 1996). Hard bottom communities have a markedly different fauna to that associated with soft bottoms. In shallower waters, they are particularly evident along the coast of western Norway, western Scotland, western Ireland, and in France on the coast of Brittany, and are associated with seaweed-based communities that reach their maximum development in temperate areas. Most of the biomass is made up of kelps (Laminariales) dominated by *L. borealis*, which live subtidally, and rockweeds (Fucales), which are predominantly intertidal. The biomass of seaweeds in the most productive areas may reach a maximum of about 1.5 tonnes/m of shoreline, of which as much as 85% may be due to kelps while intertidal rock weeds contribute only about 9%. In some nearshore localities, the productivity of the seaweed zone may reach 1,300 g C/m^2/yr, equivalent to about six times the amount of phytoplankton production. *Laminaria* beds are more or less continuous producers of large quantities of detritus and dissolved organic matter that passes into coastal food webs.

Perennial brown macroalgae (seaweeds), such as the fucoids *Ascophyllum nodosum*, *Fucus* spp., on the littoral and upper sublittoral zones of rocky shores, compete for space with annual green algae. Kelp (e.g. *Laminaria hyperborea*) tends to dominate in deeper water where light permits photosynthesis, and form dense forests. The most developed macroalgal communities in the region are found on rocky shores and on hard bottoms in the sublittoral zone down to about 30 m. Southern Brittany is the southernmost distribution limit for northern populations.

Seaweeds, particularly brown algae (e.g. knotted wrack *A. nodosum* and kelp *L. hyperborea* and *L. digitata*) are harvested mainly from naturally growing plants for alginate production, fertilization and pharmaceutical use along some parts of the coast of the UK, Norway, France and Ireland. In the late 1990s in the NEASE, Norway, France and Ireland annually harvested about 80 thousand tonnes, 65 thousand tonnes, and 40 thousand tonnes, respectively. Regulations for the sustainable cyclical harvesting (trawling) of kelp have been implemented in Norway in order to allow the redevelopment of kelp communities.

Seaweed-systems are associated with a very high biodiversity of epiphytes, and are important as nursery, hiding and feeding areas for many species of crustaceans, bivalves, snails, limpets, echinoderms, fish, and seaducks. Dense areas of kelp, especially, act to break the effects of wave action and contribute strongly to protect against coastal erosion.

On rocky shores, herbivores control by grazing not only the level of production but also the species composition and structure of the attached vegetation. The most important of these herbivores are sea urchins, limpets, chitons, and snails. The grazers are in turn regulated by predation from starfish, lobsters, fish, octopus, and shorebirds. In some areas, however, lower intertidal and subtidal areas dominated by abundant macroalgae are interspersed with barren grounds where large sea urchins have over-grazed the vegetation. The large macrofauna of rocky coastal areas that have not been adversely affected by pollution are generally intensively harvested: these species include octopus, crabs, lobsters, whelks, mussels and scallops (OSPAR QSR 2000).

Tidal flats, marsh grass and seagrass

Tidal flats are areas of fine mud-sand sediments that have a high biomass and diversity of infauna and epifauna, particularly polychaete worms, snails and bivalves (Mann 1982). Microphytobenthos, sometimes forming mats comprising specialized diatoms, are a main source of nutrition in these and other shallow waters for larger grazers and fish. Tidal flats are important foraging areas for small flatfish and shorebirds such as ducks and waders.

Good examples of tidal flats are found in the mouths of many of the larger estuaries of the NEASE, and in areas such as the Wadden Sea and the Wash in England (OSPAR QSR 2000). The Wadden Sea covers an area of about 10,000 km^2, about 40% of which is regularly exposed in tidal cycles, forming the largest coastal wetland in Europe with more than 10 million migratory waterbirds visiting it during the year and benefiting from rich food supplies in the mudflats and shallow water.

Coastal marshlands are generally situated on low-lying alluvial deposits at the edge of the tidal plains. Tides affect the flow of water through the marshes creating salt marshes. Salt marshes are also prominent features of low-lying areas in Ireland, the UK, the Netherlands, and the French Atlantic coast. In the latter area, prominent groups of marshes are a key feature of the Coastal Vendée and Coastal Aquitaine areas, where they form a link in the water cycle between land and sea. In some areas, such as the Arcachon basin in Coastal Aquitaine, coastal lagoons are formed.

Salt-marsh communities develop intertidally in sheltered places where silt and mud can accumulate. These form a diverse and heterogeneous flora. There are marked differences between marshes bordering the North Sea, the Channel, and the Atlantic. The North Sea marshes frequently have as co-dominants sea pink (*America*), sea lavender (*Limonium*), sea plantain (*Plantago maritima*) and species of *Spergularia* and *Triglochin*. Atlantic marshes are frequently used for cattle and sheep grazing and are dominated by the grasses *Puccinella* and *Festuca*. On the south coast of England, *Spartina townsendii* and *S. anglica* have been spreading and replacing the more diverse flora which occurred there previously.

Seagrass ecosystems may occur independently of intertidal salt marshes and reach into the lower intertidal zone. In the NEASE, eelgrass (*Zostera marina*) is the most common genus, colonizing soft bottom areas. However, huge populations of eelgrass in the Wadden Sea were wiped out after an epidemic in the early 1930s, and only a few scattered stands of eelgrass have survived in the Dutch Wadden Sea. The eelgrass stand in the Ems estuary has increased from 13 to more than 100 ha in the last 10 years. This increase is due, in part, to protection from damage caused previously by the shellfish harvest.

Both marsh grass and seagrass have a tendency to form dense stands, are sites of higher biological productivity than the open water adjacent to them that act as traps for sediments, nutrients and contaminants, and provide protection against coastal erosion. The massive amounts of sediment and plant biomass serve as efficient buffers against the open sea and the dry land, owing to their capacity to absorb wave energy. Planting of marsh grasses has been shown to reduce coastal erosion, and conversely removal of such vegetation almost invariably leads to an increased rate of erosion. These effects are visible and have economic impacts. These wetlands support important nursery and forage areas for many aquatic animals ranging from shrimps and fish to birds.

Many of these wetlands are under serious threat from pollution, flooding and storm surges connected with climate change, land-reclamation and coastal engineering activities.

Deep-water benthos

In shallow, coastal waters the amount of organic matter reaching the bottom is high due to: a) phytoplankton production is higher in coastal waters than further offshore, b) the distance through which material has to sink, and hence the opportunity for it to be consumed in the water column is less, and c) there is lateral transport from the areas of intensely high primary productivity in seaweed beds and coastal marshes (Mann 1982; Gage 2001a)). Of the total biomass of benthos in the world's oceans, more than 80% is found on the continental shelves at depths less than 200 m. Accordingly, deeper benthos communities generally have a substantially reduced biomass compared with those on the continental shelf, such that less than 1% of biomass occurs at depths greater than 3,000 m. However, benthos communities play an important role in the biodiversity of fragile deep-water ecosystems (Gage & Tyler 1991; Koslow *et al.* 2000; Gage 2002)

Deep-water benthos communities in the NEASE are found primarily in the Norwegian Trench of the North Sea (700 m maximum depth), and along the steep continental slope (200 to about 2,000 m), and on the deep abyssal plains reaching down to depths of about 4,500 m in the Bay of Biscay. Due to their relatively low biomass, physiological and life history adaptations to living at greater depth, these communities are considered highly sensitive to human induced impacts, particularly from bottom trawling, mineral extraction and oil-related industries (Gage 2001b).

Particular interest has been shown recently in the madrepore 'cold water' corals (e.g. *Lophelia pertusa*, *Desmophyllum cristagalli*, *Flabellum alabastrum* and *F. chunii*), that are concentrated along the continental break between 200 and 400 m depth, but are also found down to about 3,000 m depth (Rogers 1999). *Lophelia pertusa* can form large reefs that have a tendency to lie on ridges of morainic origin and similar prominent features on the shelf. In the NEASE, prominent examples of such reefs are found at the Darwin Mounds northwest of Scotland, and in the Porcupine Seabight in Irish waters. Reefs have also been registered in the fjords of southwestern Norway and Sweden, where the shallowest distributions are found. *Lophelia* reefs provide shelter for hundreds of marine species, including fish (e.g. redfish, saithe, cod, ling, and tusk), crustaceans, molluscs, starfish, brittlestars, sea pens, and sea urchins. A wide variety of animals grow on the coral itself, including sponges, bryozoans, hydroids, and other coral species. Attention has been drawn to the distribution areas of cold-water corals in the NEASE where they may be affected by fishing (ICES 2001a). Such massive and ancient coral reefs are under threat, and there is considerable urgency for their conservation as a vulnerable and declining species habitat. These coral reefs are very sensitive to fishing activities using bottom trawls, and it is estimated that 30-50% of the *Lophelia* reefs in some areas have been damaged or impacted by trawling. In 1999, legislation was passed in Norway under the Seawater Fisheries Act making it illegal to destroy *Lophelia* coral reefs intentionally, including imposition of areas closed to bottom trawling.

Combined effects of physical disturbance and eutrophication

For more than a century, human-induced physical impacts (*e.g.* mortality and bottom disturbance from towed demersal fishing gears, the extraction of sand and marine aggregates, and dredging) and organic input (*e.g.* from increased biomass enhancement via eutrophication and discarded by-catch and offal) have increased (Svelle *et al.* 1997; Newell *et al.* 1998; OSPAR QSR 2000; Nilsen *et al.* 2002). These impacts have favoured opportunistic species with flexible life history traits and eliminated vulnerable ones with conservative life histories. The resulting changes in the benthic fauna and flora in the shallower heavily trawled and more eutrophic areas have been moved towards non-fragile fast growing and mobile scavengers, predators, and sediment or suspension feeders such as polychaetes, amphipods, and starfish. These shifts have occurred at the expense of slow-growing and longer-lived organisms such as many of the larger, sessile and frequently fragile filter-feeding bivalves, reef forming polychaetes, maërl and corals. The impacts of the above-mentioned anthropogenic activities have together resulted in elevated productivity and biomass, and a change in the structure of the demersal and benthic communities. Among the sources of anthropogenic disturbance and natural disturbance (*e.g.* sediment movements caused by storm exposing or burying organisms) affecting the benthos, none produce as far-reaching effects as demersal trawl fisheries, (using *e.g.* otter trawls and especially beam trawls), by physically crushing and damaging benthic species and habitats (Nilsen *et al.* 2002).

In the NEASE, dredging is currently mainly conducted as maintenance dredging on shipping routes and in harbours. In the case of marine aggregate extraction (*e.g.* sand and gravel), restrictions are enforced and in some cases aggregate extraction is not allowed on environmental grounds.

A major project on the effects of fishing gear on the North Sea benthic ecosystem ('IMPACT-II Study') has published its results (Lindeboom & de Groot 1998). The scientific information from the IMPACT II report and additional literature has been reviewed by ICES with a view to evaluating the effects of bottom trawling on macrobenthos and associated fish, and thereby proposed measures to reduce the effects of fisheries on benthic species and habitats (ICES 2000b). It was concluded that there is clear scientific evidence of the following effects in the North Sea and Irish Sea:

- Effects on habitats: removal of major physical features, reduction of structural biota, reduction in habitat complexity, changes in sea floor structure;
- Effects on species: reduction in geographic range, decrease in species with low turn-over rates, changes in relative abundance of species, fragile species more affected, surface-living species more affected than burrowing species, sub-lethal effects on individuals, increase in species with high turn-over rates, increase in scavenger populations.

The IMPACT-II Study found that mortalities of benthic infauna occur most frequently from damage by tickler chains, the teeth of scallop dredges, and the doors of otter trawls. Ground ropes of otter trawls rigged without chains mainly have an effect on epifauna. For those gears where there is little penetration of the gear into the seabed, the main effect is on epibenthos, either as the gear passes or by capture with consequent damage in the cod-end or on deck. The quantity of epibenthos that is brought on board can be minimized when the ground rope is rigged with rollers or bobbins or other devices to keep it clear of the bottom. Fixed gill and tangle nets have minimal effects on benthic taxa, with the exception of crabs and certain echinoderms that become entangled.

The method of rigging the gear substantially influences the level of disturbance, and in the case of the beam trawl there is a clear positive relationship between the number of tickler chains used and the biomass of benthos caught. Traditionally, modifying gear to enable greater catches of the target finfish and shellfish has resulted in increases in the by-catch of non-target invertebrates and fish. Although the nets have been modified to reduce the by-catch of non-target and undersized fish, negligible progress has been made in reducing the by-catch and discards of invertebrate benthic species. The catch of beam trawls per haul is substantially greater than for otter trawls for both marketable fish and for discards, the mortality of non-target benthos caused by beam trawl hauls is on average at least 10 times greater than that caused by otter trawls.

3.4 Fish, shellfish and cephalopods

Fish, shellfish and cephalopod resources

Fish are important components in the marine ecosystem due to their frequently high biomass and role in food chains as predators on zooplankton, benthos and other fish, as well as in turn providing food for higher trophic levels including seabirds, marine mammals and mankind. Accordingly, their management and exploitation, both as target and non-target (*i.e.* incidental mortality and by-catch) species in various fisheries, are an ecological concern and need to be seen in a wider ecosystem perspective and not only an economic perspective.

Several reviews have been made of the fish stocks and fisheries pertaining to the NEASE (Svelle *et al.* 1997; Lindeboom & de Groot 1998; OSPAR QSR 2000 including its sub-regional reports; Callaway *et al.* 2002; Christensen *et al.* 2002; ICES 2002a; Nilsen *et al.* 2002).

About 1,100 species of fish have been described for the North-East Atlantic: in the NEASE, this varies from about 230 species in the North Sea to about 700 in the Bay of Biscay. In terms of biogeography, many species reach their southern or northern limits of distribution in the Bay of Biscay. The boundary for the cold temperate species occurs at around 47^{o} N.

In the NEASE, about 20 species account for over 95% of the total fish biomass. Most of the common species are those typical of shelf seas, although deep-water species are found outside the shelf edge, and in some deepwater channels such as the Norwegian Trench and the Skagerrak. Many deep-water species have an extensive geographical distribution owing to the environmental uniformity of their deep habitat.

The NEASE constitutes one of the world's major shelf areas and, as such, one of the major fish producing ecosystems in the word. The great majority of the fish species occurring in the region spend most, if not all, of their life cycle - involving their spawning, nursery and feeding areas - on the continental shelf. Some larger pelagic fish make annual feeding migrations to the area, such as tunas from the subtropical areas of the western North Atlantic. The fisheries are important for the socioeconomic survival of many coastal communities. Currently, about 4.3 million tonnes of fish and shellfish are landed from the ICES fishing areas comprising the NEASE, of which roughly about 70% is caught in the North Sea, 23% is caught in the Celtic Seas, and the remaining 7% is caught in the Bay of Biscay.

The fisheries may be divided in the following three categories: pelagic fisheries (aimed at species that mainly live off the bottom) and demersal fisheries (aimed at species that live on or close to the seabed, of which roundfish and flatfish are distinguished as two groups) for human consumption purposes, and industrial fisheries for reduction purposes (*i.e.* fish meal and oil).

With a current annual production in the range of three million tonnes, the North Sea contributes 4% of the world's fish production of 90 million tonnes. However, in the beginning of the 20th century, the annual catch from the North Sea was in the range of one million tonnes, and comprised 50% demersal and 50% pelagic species that were fished for human consumption. Since about the 1950s, there has been a steady decline in the size of the demersal fish stocks and in their catches. A fishery for industrial purposes started in 1960 and increased up to 1980, with the landings since then having remained in the range 1 - 3 million tonnes. Over the last two decades, the proportion of demersal fish making up the North Sea catch has decreased and since 1990 has accounted for about 20% of the total fish catch.

In the North Sea, the main species targeted by the pelagic fisheries are herring (*Clupea harengus*), mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*). Although most of the landings of these species may be intended for human consumption purposes, part of the landings are used for fishmeal and fish oil. The most important roundfish species are cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*) and saithe (*Pollachius virens*), while the most important flatfish species are plaice (*Pleuronectes platessa*) and sole (*Solea vulgaris*). In addition to these species, the demersal fisheries also take variable quantities of other species. The landings from the industrial fishery mainly consist of sandeels (the species *Ammodytes marinus* accounts for most of the catch), Norway pout (*Trisopterus esmarkii*) and sprat (*Sprattus sprattus*). The industrial catches also contain by-catches of other species including herring, haddock and whiting.

In the Celtic Seas, the average annual landings of fish since 1990 was about 850 thousand tonnes, comprising about 75% pelagic species and the rest demersal species. The pelagic fisheries mainly catch mackerel, horse mackerel, and herring. Other species of pelagic fish landed include sprat, pilchard (*Sardina pilchardus*) and tunas. The herring fishery is principally a "roe" fishery. There is also a small directed-fishery for sprat in the Western Channel. The demersal fisheries of the area are mainly directed at cod, whiting, haddock, hake, anglerfish, megrim, plaice and sole. The major commercial shellfishery is for Norway lobster (also called Dublin Bay prawn, *Nephrops*) in the Irish Sea. Other important shellfisheries include those for scallop (*Pecten maximus*) and queen scallop (*Chlamys opercularis*). Mussel, clam, and cockle fishing is concentrated in nearshore waters and estuaries. Crab, lobster and shrimp are also caught. Irregular industrial fisheries occur in the Celtic Seas, but these are much smaller than in the Greater North Sea, accounting for less than 5% of the total fish and shellfish landings.

The most commercially important pelagic species in the coastal and offshore waters of the northern Bay of Biscay area are sardine, anchovy (*Engraulis encrasicolus*), horse mackerel, mackerel, albacore (*Thunnus alalunga*), bluefin tuna (*Thunnus thynnus*) and swordfish (*Xiphias gladius*). Demersal species comprise the majority of the fish species in the area, with the most commercially important species being cod, whiting, hake, anglerfish, megrim, sole, plaice, plus smaller catches of black scabbardfish (*Aphanopus carbo*), and silver scabbardfish (*Lepidopus caudatus*). In addition, fisheries for Norway lobster, cuttlefish, squid and octopus are important.

There are several commercially important shellfish species, both crustaceans and molluscs in the NEASE. Among the crustaceans are: the pink shrimp (also called deep-sea shrimp) (*Pandalus borealis*), brown shrimp (*Crangon crangon*), edible crab (*Cancer pagurus*), spider crab (*Maja squinado*), Norway lobster (*Nephrops norvegicus*, also called Dublin Bay prawn), and lobster (*Homarus gammarus*). Among the molluscs are bivalves such as oysters (e.g. the native *Ostrea edulis* and imported Pacific species), mussels (e.g. *Mytilus edulis*), scallop (*Pecten maximus*), *Spisula*, cockles (*Cerastoderma*), razor clam (*Ensis* species), gastropods such as whelks (e.g. *Buccinum*), and cephalopods. Mussel, whelk, winkle, cockle, crab, lobster and brown shrimp (*Crangon crangon*) fishing activities are concentrated in the coastal zones and estuaries. Only for Norway lobster and pink shrimp international assessments are made of the state of the stocks. For most of the other species, the main information available is based on landings data.

The main commercially exploited cephalopods in the NEASE are a) cuttlefish, dominated by the common cuttlefish, *Sepia offinialis*, b) squid, including the long-finned squids *Loligo forbesi*, *L. vulgaris*, *Alloteuthis subulata*, and *A. media*, and short-finned squid (*Ilex coindetti* and *Todarodes elbanae*), European flying squid (*Todarodes sagittatus*) and neon flying squid (*Ommastrephes bartmami*), and c) octopods, including *Octopus vulgaris* and *Eledone cirrhosa*). Cuttlefish are the target of the most important cephalopod fisheries in the ICES area of the North-East Atlantic, accounting for about 24,000 tonnes out of the total cephalopod catch of about 54,000 tonnes in 2000, with the most active fishing nations in the region being France (about

23,000 tonnes), Spain (about 15,000 tonnes) and Portugal (about 12,000 tonnes), and most of the landings originating from the Channel, the Bay of Biscay and the Celtic Sea (ICES 2002b). Cephalopods form important prey items for toothed whales, and several species of seabirds and fish (Piatkowski *et al.* 2001).

State of the stocks

The state of the main commercially exploited stocks in the NEASE are assessed on an annual basis by scientists of the coastal States under the coordination of the International Council for the Exploration of the Sea (ICES). A number of biological reference points have been identified to provide benchmarks for the interpretation of the state of each assessed stock. A biological reference point is a level of fishing mortality (a measure of the proportion of a stock taken by a fishery) or stock size estimated through agreed procedures. The values correspond to states of the fishery or stock.

ICES uses the concept of 'safe biological limits'[4] (SBL) to provide scientific advice for fisheries management. A stock 'outside safe biological limits' suffers increased risk of low recruitment, i.e. average recruitment will be lower than if the stock were at its full reproductive capacity, and this causes a reduction in the potential catch fisheries can take from the stock. A stock that undergoes severely reduced productivity is described as 'collapsed'. ICES has been requested to give advice based on the precautionary approach, and has established a system of limit reference points for the stocks that the fisheries managers have required. However, the UN Agreement on Straddling Fish Stocks and the FAO Code of Conduct for Responsible Fisheries call for target reference points for stocks (i.e. optimum stock size) and pre-agreed measures ('recovery plans') if reference points are exceeded (FAO 1995; UN 1995). The system of setting precautionary reference points for commercial fish populations is considered as an important contribution to the set of EcoQOs, but it has been underlined that there is a need to develop target-based reference points in a next step.

Throughout the NEASE, fishing mortality is generally high and has reached for most stocks the highest historical values in recent decades. Almost all demersal species have been exposed to high levels of fishing mortality for many years, and for most of the fish stocks - particularly in the North Sea - their lowest observed spawning stock size has been seen in recent years and the majority of the stocks are outside 'safe biological limits' (ICES 2001b). For most of the stocks of large piscivorous fish, such as cod, in the North Atlantic including the NEASE area, about 66% of their biomass has been eliminate by excessively high fishing pressure since the 1960s (Christensen *et al.* 2001). The North Sea cod stock is in an especially precarious state and the biological advice emphasizes the danger of stock collapse (ICES 2002a). Substantial reductions in fishing mortalities have been advised for stocks that are outside safe biological levels.

Unsustainably high fishing mortality is a result of excessive fishing effort. This, and the poor performance of total allowable catches (TACs), as implemented, in reducing fishing mortality, has led to ICES reiterating that the required reductions in fishing mortality can only be achieved if reductions in effort are included in management. Most fisheries on roundfish and flatfish in the NEASE are characterized by extensive discarding. Discarding and high-grading also take place in pelagic fisheries, but little and incomplete information on discarding practices in these fisheries is available. Management measures, which reduce the amount of juveniles caught, would contribute to the recovery of spawning stocks and benefit yields.

A notable feature of the demersal fisheries in this area is their mixed nature, i.e. comprising several fish species. The effectiveness of single species TACs is likely to be diminished unless this is taken into account. Use of measures to reduce fishing mortality directly, such as effort reductions in fleets, is likely to avoid a

[4] A stock is considered to be harvested outside 'safe biological limits' (SBL) when the spawning stock biomass is below Bpa, which is the lowest biomass where there is a high probability that the production of offspring/recruits is not impaired, or when the fishing mortality is higher than Fpa, which is a fishing mortality that with high probability is not sustainable (ICES 1999).

number of the disadvantages of catch controls in regulating the exploitation rate.

By the end of 2002, no explicit management objectives or recovery plans have been implemented for fish stocks in the NEASE, with the exception of the combined stock (Southern, Western and North Sea spawning components) of mackerel. Fishing capacity has surpassed the productive capacity of the resource system and the impacts of fisheries on the overall ecosystem are great.

Compared to the data available for the target fish species, there is a paucity of data on non-target and non-assessed fish species.

Atlantic salmon

Wild Atlantic salmon (*Salmo salar*) stocks are at their lowest recorded level in the North Atlantic as a whole with a consistent decline in recruitment having occurred over the last two decades for both maturing[5] and non-maturing[6] salmon (WWF 2001b; O'Maoléidigh 2002). In the North-East Atlantic area, about 1,500 stocks have been identified. In the NEASE, declines have been most significant in Southern Europe (mainly Ireland, UK, and France) where recruitment in these stocks is just above the minimum recommended level - the so-called spawning escapement reserve (SER) - needed to meet conservation requirements. In general, the overall situation for Northern European stocks (mainly Russia, Norway, Finland, Sweden, and Iceland) does not appear to be so severe.

The major threats to wild Atlantic salmon populations have been identified by WWF (2001b) as:

- Overfishing in the sea, estuaries and rivers reduces the stock size to below a critical level;
- Hydropower dams and other man-made river obstructions form severe obstacles to migration of salmon, reducing population viability;
- River engineering schemes (e.g. for flood defence or navigation) result in habitat loss and disconnection of the main river from the complex of floodplain habitats. Habitat degradation also occurs through the resulting changes in ecological processes (e.g. nutrient cycling, sedimentation and flooding);
- Pollution from industry, urban settlements and agriculture, resulting in acid rain, inputs of excessive nutrients and upstream sediments, heavy metals and other toxic substances, including endocrine disrupters. Pollutants degrade salmon habitats and some have direct impacts on species mortality and behaviour;
- Salmon aquaculture results in erosion of the natural gene pool through interbreeding with escapees, resulting in competitive disadvantage to the wild stock. Diseases and sea lice transferred from caged to wild salmon are a severe hazard to juveniles in countries where there are major salmon aquaculture industries, e.g. Norway, Scotland and Ireland in the NEASE. Salmon aquaculture now constitutes a major threat to wild salmon stocks.

Marine survival, i.e. between the time of smolt migration from freshwater and the return of the adults from the sea, has been significantly lower in recent times than in the past. There is a well-recognized relationship between marine habitat (measured as the index of the area suitable for salmon at sea using sea surface temperature data) and recruitment, which is dependable enough to predict the abundance of salmon in any year prior to the fisheries. Although the mechanism by which salmon mortality is affected is not clearly understood, there is evidence that sea temperatures influence migration speeds and routes and the degree to which migrants are killed by predators, as well as affecting food availability.

An increasing awareness has occurred recently of the impacts of marine fisheries on salmon survival, particularly at the post-smolt stage, i.e. until August/September of the first year at sea. Research has indicated that post smolt catches are generally made

[5] Maturing salmon that will return to spawn in their native rivers after one winter at sea. These are called maturing 1-sea-winter or 1SW salmon.

[6] Non-maturing salmon that remain at sea for more than one winter before returning to their native rivers to spawn. These are called non-maturing 2SW or multi-sea-winter (MSW) salmon in subsequent years.

with large mackerel by-catches, raising the possibility that commercial trawl fisheries for mackerel can catch post-smolts and that this may be a significant proportion of the total recruits available.

Atlantic salmon has been farmed in fish cages in southwestern Norway since the 1970s with production having reached a maximum within this area of about 200 thousand tonnes per year. Since then substantial production has also taken place in other countries (e.g. Scotland, Ireland, and France) reaching about 100 thousand tonnes per year.

The North Atlantic Salmon Conservation Organization (NASCO) has expressed increasing concern that interactions between farmed and wild salmon lead to changes in the genetic composition of wild salmon (e.g. from escaped fish), the introduction of pathogens/diseases and parasites and other effects with adverse ecological consequences. Recently, NASCO has promoted work to minimize impacts from salmon farming on wild populations and implementation of the precautionary approach. Activities related to the precautionary approach include guidelines to limit escapees from salmon farming and an action plan, adopted in 2001, to rehabilitate wild salmon habitats.

Changes in fish communities

Fish community data collected from the North Sea in the 20th century have shown a decrease in the abundance of larger fish resulting in a shift in both relative and absolute abundance towards smaller-sized fish as well as fish species (Svelle *et al.* 1997; Nilsen *et al.* 2002). This applies to both target (i.e. commercial) fish and non-target fish. These changes have been mainly due to selective and increasing fishing pressure on larger species of fish and the size groups within species that are caught. The decrease in the relative abundance of the larger fish is more pronounced in the heavily fished North Sea than in other areas. Overfishing of the higher trophic level stocks (*e.g.* larger piscivorous fish like cod) has resulted in ‘fishing down the food web’ whereby fishing effort has been increasingly directed at lower trophic levels (*e.g.* smaller planktivores and benthos feeders), resulting in a disturbance of the structure and functioning of the food web. In the North Sea, the average size of an individual fish in the community has decreased substantially between 1974 and 2000 due to increasing fishing pressure.

Fish communities are also affected by climate change. Since the 1960s, a variety of tropical fish species have extended their ranges northward along the European continental slope (Quero *et al.* 1998), and records of fish catches from southern Portugal to northern Norway since the 1980s show northward shifts in the distribution of many commercial and non-commercial species (Brander *et al.* 2000, Brander 2003). On the European continental shelf, red mullet (*Mullus surmuletus*) and bass (*Dicentrarchus labrax*) extended their ranges northward by several hundred kilometers during this period and have been recorded as far north as western Norway. The abundance of commercial gadoid and flatfish species that occur in warmer waters (e.g. pollock and sole) increased relative to colder water species (e.g. saithe and plaice), in areas where their distribution overlaps. The absolute abundance of sole doubled during the 1990s in the Skagerrak and Kattegat, where it is found at the cold end of its range. The scale and geography of the northward changes in fish distribution are similar to those occurring in calanoid copepods during the period 1960-1999 (Beaugrand *et al.* 2002a, b). If these climatic and biological regime shifts continue, they could lead to substantial changes in the abundance of fish, with further declines or collapses in the stocks of boreal species (e.g. cod) that are already stressed by overfishing.

The effects of changing climate variability, including climate change, on the harvested species and the supporting ecosystem as a whole need to be used to predict the levels and patterns of exploitation. However, currently neither climate effects on individual target populations nor the associated effects of fishing on non-target populations and ecosystems are taken into account in the formulation of operative scientific advice for fisheries management purposes.

Particularly vulnerable fish species

A significant number of elasmobranch fish (e.g. sharks, rays, and skates) are slow growing, long-lived, attain sexual maturity at a large size and have a low fecundity compared with other exploited fish species. These life history strategies also apply to many deep-sea fish species, making them susceptible to local extinction by continued fisheries overexploitation (Nilsen *et al.* 2002).

The general pattern found in most elasmobranch fisheries has been one of high initial exploitation followed by a rapid collapse. In most of the NEASE, the landings of skates and rays have decreased by more than half compared to the post-war level. The so-called common skate *Raja batis* has virtually disappeared from the North Sea and the Irish Sea, and the only effective protection for this critically endangered species is a drastic reduction or complete halt to all kinds of demersal fishery, e.g. through establishing closed areas, where relict populations exist. Unless this occurs, similar species will probably be fished out due to their vulnerability to demersal fisheries. The most heavily targeted ray, the thornback ray *Raja clavata*, has almost disappeared from the southeastern North Sea. In 1997, ICES advised limiting the impact of demersal fisheries particularly in those areas where the thornback ray still occurred in order to conserve the North Sea stock.

The International Plan of Action for the Conservation and Management of Sharks[7] (IPOA-SHARKS) was adopted by FAO in 1999, and a preliminary draft European Community Plan of Action for the Conservation and Management of Sharks was presented to FAO in 2001. Integrated action to support research and monitoring activities regarding elasmobranchs should extend beyond classical management strategies to include the role of elasmobranchs in the structure and functioning of the marine ecosystem and more specifically fish assemblages.

[7] The term 'shark' includes all species of sharks, skates, rays and chimaeras, and the term 'shark catch' includes directed, by-catch, commercial, recreational and other forms of taken sharks.

Fisheries carried out in waters deeper than about 400 m are generally considered 'deep-water fisheries'. In recent years, fishing in deep waters has increased as traditional fish stocks have declined. Increasing fishing effort on deep-sea species, because of their sensitive life history characteristics, poses a serious threat to deep-water fish stocks and their associated ecosystem (Koslow *et al.* 2000; Gordon 2001; Nilsen *et al.* 2002). In the NEASE, the stocks of deep-water fish facing significant declines and overfishing include ling (*Molva molva*), blue ling (*M. dypterygia*), orange roughy (*Hoplostethus atlanticus*), roundnose grenadier (*Coryphaenoides rupestris*), black scabbardfish (*Aphanopus carbo*) and several squalid sharks.

In the North-East Atlantic and its adjacent seas, the assessment of the status of deep-water stocks has almost entirely been derived from catch per unit effort (CPUE) analyses rather than analytical stock assessments. It has caused concern that CPUE series for several species cannot be updated due to unavailable data. There is also concern that catch rates can only be maintained by sequential depletion of relatively isolated concentrations/sub-units of a stock. The urgent need to implement the precautionary approach to manage deep-water fish stocks is exacerbated by the low survival rate of discarded species and escapees. Thus, increasing fishing effort will affect deep-water fish assemblages in general and not just species of commercial importance.

The 2000 ICES ACFM report states that *'most exploited deep water species are, at present, considered to be harvested outside safe biological limits. ICES recommends immediate reduction in these fisheries unless they can be shown to be sustainable.'* Particular concern has been expressed that the landings statistics may not reflect the true scale of the recent fishing activity in waters outside the national EEZs.

Fish diseases

The majority of diseases in marine fish are caused by infectious pathogens or parasites, but pollution may cause lesions and exacerbate the prevalence in some species and areas (NSTF 1993; OSPAR QSR 2000; Degnbol & Symons 2000). The bacteria, viruses, and parasites responsible are relatively widespread and some cause serious problems in farmed and wild fish, and some diseases may be transferred between farmed and wild fish and vice versa.

Reports indicate that a high prevalence of some fish diseases occurs in known areas of pollution in the North Sea (NSTF 1993). High prevalence of epidermal hyperplasia/papilloma in dab (*Limanda limanda*) have been found in the former dumping grounds for wastes from titanium dioxide production in the German Bight and off the Dutch coast as well as at the outflows of the rivers Rhine/Meuse, off the Humber Estuary, and on the Dogger Bank. There is also a correlation between the occurrence of liver tumours in North Sea flatfish and contaminants, particularly chlorinated hydrocarbons and PAHs. Above average prevalence of liver tumours has been found in dab in the German Bight, off the Dutch coast, on the Dogger Bank, and off the Humber Estuary. Pathological changes in the liver have been found in flounder (*Platicthys flesus*) from the Elbe Estuary and off the Dutch coast.

Under low dissolved oxygen concentrations in the environment, higher prevalence of lymphocystis and epidermal hyperplasia/papilloma in dab have occurred along the Danish west coast and in the Kattegat.

3.5 Seabirds and shorebirds

Seabirds and shorebirds play important roles in the marine ecosystem due to their abundance and position as predators at or near the top of food chains (Reid 1997; Furness & Tasker 1999). The majority of offshore seabirds eat fish, including live and as discards and offal, many feed on benthos, and a few eat zooplankton. These birds are liable to ingest and further accumulate contaminants already present in their prey, and to experiencing the biological effects of pollution (Nilsen *et al.* 2002).

The NEASE supports a large number of breeding and migratory seabirds and shorebirds. About 10 million seaducks, and over a million waders and several thousand gulls feed on shellfish in northwest Europe during the winter. The most detailed regional data are available for the southeastern North Sea for the eider, common scoter, oystercatcher and herring gull. Proportionately the greatest numbers of breeding seabirds nest on the coasts of Scotland, northern England and around the coasts of Ireland (Figure 8). The total numbers of individuals of these northern colonies are several orders of magnitude greater than in the southern regions of the area, with the neritic regions having substantially higher densities than the oceanic regions. Large intertidal flats, e.g. in estuaries and in the Wadden Sea, are important for wading birds. In the greater North Sea area, about 10 million seabirds and shorebirds are present at most times of the year.

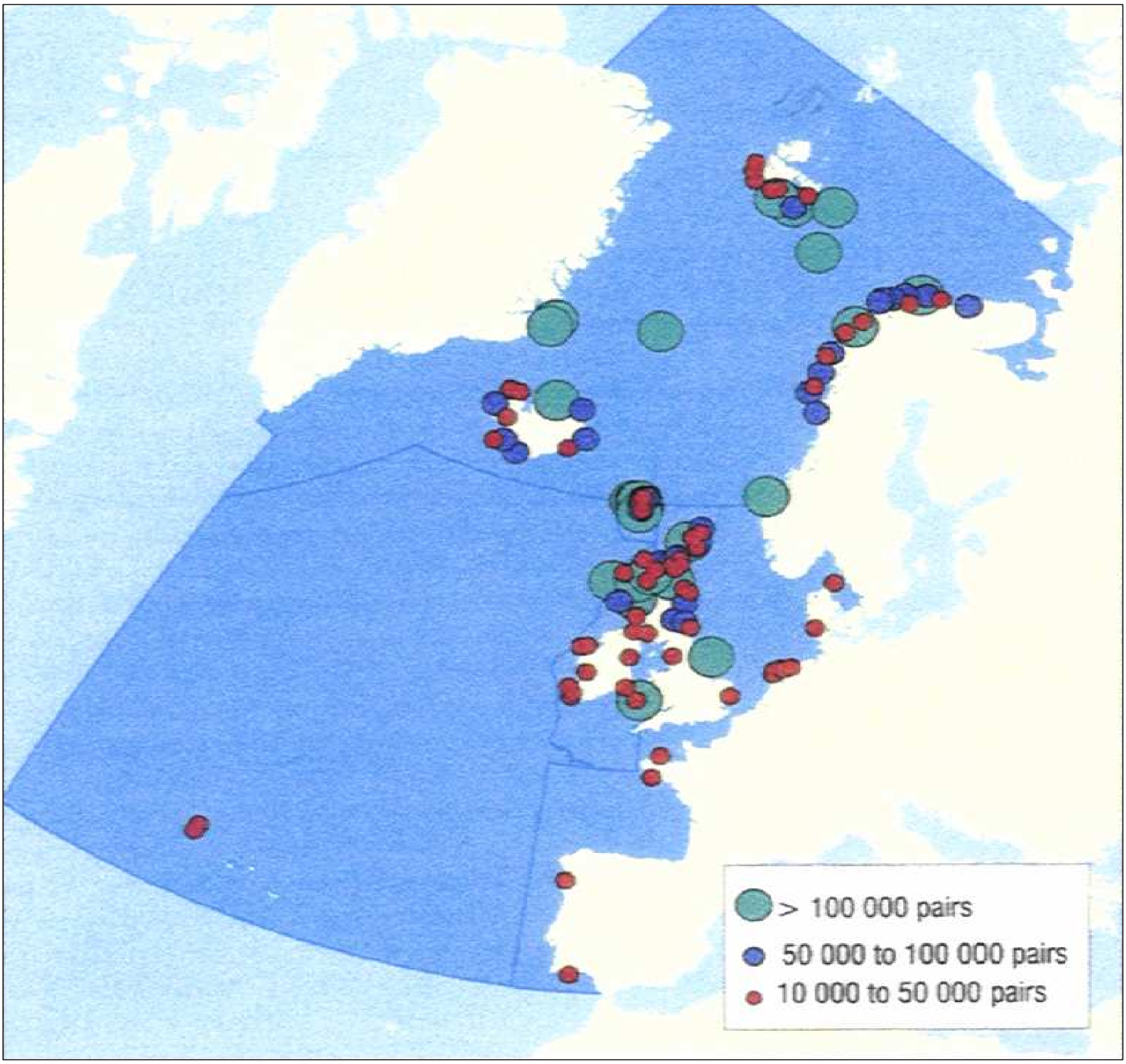


Figure 8. Location of large seabird-breeding colonies in the OSPAR area (After OSPAR QSR 2000 from data of Grimmett & Jones 1989).

The most common species of seabirds in the NEASE include kittiwake (*Rissa tridactyla*), common guillemot (*Uria aalga*), fulmar (*Fulmarus glacialis*), herring gull (*Larus argentatus*), black-headed gull (*Larus ridibundus*), puffin (*Fratercula arctica*), arctic tern (*Sterna paradisea*), common tern (*Sterna hirundo*), common gull (*Larus canus*), lesser black-backed gull (*Larus fuscus*), gannet (*Morus bassanus*), and razor bill (*Alca torda*).

About 110 species of birds are recorded for the North Sea: about 50 of these feed intertidally, about 30 feed in nearshore shallow waters, and about 30 feed offshore. The nearshore and intertidal groups tend to feed on benthic invertebrates, while those further offshore exploit fish and zooplankton. Some birds visit the area in the summer, and others are present only in the winter. The abundance of many inshore and inter-tidal species increase in the winter as birds move to the coasts from colder areas to the north and east.

Some of the species among the intertidal and nearshore groups breed on North Sea coasts, but many more move into the area outside their breeding seasons.

Proportionately more of the offshore group of seabirds nest on North Sea coasts but considerable numbers use the North Sea outside the breeding seasons. The coasts of north Britain in the northwestern North Sea hold the largest numbers and greatest species diversity. The Channel, southwest Norway and the Bay of Biscay have the fewest seabirds and shorebirds of any of the regions.

Seabirds and their eggs used to be taken for human consumption, but this has generally ceased allowing populations to increase. Oil pollution and the increasing incidence of sea bird catches in gillnets has been more prevalent in the Channel than in the North Sea.

The species that are particularly associated with scavenging on discards and offal have increased (e.g. fulmar, gannet, great skua, the larger gulls and kittiwake), as have the species that dive to depth to catch small fish (e.g. guillemot, razorbill, black guillemot and puffin).

Human induced factors that have affected overall population levels of seabirds include:

I. *positive factors* such as increases in food supply due to reduction in large fish competitors, dumping of offal and discards from fishing, and the reduction of directed hunting, and
II. *negative factors* such as introduced predators, oil pollution, disturbance in general, and other pollutants including litter at sea.

Introduced predators - especially rats and mink - that eat eggs, young and adults, are a major threat to seabirds and shorebirds, particularly in the North Sea region. These predators have affected the distribution and abundance of black guillemot and reduced the breeding success of several seabird species in Scotland during the 1990s.

Oil pollution causes death and sub-lethal effects on organisms, destruction of habitats, and disruption of food chains (Nilsen *et al.* 2002). The impacts of spills are variable but even small spills can cause substantial casualties. The degree of impact depends on the location and seasonal timing of the spill, as well as on the type of oil. Most oil enters the sea from land-based sources or deliberate discharges from ships: most seabird mortalities from oil pollution occur from these events. Seabird species that congregate on the sea surface are at greatest risk, *e.g.* divers, seaducks, Manx shearwater, razorbill, guillemot, black guillemot, and puffin.

Marine litter, including small particles of plastic that may be eaten, can cause death through entanglement or ingestion, or through reduced feeding opportunities. This is particularly a problem in the North Sea and Celtic Seas.

'Windmill farms' constructed at sea have received attention recently with regard to their possible disturbances on aquatic birds.

Seabird surveys are conducted to estimate the abundance and distribution of birds. The North Sea observations form the world's largest effort-correlated database on the distribution of seabirds and marine mammals at sea. The database is used to produce vulnerability atlases for birds from oil pollution, indicate the most sensitive times of the year for offshore birds from oil exploration activities, identify the important areas for piscivorous birds that might be vulnerable to local overfishing of their prey, and identify areas suitable as Special Protection Areas (SPAs) under the EC Wild Birds Directive.

The growth of commercial fisheries in the North Sea has impacted some seabirds (Nilsen *et al.* 2002) through:

a) Processes affecting trophic ecology
The removal of large piscivorous fish by fisheries has enhanced the stocks of some small pelagic fish (e.g. sandeels) and probably contributed to an increase in some seabird populations. On the other hand, collapses in stocks of small pelagic fish (e.g. herring) - from fisheries and/or natural causes - can lead to marked declines in the breeding success of a number of seabirds. Fisheries may also compete directly for the same prey as seabirds, e.g. inshore fisheries for mussels

and cockles and industrial fisheries for sandeel and sprat. Discards and offal form a major by-product of fisheries, and these have supported substantial population increases in several seabird species that can scavenge, e.g. fulmar, gannet, great skua, and kittiwake.

b) Incidental mortality

Long-lines and most types of fishing nets can drown seabirds. However, amongst these, gill- and other static nets pose the greatest risk to seabird populations (Dunn & Steel 2001).

The primary effect of seabirds on the recruitment of fish stocks occurs mainly through predation on young fish, but the impact of this is probably less than that from predatory fish.

Discarded offal, fish and benthic organisms constitute an important food source for seabirds. In the North Sea, not including the Channel, a maximum of 800 thousand tonnes of discards are estimated as eaten annually by seabirds. Despite the consumption of offal and discards by many gull species, more offspring are produced in seasons when their natural prey is available and consumed in abundance than in years when discards form the greater part of their diet.

Based on ICES advice on how an ecosystem approach can be applied involving seabird breeding colonies and industrial fisheries, the Council of EU Fisheries Ministers accepted in December 1999 the proposal to close an area of the north-western North Sea to sandeel fisheries in 2000. This decision has been extended for several years following annual reviews. The resulting EC Council Regulation No. 1239/98 of 8 June 2000 restricts fishing for sandeels on the basis that the amounts of this fish were insufficient to support both the fisheries directed at them and the requirements of various species for which sandeels are a major food component.

The incidental seabird catch in commercial longline fisheries has caused substantial concern, regarding both the mortality effects on the impacted seabirds and the adverse effect on fishing productivity and profitability. Accordingly, FAO adopted in 1999 the International Plan of Action for the Reduction of Incidental Catch of Seabirds in Longline Fisheries (IPOA-SEABIRDS). Research is being conducted in Norway on the mortality of birds in fishing equipment, with special attention on longline fisheries, and the development of seabird-friendly fishing gear. Measures that can significantly reduce seabird by-catches include bird-scaring devices towed behind the fishing vessel during the shooting of the longline, and setting of the lines through a protective tube into deeper water.

3.6 Marine mammals

The marine mammals can be divided into two major groups: seals and cetaceans (whales, including porpoises and dolphins) (Perrin *et al.* 2002). The cetaceans can be further divided into baleen whales and toothed whales. The seals and toothed whales occupy the upper levels of the marine food web, feeding mainly on fish, and fish and squids, respectively, while the baleen whales have become adapted to occupy the lower trophic levels by filter feeding on zooplankton and small pelagic fish. Accordingly, marine mammals may compete with fisheries for fish food-species. Because of their longevity and tendency to fat storage, marine mammals are prone to further accumulating contaminants already present in their prey and to be affected by the biological effects of pollution.

Information on the presence of marine mammals in the NEASE is based on past whaling activities, coastal strandings, and systematic surveys and opportunistic sightings. A large variety of boreal and temperate species have been reported in the region (Evans 1980; Evans *et al.* 1986; OSPAR QSR 2000; Reid *et al.* in press), including:

- Seven species of baleen whales (minke, sei, fin, blue, Bryde’s, humpback, northern right);
- Twenty-three species of toothed whales (rough toothed dolphin, bottlenose dolphin, striped dolphin, Atlantic spotted dolphin, common dolphin, white-beaked dolphin, Atlantic white-sided dolphin, Risso’s dolphin, false killer whale, killer whale, long-finned pilot whale, short-finned pilot whale, harbour porpoise, white/beluga, sperm,

pygmy sperm, dwarf sperm, Cuvier's beaked, northern bottlenose, True's beaked, Gervais' beaked, Sowerby's beaked, Blainville's beaked);
- Seven species of seals/walrus (walrus, harbour seal, ringed seal, harp seal, grey/common seal, bearded seal, hooded seal).

The status of the majority of marine mammals in the NEASE is considered rare[8] or exceptional[9], with relatively few being viewed as frequent[10] (OSPAR QSR 2000).

Cetaceans

The Harbour porpoise (*Phocoena phocoena*) is the main cetacean observed in the NEASE, with stocks found in the North Sea including the Skagerrak and Kattegat. Their densities are relatively high on the western side of the Schleswig-Holstein/Jutland peninsula, particularly off Sylt and on the Amrum Bank and Horns Reef. Around northern Scotland, including Shetland, and off the east coast of Britain, harbour porpoises are relatively abundant. Abundances are lower in the central North Sea than in the western area, and examples are rarely seen in the southernmost part of the North Sea or in the eastern Channel. The abundance of harbour porpoises in the North Sea, including the Channel and the Kattegat, was estimated at 304,000 (242,000 – 384,000) animals in 1994 (Svelle *et al.* 1997)

The harbour porpoise has become rare in the Southern Bight of the North Sea, the English Channel, and the Baltic Sea. This is the most common species taken as by-catch in the central and southern North Sea, the Irish Sea and Bristol Channel, particularly in bottom-set gill nets. In the North Sea, in the combined Danish fisheries alone, the by-catch was estimated by extrapolation to be about 3,000 individuals in 2000 but as many as 8,000 have died per year in the recent past. UK fisheries in the same area have probably caught about 400-800 individuals annually from 1995 to 1999. Total by-catch levels have exceeded the sustainable mortality levels for harbour porpoises in this area of the North Sea and will lead to population decline if not redressed. A number of fisheries in the same area that are not monitored for by-catch (e.g. Norwegian fisheries) limit an assessment of the full impact of harbour porpoise by-catches (Nilsen *et al.* 2002).

Recent declines in harbour porpoise by-catch levels from Danish and UK fisheries are due to reduced fishing effort (i.e. decreased TACs) for demersal fish. Denmark requires fishermen to use acoustic deterrents 'pingers' in gillnet fisheries over wrecks where the by-catch rate of harbour porpoises is considered high. Preliminary results from these fisheries and the Cornish hake gillnet fishery indicate that pingers are capable of effectively reducing porpoise by-catch rates, in some cases by over 90% (Nilsen *et al.* 2002).

Drift nets have been responsible for significant casualties of marine wildlife, including Risso's and bottlenose dolphins, and pilot, sperm, minke and fin whales.

Bottle-nose dolphins (*Tursiops truncatus*) are resident in the Moray Firth, off the west coast of Normandy, off Dorset and off Cornwall. The total number is estimated at about 250 animals. The resident groups are small; the largest known being that in the Moray Firth, which is estimated to contain 130 animals. Elsewhere they are rarely seen. There is good historical evidence that these dolphins were commoner and more widely distributed in the North Sea in the past (Svelle *et al.* 1997)

The white-beaked dolphin (*Lagenorhynchus albirostris*) is the most frequently sighted dolphin species in the area, particularly in the north and west of the North Sea. There have also been several sightings of groups of more than 100 white-sided dolphins (*L. acutus*) in the central North Sea, often in mixed herds with white-beaked dolphins. The total number of white-beaked and whitesided dolphins in the North Sea was estimated at 10,900 (6,700 – 17,800) animals in 1994 (Svelle *et al.* 1997) Risso's dolphins (*Grampus griseus*)

[8] 'rare' implies a species within its main area of distribution but which is not abundant.

[9] 'exceptional' implies a species that has been observed in the area but which is outside its distribution range or its supposed range of distribution but which is extremely scarce.

[10] 'frequent' implies a species considered to be abundant or frequently sighted within the area.

occur in small numbers, mostly in the northern North Sea. Common dolphins (*Delphinus delphis*) are rarely seen in the North Sea proper, but are the most commonly found species in the Channel. There is no reliable information on the trends in the status of these species in the NEASE.

Pilot whales (*Globicephala melas*) occur commonly in the NEASE. It is common in the northern and northwestern North Sea, with an indication of a higher occurrence in winter. The total estimate for the central and northeast Atlantic is about 778,000 animals (Svelle *et al.* 1997).

Minke whales (*Balaenoptera acutorostrata*) observed in the NEASE belong to the migratory North-East Atlantic stock for which the Scientific Committee of the International Whaling Commission (IWC) estimates their abundance at about 112,125 animals. The stock in the North Sea is estimated at about 20,000 animals, which occurs in the northern and central North Sea during the summer, especially in the western part (Svelle *et al.* 1997).

Cetaceans are common in the Celtic and Irish Seas, particularly bottlenose dolphins and harbour porpoises that are seen throughout the year. Other species are seen on a seasonal basis rather than throughout the year, such as Risso's dolphins and common dolphins. By-catch studies in the Celtic Sea estimated that 2 200 harbour porpoises, equivalent to 6.2% of the total population size, were annually caught in fisheries, which is unsustainable (Tregenza *et al.* 1997).

A large variety of species of cetaceans have been reported in the southern areas of the NEASE including in the Bay of Biscay and in French waters (OSPAR rQSR IV 2000). However, the majority of these are not common and/or outside their distributional range. Of the baleen whales, which are all migratory, only fin whales (*Balaenoptera physalus*) are common in these areas. Of the toothed whales, sperm whales (*Physeter macrocephalus*) frequently occur, tending to aggregate in the summer over the continental slope while feeding on squids. The common dolphin (*Delphinus delphis*) is the cetacean species most frequently seen at sea, and accounts for about 50% of strandings in the Bay of Biscay area. Bottle-nosed dolphins (*Tursiops truncates*) are resident in several bays from Brittany southwards as far as Portugal. Harbour porpoise was considered one of the most common species in the area, but sightings and strandings are now common only in certain areas.

Seals

Six species of seal - the harbour (or common) seal (*Phoca vitulina*), the ringed seal (*Phoca hispida*), the harp seal (*Phoca groenlandica*), the bearded seal (*Erignathus barbatus*), the hooded seal (*Cystophora cristata*), and the grey seal (*Halichoerus grypus*) - occur more or less regularly in the North Sea (Svelle *et al.* 1997). However, only the harbour seal and the grey seal breed there. Harp, ringed and hooded seals are recorded annually and harp seals may occasionally invade the North Sea in large numbers, e.g. in 1987 (Svelle *et al.* 1997).

The harbour seal is an abundant species with a circumpolar distribution. Harbour seals are relatively stationary. It is found throughout the North Sea, with the largest concentrations in the Wadden Sea (about 9,000 animals), Orkney (about 8,000 animals) and Shetland (about 7,000 animals), and the Kattegat/Skagerrak (about 5,000 animals). Other smaller populations occur on the east coast of England in the Wash. The total number of harbour seals in the North Sea is estimated at about 36,000, which is about 45% of the European population and 5% of the world population (Svelle *et al.* 1997). The UK alone accounts for about 40% of the European stock of harbour seals. Harbour seals feed on sandeels, whitefish (e.g. cod, haddock, whiting, ling), herring and sprat, flatfish, octopus and squid.

Most of the grey seals in the North Sea breed around the coast of the British Isles, with the largest concentration of breeding colonies situated in Orkney. Some pups are annually born in the Wadden Sea, the Skagerrak/Kattegat, and Brittany. The North Sea holds about 40% of the European population of grey seals and 15% of the world population. Grey seals spend most of their time close to traditional resting sites, but individuals may occasionally travel over 1,500 km. The total number of grey seals in the North Sea is estimated at about 52,000 animals (Svelle *et al.* 1997). Grey seals feed mostly on fish that live on or close to the seabed, with their main prey comprising sandeels, white fish (e.g. cod, haddock, whiting, ling), and flatfish (e.g. plaice, sole, flounder, dab).

The harbour seal tends to frequent estuaries and coasts where offshore banks and rocks are exposed at low tide. Grey seals have a more limited distribution than harbour seals, with 40% of the world population breeding in European waters, mostly on remote islands along the coasts of the UK.

The bulk of the Irish harbour and grey seal populations are found in colonies on the west coast of Ireland. On Irish Sea coasts, both species occur but most colonies are small, with a lack of suitable haul-out sites being a major factor influencing the small numbers (OSPAR rQSR III 2000).

Seals are not considered part of the resident breeding fauna of the southern area of the NEASE, although regular sightings occur in the Bay of Biscay and on the Atlantic Iberian coast (OSPAR rQSR IV 2000). The most commonly seen species are the grey seal and the harbour seal. The presence of the grey seal is due to the dispersion of young individuals from breeding colonies on the British Isles.

Besides the effects of hunting, the only major change in the population of seals resulted from the 1988 phocine distemper virus (PDV) outbreak that reached epidemic proportions (Reijnders *et al.* 1997). This virus caused a major mortality, amounting to about 16,000 animals, among harbour seals and grey seals in the North Sea region. The greatest impact occurred on the eastern side of the North Sea where the harbour seal population of the Wadden Sea was reduced from about 10,000 to 4,000 individuals in a year (1988/1999) but recovered to its pre-PDV abundance by 1999 and increased to about 20,000 by 2002 (Abt *et al.* 2002). The overall population size in the Greater North Sea area has since increased again to approximately pre-epidemic levels. However, a new outbreak of the virus epidemic occurred in 2002 (Abt *et al.* 2002).

Threats and measures to reduce by-catch

Prior to World War II hunting was the major source of mortality for marine mammals, particularly seals, of the NEASE. More recently, mortality is due to ‘incidental take’ (i.e. by-catch) in fisheries and possibly by pollution that may compromise immune systems (e.g. resulting in increased incidence of phocine distemper). By-catches in fisheries usually result in serious injury or mortality to the marine mammals and may result in damaged fishing gear and reduced fishing time and catch.

OSPAR has asked contracting parties and ICES for information on the health of marine mammals in relation to habitat quality, but little information exists and proposals have been made to tackle this issue.

In recent years, ICES has reviewed requirements for scientifically sound programmes for collection and handling of data on by-catches, including a review of methods for monitoring cetacean by-catch. ICES Member Countries have been urged to monitor their fisheries to identify gear types, areas and seasons where marine mammal by-catches occur in order that robust estimates of abundance and information on the distribution (stock identity) of affected species need to be obtained in addition to estimates of total by-catch.

The EC Council Regulation No. 1239/98 of 8 June 1998 banned the utilization of drift nets from 1 January 2002 in order to conserve small cetaceans and other non-target species. The UK has encouraged a more rapid phasing-out of the drift net fishery, by restricting licences in the intervening period to those vessels that had used drift nets in either 1996 or 1997.

ICES has recommended that, in order to reduce by-catches below the agreed target of 1.7%, mitigation measures should be established giving particular priority to the Southern North Sea and the Celtic Sea, where by-catches of harbour porpoise are a serious problem. Effort reductions will not only reduce the opportunities for by-catch of small cetaceans but also will reduce the overall ecosystem impacts.

Scientific tests indicate that acoustic 'pingers', as warning devices, appear to be effective in reducing the by-catch of porpoises in gillnets by up to 90% (Nilsen *et al.* 2002). However, the deployment of these devices on a large scale by the fishing industry has not yet occurred, possibly due to the unilateral deployment of pingers on the vessels of single State alone being seen as discriminating against its fishermen. Although an European Community approach is required, the European Commission has not yet made any Europe-wide proposals on this matter.

Seal-safe eel traps (fyke nets and pond nets) are being devised, and methods are being developed for scaring seals away from fishing operations, including mechanical means of protecting fishing gear and alternative fishing methods. Financial inducements can enable fishermen to purchase seal-safe fishing gear, e.g. replacement of old salmon traps.

International conservation of marine mammals

Management and conservation measures have been proposed or implemented to reduce marine mammal by-catches on both global (*e.g.* UN Resolution 44/225 § 4a that called upon Member States to impose a moratorium on high seas drift nets by 30 June 1992) and regional levels (*e.g.* ASCOBANS).

Research on small cetaceans is conducted throughout the ASCOBANS area, but the need for increased data collection on seasonal and spatial distribution as well as long-term monitoring of population trends has been emphasized. A second full Small Cetaceans Abundance in the North Sea survey (SCANS II) is planned to follow the 1994 SCAN I survey.

ASCOBANS is collating information on threats affecting small cetaceans, and contributes to discussions on protected areas for harbour porpoises in other relevant forums. ASCOBANS is also addressing the most important threat facing small cetaceans, *viz.* incidental take or by-catch. A study on potential measures for by-catch reduction in the Agreement area has been commissioned by ASCOBANS.

The 3rd Meeting of Parties to ASCOBANS (July 2000) adopted a resolution that recommended that competent authorities take precautionary measures to ensure that the total anthropogenic removal of small cetaceans in the Agreement area and its adjacent waters be reduced as soon as possible to below 1.7 % annually of the best available abundance estimate. Moreover, as a precautionary objective, an annual by-catch of less than 1 % of the best available population estimate has been set.

At the 2002 5NSC, the Ministers agreed to aim at reducing the by-catch of harbour porpoises below 1.7% of the best population estimate. The Ministers also agreed on a precautionary objective to reduce by-catches of marine mammals to less than 1% of the best available population estimate, and urged the competent authorities to develop specific limits for the relevant species.

The 'Conservation and Management Plan for the Wadden Sea Seal Population' (Seal Management Plan, SMP) has established seal reserves in the entire Wadden Sea.

3.7 Turtles

Sea turtles are mostly tropical or sub-tropical, but a few species use the warm Gulf Stream current to visit the Bay of Biscay, the Irish Sea and North Sea and the wider NE Atlantic as vagrants (Bjorndal 1995; OSPAR QSR 2000). The most frequently recorded species in the NEASE as a whole are leatherback turtle (*Dermochelys coriacea*) and the loggerhead turtle (*Caretta caretta*). Besides this species, green sea turtles (*Chelonia mydas*), hawksbill turtles (*Eretmochelys imbricata*) and Kemp's ridley turtles (*Lepidochelys kempii*) are occasionally seen in the NEASE. All five species are listed on Appendix I of the Convention on the International Trade in Endangered Species of Flora and Fauna (CITES) 1975, Appendix II of the Bern Convention 1979, Appendices I and II of the Bonn Convention 1979 and Annex IV of the EC Habitats

Directive. The loggerhead is also listed as a priority species on Annex II of the EC Habitats Directive. While impacts from tourism and exploitation for food are suffered in breeding areas, entanglement and drowning in fishing gear, damage by boat propellers and pollution are the major threats to turtles in the NEASE. Important pollutants include oil, and ingested plastics that block the alimentary system.

3.8 Non-indigenous organisms

Non-indigenous organisms (also called alien, exotic, invasive etc.) are organisms that have moved beyond their natural geographical range of habitat, and represent all phyla, from microorganisms to various plants and animals, both terrestrial and aquatic (OSPAR 1997; Weidema 2000). The issue of non-indigenous marine organisms has been identified as one of the most critical environmental issues facing aquatic species and habitats, and biodiversity in general (CBD 1992, 1995; WWF/IUCN 1998). Introductions and transfers of non-indigenous organisms are potentially hazardous in terms of ecology, biodiversity and socioeconomics. A series of key international agreements and instruments (*e.g.* UNCLOS 1982; CBD 1992) have played a seminal role in fostering the requirement to prevent, reduce and control the introduction and transfers of alien species.

Shipping and aquaculture are the main potential vectors responsible for about 90% and 10%, respectively, of the introductions of marine alien species in Europe, including the NEASE (Leppäkoski & Gollasch 2002). In the case of shipping, unintended introductions and transfers of alien species mainly occurs by the transport and discharge of ballast water and by transport of fouling organisms on hulls. In the case of aquaculture, this occurs either as intended introductions of the non-indigenous target species (*e.g.* macroalgae, bivalve molluscs, fish) for industrial production purposes in a new area or as non-intended introductions and further transfers of the target species via, for example, escapement and spreading from their originally confined environment. In both intended and non-intended introductions and transfers, the further transmission and transfer of other 'stowaway' (i.e. unintentional) aliens may occur together with the original target species. The 'stowaways' that occur together with the target species are associated biota (*e.g.* spores of macrophytes and toxic phytoplankton found on or in benthic organisms such as bivalves) and parasites and pathogens/diseases. Having been introduced to an area, natural transfer processes (e.g. dispersion by ocean and coastal current systems) may supplement the further spread of alien species.

The problems associated with the introductions and transfers of alien species are likely to be exacerbated, due to pressures from global and regional trade agreements that encourage increased transport of alien species by existing vectors (Hopkins 2001). Furthermore, climate warming favours the establishment of more cosmopolitan species across wider geographic areas, widening the 'match' between areas acting as donors and recipients, increasing the likelihood of introductions and transfers in boreal and polar waters (Hopkins 2001).

Despite the intentions of international agreements and instruments to contain the movements of alien species, there is clear evidence that they are largely ineffective in dealing with the problem as emphasized by the exponentially increasing establishment of marine alien species in the North-East Atlantic area and its continental shelf seas (*e.g.* the North Sea) (Hopkins 2000, 2001, 2002). Although several important intergovernmental organizations currently address matters related to marine alien species in the North Atlantic and the North Sea area, it has been emphasized that additional steps should be taken to place the issue of alien species high on both the international and the national agenda (Hopkins 2001; Nilsen *et al.* 2002). In support of such steps, a number of commitments are necessary at the scientific and policy levels to implement a series of actions in order to *effectively* prevent, reduce, monitor and control the introduction and transfers of alien organisms in Norway in accord with the precautionary principle and the ecosystem approach.

The North Atlantic Salmon Conservation Organization (NASCO) has expressed increasing concern that interactions between farmed and wild salmon (*Salmo* *salar*) lead to changes in the genetic composition of wild salmon, the introduction of pathogens/diseases and parasites, and other effects with adverse ecological consequences. Recent work carried out by NASCO includes measures to minimize impacts from salmon farming on wild populations and implementation of the precautionary principle. Activities related to the precautionary principle include guidelines to limit escapees from salmon farming and an action plan to rehabilitate wild salmon habitats adopted in June 2001.

ICES and NASCO have collaborated on the genetic threats to wild salmon posed by aquaculture as well as other relevant interactions. Thus, a symposium was arranged in 1997 that provided an overview of the problems (*e.g.* threats to the natural genomes, parasites and pathogens/diseases) faced by wild salmon and possible measures to redress the situation.

In 1995, ICES published a Code of Practice on the Introductions and Transfers of Marine Organisms. Since then there has been close collaboration between ICES, the Intergovernmental Oceanographic Commission (IOC) and the International Maritime Organization (IMO) on ballast water and shipping vector matters including the formation of a joint study group on this topic. The ICES Code of Practice is currently being updated.

IMO is working towards completion of a legally binding self-standing International Convention for the Control and Management of Ships' Ballast Water and Sediments and associated guidelines (see Section 4.12). The convention is expected to be adopted in 2003.

Within OSPAR, non-indigenous organisms are included within the Joint Assessment and Monitoring Programme, but modest activity has occurred on this issue since 1998 and the QSR 2000 provides little information on this matter.

Many States in the NEASE region have established or are preparing policy and legislation reviews on the introduction and transfer of non-indigenous aquatic organisms. There is a growing policy when rearing and releasing fish for stock enhancement to use local wild fish rather than reared strains as parent fish in order not to dilute the natural gene pool. Additionally, national strategies on sustainable development and Biodiversity Action Plans are highlighting the risks from non-indigenous species and genetically modified organisms (GMOs). The threat to biodiversity and its use occurring from the introduction of non-indigenous organisms via ballast water from ships has received increasing awareness and concern.

As a substantial 'pool' of non-indigenous species is already present in North-East Atlantic waters, effective measures to limit unintentional and unwanted introductions into regional or local European waters in general, and the North Sea area in particular, are needed. Secondary human-induced introductions between European countries account for the greatest further dispersal of species within the region. Thus, better measures for controlling the intra-regional movement of species are required to prevent further unintentional dispersal. Secondary introductions that are mediated by natural dispersal cannot be stopped by regulations. The developing IMO Convention, in its present draft form, will apply to all ships engaged in international traffic that carry ballast water. Ships vary in their ability to undertake ballast management measures and those that rely on ballast exchange at sea may be unable to complete the process during the voyage or in the prevailing weather conditions. A ship on a coastal voyage may encourage the spread of non-indigenous organisms by exchanging ballast water near to shore. Effective monitoring programmes are needed to aid in the early detection and in determining the status of non-indigenous organisms if effective combat and control measures are to be taken. Further, introductions and transfers of non-indigenous marine organisms are likely to increase, due to expanding free-trade agreements and climate warming favouring the wider establishment of more cosmopolitan species.

Genetically modified organisms are a form of non-indigenous organism. In recent years, increased attention has been focused on the risk of GMOs escaping into the natural environment and causing similar adverse effects on indigenous species and their

environment as certain non-indigenous species have done.
EC Directive 90/220/EEC on the deliberate release into the environment of GMOs has now been replaced by Directive 2001/18/EC, which must be implemented by Member States by October 2002. Both these Directives prohibit the release of GMOs into the environment without explicit prior consent.

In 1997, NASCO adopted Guidelines for Action on Transgenic Salmon (NASCO 1997), and as recently as 2001 NASCO reiterated its concern about the threats posed to wild salmon from genetically manipulated salmon. In particular, emphasis has been given to the potential escape of genetically modified Atlantic salmon that may grow up to six times faster than their natural counterpart. Such transgenic salmon have recently been promoted for future farming, despite firm opposition to the development of genetically modified salmon being voiced by the salmon culture industry, custodians of wild salmon stocks, consumers and environmentalists.

The ICES recommended procedure for the consideration of the release of GMOs requires that the transgenic organisms must be reproductively sterile in order to minimize impacts on the genetic structure of natural populations. However, ICES stressed in 1999 that unless procedures are controlled, the risk of sterilization of the whole population (wild and cultivated) exists.

Health and environmental risk assessment, and ethical and socioeconomic concerns should be considered before releasing GMOs into the natural environment. The precautionary principle indicates that consent for such release should not be given if unacceptable adverse effects may arise. Because of the potential risk of using GMOs, several States (e.g. Norway, and Sweden) have strong regulations in this field. Production and use of GMOs should be based on ethical and social considerations according to the precautionary principle and without adverse effects on health and the environment.

The release of GMOs is an emerging issue owing to the inherent, potentially severe, irreversible and transboundary effects. Thus, there is a need to apply the precautionary principle within the requirements of EC Directive 2001/18/EC, and comparable national legislation, to ensure that the culture of GMOs is confined to secure, self-contained, land-based facilities in order to prevent their release to the marine environment.

In accord with Article 8h of the CBD, steps should be taken to reduce the risk and minimize adverse effects on ecosystems habitats or naturally occurring species arising from the introduction or release of non-indigenous species or organisms. In the case of intentional introductions, this should entail developing and implementing systems of approval based on the precautionary principle and environmental impact assessments to ensure confinement of potentially invasive non-indigenous organisms and associated biota, taking into account the ICES Code of Practice on Introductions and Transfers of Marine Organisms. For unintentional introductions, action must be taken as soon as possible in order to prevent the establishment of the introduced organisms.

Other steps that need to be emphasized are:

- Monitoring programmes should be established for introduced non-indigenous species and genetically modified organisms.
- Further, databases on non-indigenous organisms need to be developed.
- Appropriate systems of risk assessment and risk profiles need to be developed and applied connected with appropriate human activities (e.g. shipping and aquaculture) in particular regions and localities.
- Consideration should be given to the best possible measures to prevent, control or eradicate the introduction of harmful invasive species or to control or eradicate GMOs that may adversely affect the marine environment.

Protection of vulnerable species and habitats
Protection of habitats is vital for protecting the species that are dependent on the habitats for their viability. Degradation, fragmentation, and eventual loss of habitat caused by the impacts from human activities represent serious threats to marine biodiversity (GESAMP 1997). The coastal zone includes some of the most productive areas of the NEASE, and provides habitats, breeding and nursery grounds for fish and shellfish that support commercial and recreational fisheries, as well as seabirds and shorebirds and marine mammals, plankton and benthos. Examples of such special habitats in the NEASE are sea cliffs, sand dunes, shingle banks, salt marshes, intertidal mud flats, subtidal sediments, subtidal rocks, salt marshes, saline lagoons, and in deep waters including hydrothermal vents and sea mounts Many of these habitats have specific faunal and floral communities associated with them. Most of these habitats and their associated communities have been threatened over the past century by human activities and changes in climate.

3.9 Protected areas, and vulnerable species and habitats

There has been agreement within OSPAR to promote the establishment of a network of marine protected areas (MPAs) to ensure the sustainable use, conservation and protection of marine biological diversity and its ecosystems.

In order to implement the OSPAR Strategy for Annex V, so-called Texel/Faial Criteria have been developed for the selection of species and habitats needing protection. However, the establishment of full lists using the Texel/Faial Criteria has been delayed and it is unlikely to be finalized before the end of 2003. A parallel process has collated initial priority lists of species and habitats undergoing rapid decline or under immediate threat, as well as indications of possible programmes and measures. As result of this process, an OSPAR workshop held in the Netherlands in September 2001 proposed four lists of such species and habitats:

- threatened and/or declining species and habitats;
- species and habitats for which indications for serious decline and/or threat exists, but for which the exact status needs clarification;
- priority threatened and/or declining species and habitats across their entire range within the OSPAR maritime area;
- priority threatened and/or declining species and habitats for specific regions.

There is a pressing need to finalize the Texel/Faial Criteria and to have them adopted and applied in the NEASE.

Currently, there are about 300 candidate threatened and declining marine species identified by international programmes (e.g. 'Red Lists') and by sovereign States relevant to the North Sea and adjacent sea areas of the NEASE (Gubbay 2001).

In accordance with OSPAR Annex V and the OSPAR Strategy, Contracting Parties must take measures to conserve and protect the ecosystems and the biological diversity of the maritime area, and to restore, where practicable, marine areas which have been adversely affected by human activities. In order to facilitate this, it has been proposed to establish a network of Marine Protected Areas (MPAs) and to agree on measures to ensure the sustainable use of the marine ecosystem. The OSPAR MPAs, individually and collectively, aim to:

a. Conserve, restore and if necessary protect species, habitats and ecological processes which are adversely affected as result of human activities;
b. Prevent degradation or depletion of or excess damage to species, habitats and ecological processes following the precautionary approach;
c. Conserve and if necessary protect areas which best represent the natural range of species, habitats and ecological processes in the OSPAR area.

The network of MPAs recognizes the linkages between different parts of the marine ecosystem and the dependence of some species and habitats on processes that occur outside the MPAs, and should form an ecologically coherent network of well-managed MPAs. The selection and establishment of MPAs is related to the assessment of species and habitats in need of protection, habitat classification and identification of biogeographic regions, and to developing the ecosystem approach including the development of EcoQOs.

Guidelines for the Identification and Selection of Marine Protected Areas in the OSPAR Maritime Area have been developed, and have been supplemented by Guidelines for the Management of Marine Protected Areas in the OSPAR Maritime Area. An inventory of existing MPAs in the OSPAR maritime area has been established to assist the programme to develop the network of MPAs. There is a reasonable coverage of the near coastal zone with MPAs in most of the coastal States, but currently very few protected areas occur beyond 3 nm from national baselines, apart from areas where fisheries restrictions apply. Thus, the methods for identification and establishment of MPAs place emphasis on waters beyond 3 nm from national baselines.

Natura 2000 aims to establish a coherent European ecological network of Sites of Community Importance (SCIs) in order to maintain the distribution and abundance of all naturally occurring species and habitats in the EC, both terrestrial and marine. Natura 2000 will comprise a network or a system of Special Areas of Conservation (SACs) under the Habitats Directive and Special Protection Areas (SPAs) under the Wild Birds Directive (Boedeker & Nordheim 2002). The aim is to enable habitats and species to be maintained and/or restored to a favourable conservation status in their natural range. To conserve Natura 2000 sites, conservation measures must be established involving appropriate management plans and statutory, administrative or contractual measures. The adoption of Community lists of sites has been unreasonably slow, and the European Commission is taking steps, including legal action, to accelerate matters. Although the designation of sites is greatly behind schedule, the management of threatened sites is essential.

The European Commission has emphasized that the Habitats and Wild Birds Directives apply to the whole EEZ of the Member States, and not just in territorial waters. However, implementation of these Directives outside the 12-mile limits is still held back by legal problems in some States, although most States are applying the Directives to all waters and are proposing Natura 2000 sites in the offshore zone.

As a contribution to the process of implementation of the EC Habitats Directive offshore, WWF has examined possible candidate Natura 2000 sites for reefs and submerged sandbanks in the North-East Atlantic and the North Sea (WWF 2001a). WWF is also developing a directory of MPA proposals by 2003, and as a first step has identified a pilot tranche of potential offshore MPAs. These MPAs focus on conserving a range of strategically important ecosystems from human impacts. The current 10 candidates that are approximately located within the NEASE are described in Table 5.

Table 5. Overview of pilot tranche of 10 potential offshore MPAs located approximately in the NEASE.

Their location within the NEASE is found at:
http://www.ngo.grida.no/wwfneap/Projects/MPAmap.htm

- The Dogger Bank falls within the 200 nm zones of Germany, the United Kingdom, the Netherlands and Denmark. It is a shallow area (18-40 m deep) of unusual year-round high primary productivity and representing important spawning grounds for commercial fisheries and feeding grounds for seabirds.
- The Waters west of Amrum /Sylt are situated within the German 12 nm zone (territorial waters), adjacent to the northern Wadden Sea which is a critically important area for harbour porpoise, grey seals and waterfowl. This site is designated as a small cetacean sanctuary by the Schleswig-Holstein Government in 1999.
- The Western Irish Sea Front is a distinct oceanographic feature of high productivity occurring from March/April through September/October and is an important feeding ground for fish, seabirds and basking sharks. It occurs across the boundary between the 200 nm zones of the United Kingdom and Ireland.
- The Rockall Bank is a relatively shallow bank (65-220 m) situated beyond the continental shelf but partly falling into the 200 nm limits of the United Kingdom and Ireland, with more than 80 species of fish recorded. It is a spawning ground for the blue whiting.
- Rockall Trough and Channel is a deepwater (200-3,500 m) region adjacent to the Rockall Bank. The area supports a number of diverse ecosystems: coral colonies, distinct water masses with characteristic fauna, and rich fish communities in the deepwater areas.
- The Celtic Shelf Break extends through the waters south of Ireland, southwest of England and west of France, within the 200 nm zones of these countries. There are important spawning grounds for commercial fish species such as megrim, blue whiting, and mackerel, and also an important area for leatherback turtles, basking sharks, young oceanic birds, and cetaceans (harbour porpoise, common dolphin, and white-sided dolphin).
- The Darwin Mounds lie within 200 nm limit of the United Kingdom. They are a novel geographical formation in the northeast corner of the Rockall Trough at around 1,000 m depth. The field contains hundreds of individual mounds typically 5m high and 100m in diameter that support coral colonies of Lophelia pertusa, and a diversity of benthic invertebrates and deepwater demersal fish. They are under immediate threat from trawling. The Darwin Mounds are considered as offshore Special Area of Conservation (SAC) by the UK Government.
- Lilla Middelgrund is an offshore bank, 40-100 m in depth and located in the sea connecting the North Sea and the Baltic (Kattegat). The bank and adjacent sea area are mainly in the territorial waters and 200 nm zone (EEZ) of Sweden, parts of it extending into the 200 nm zone (EEZ) of Denmark. Lilla Middelgrund has a rich and diverse fauna and flora including kelp beds and rare species of red and brown algae. It is an important nursery area for herring and wintering area for seabirds.
- The Grande Vasière is a large mud plain situated partly in territorial waters, partly within the 200 nm Exclusive Economic Zone (EEZ) of France. Along with the adjacent coral reef on the continental slope off the Biscay coast of France, it is the natural habitat for communities of fragile species which are particularly sensitive to physical damage. While biogenic reefs ought to be subject to conservation measures under the EU Habitats Directive, there are currently no national or international protection mechanisms applied to fine sediment habitats. However, sublittoral fine sediment habitats like those characterized by sea-pens and burrowing macrofauna have been proposed as being of special concern to OSPAR.
- Fladen is an offshore bank situated in the Kattegat, 17 km west of the Swedish coast. The bank and adjacent sea area are mostly situated in Swedish territorial waters, but the southern parts also extend into Sweden’s Exclusive Economic Zone (EEZ). Fladen is representative of the rich offshore banks in the eastern Kattegat, displaying lush vegetation with high diversity and dense growth of macroalgae. The water is clear and the area still has a rather intact ecological structure, making it a potential breeding and nursery area for a great variety of invertebrates associated with hard bottoms, soft bottom and kelp beds, as well as for fish. Fladen also is a very important feeding and wintering area for seabirds and an important feeding area for grey and common seals.

In March 2002, the Fifth Conference on the Protection of the North Sea adopted the Bergen Declaration (NSC 2002) including follow-up action with regard to marine protected areas. North Sea Ministers agreed that "*by 2010 relevant areas of the North Sea will be designated as marine protected areas belonging to a network of well-managed sites, safeguarding threatened and declining species, habitats and ecosystem functions, as well as areas which best represent the range of ecological and other relevant character in the OSPAR area*."

Besides substantial concerns over the undue length of time taken to establish and adopt a list of vulnerable species and habitats in the OSPAR Maritime Area including the NEASE, one must identify the key threats and human pressures affecting such species and habitats with a view to outlining conservation measures for restoration programmes. Thus, there is a need for implementing management actions rather than calling for more science.

Habitat mapping and classification

The OSPAR Strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area, adopted in 1998 to implement Annex V of the Convention, depends on assessing which habitats need to be protected. As protection requires knowledge of which habitats are present and their locations, collaboration occurs between OSPAR, ICES and the European Environment Agency to classify and map habitats by developing and applying the EUNIS (European Nature Information System) classification. The collaborative work comprises:

a. Habitat classification: developing a classification system, for all marine habitats within the OSPAR area (inshore and offshore shelf rock and sediment, deep water and pelagic), which is fully compatible with the EUNIS classification.
b. Habitat mapping: preparing maps of the OSPAR maritime area, showing the spatial distribution and extent of habitats according to a consistent classification system, to meet the needs in the assessment and protection of marine habitats.

Subject to adequate testing and refinement, the overall approach and structure of the EUNIS marine classification is generally applicable for use in the OSPAR area (Nilsen *et al.* 2002). The EUNIS classification scheme has been improved regarding a) the intertidal and shelf-seas rock and offshore sediment habitats; b) the deep-sea and pelagic habitats; and c) the need to better reflect biogeographic variation. A preliminary classification of marine landscapes (habitat complexes) has been developed to complement the habitat classification approach, often being at a more appropriate scale for ecosystem management and site protection. An integrated approach to deep-water habitat mapping has also been developed.

Despite progress with the EUNIS classification, its full application for assessment and mapping requires further work to include information on biota (i.e. EUNIS level 4 and above) in addition to the current information levels that focus on the physical characteristics of habitats. Otherwise, the classification will not operate effectively in the North Atlantic area. Ongoing OSPAR activities (*e.g.* the identification of habitats requiring protection and the development of EcoQOs) will use the classification, to provide consistency across the OSPAR area in this work and to test the classification. Recent work within OSPAR includes: a) preparation of a correlation between the marine EUNIS classification and the marine habitats in Annex I of the EC Habitats Directive; b) further development of the marine landscapes (habitat complexes) approach and its correlation with the habitat classification; c) consideration as to how best to incorporate into the habitat classification system those habitats which appear to be degraded. The habitat classification for the OSPAR area should be carried out to a satisfactory level of detail by 2003 in order to start habitat mapping by that time.

A representative network of marine protected areas requires a systematic identification of marine habitat types and the delineation of their boundaries in a consistent classification. Day & Roff (2000) have proposed an important framework for MPA planning based on ecological principles and the enduring geophysical and oceanographic features of the marine environment. This classification system uses physical attributes alone to predict the expected species assemblages on the basis of habitat characteristics. Five axioms provide the foundations of the approach: 1) biological communities can be differentiated and delimited as a function of geophysical factors; 2) geophysical factors (physiographic and oceanographic) can be regarded as "enduring" or "recurrent" and characterize a region on some spatial/temporal scale; 3) each physical factor exerts a predominant effect on biological communities at a particular scale; 4) these scales can be ranked hierarchically; and 5) based on these physical factors, biological communities can be hierarchically classified. A major advantage of this approach is that the range of conditions influencing the distribution of marine organisms can be delineated into geographic units ("seascapes") by using remote sensing or geographical features that are already mapped. Thus, habitat boundaries can be defined functionally should biological data be lacking. This classification system has predictive potential, and describes the relationships between physical environments and biotic communities, without requiring a substantial amount of field-based survey work. A basic principle of this approach is that equivalent biotopes may differ in species composition, but the species assemblages within them serve similar ecological roles. The advantage of 'seascapes' is that they include the whole water column with both the benthic and the pelagic realms. A representative network of MPAs is one that a) samples the full range of environmental gradients, or habitat types, at a given scale, and b) is based on a systematic, scientific framework for site selection and subsequent monitoring. It is recognized that MPAs chosen on the basis of 'representativeness' will not automatically include all of the unique or special marine features worthy of protection. However, MPAs chosen to protect special marine features will contribute to a representative system, provided they are designed on sound ecological criteria, e.g. size, level of protection, connectivity, etc. MPAs should exist within the context of large sustainable-use management areas, rather than isolated, highly protected enclaves within otherwise unmanaged areas. MPAs can contribute to the long-term viability and maintenance of marine ecosystems, if they are adequate in size and connectivity, and if they are part of a system of integrated coastal or marine management. Selecting MPAs without a robust classification system for determining representative marine areas is likely to be arbitrary.

Many activities of direct relevance to marine habitat mapping are occurring, including surveying and monitoring of marine fauna and flora and their associated biological, chemical, and physical environment. A series of strategic environmental assessments have occurred or are planned in several States. The oil industry has conducted numerous environmental surveys. Surveying and mapping activities are taking place to determine sites suitable for protected areas.

4. THREATS ANALYSIS

This Threats Analysis provides a review of the most important *human activities* in the NEASE that put pressure on biodiversity through various forms of *impacts*. Wherever information has been readily available, attention is drawn to the geographic areas and typical localities where the environmental and biodiversity impacts are most prevalent. An overview is also provided of the *management and regulatory measures* that are in place and/or should be enhanced, and attention is drawn to associated *gaps in knowledge and needs for additional action*.

This section draws substantially on the basic information provided in the rQSRs 2000 for OSPAR Regions II (Greater North Sea), III (Celtic Seas), and IV (Bay of Biscay and Iberian Coast). For OSPAR Region II, the basic information has been supplemented from the Assessment Report and Bergen Declaration from the 2002 Ministerial Conference on the Protection of the North Sea.

The QSR 2000 draws attention *inter alia* to the variability of information provided by the respective administrations of the OSPAR Contracting Parties on various human impacts, including their specific geographic location. In particular, a lack of information concerning many aspects of the human activities in Region IV was noted such that *'unambiguous conclusions about the effects of these activities could not be drawn and that it was difficult to establish the appropriate levels of concern'*.

Following completion of the QSR 2000, a number of environmental non-governmental organizations provided a joint critique of the result, drawing attention to limitations and gaps in the report regarding fisheries, mariculture, hazardous substances, radioactive substances, offshore industry, nutrients, eutrophication, litter, climate change, degradation of coastal habitats, and science and policy (Table 6). In producing the following analysis, due attention has been taken of the points by the author, with the intention of attempting to appropriately redress such matters as relative weakness of information content and corresponding underemphasis of some issues.

Table 6. Joint response to the Quality Status Report 2000 on the Marine Environment of the North-East Atlantic by BirdLife International, GreenPeace International, Local Authorities International Environmental Organization (KIMO), Seas at Risk (SAR), and World Wide Fund for Nature (WWF).

We welcome the initiative to compile the OSPAR Quality Status Report 2000. Furthermore, we recognise the quantity of hard work that has been undertaken to produce such a review. It is the first ever published audit of the resources of the entire maritime region and the threats they face. However we do not feel it to be comprehensive or arriving at conclusive measures for actions.

Only two years after the Sintra Ministerial Meeting which adopted historic milestone commitments to prevent further damage to the North-East Atlantic Marine Environment and to eliminate pollution, we do not feel it is the right moment for Ministers to start congratulating themselves by suggesting that e.g. worsening trends of pollution have been reversed. From the perspective of the environmental NGO community this statement is questionable and work is just beginning. The conclusion of the QSR „that the implementation of the OSPAR Strategies should remain a high priority for the Commission" goes without saying. We would rather like to see their implementation accelerated drastically from now on. Otherwise, the targets of cessation of discharges and emissions and losses of hazardous and radioactive substances by the year 2020 will be missed.

With regard to the health of the North-East Atlantic as a whole, the QSR reveals that the pressure on marine ecosystems and wildlife by human impacts is in general dramatically increasing. It highlights new threats and warning signals from the marine environment.

We have identified the following limitations and gaps in the QSR 2000:

Fisheries

We believe the Report should be calling for an outright 'ecosystem approach' to fisheries management and has missed a unique opportunity to give a stronger steer on needed action to regulatory bodies and Contracting Parties responsible for fisheries management.

The one human activity of the greatest concern identified by the QSR 2000 is fisheries. The QSR states that in 1999, 40 of the 60 main commercial fish stocks in the region were believed to be 'outside safe biological limits' which can be translated as currently being unsustainable, severely depleted, or in danger of becoming so. The QSR quite rightly identifies that bycatch rates of marine mammals have reached unacceptable levels and vulnerable seabed communities such as cold water coral reefs are at stake by harmful fishing practices. The Report also warns that most deep-water fish species are harvested outside safe biological limits which is in breach of the precautionary principle. Although a key measure for protecting deep-water stocks and associated fragile sea-bed communities must be Marine Protected Areas closed to fishing, no such linkage is made in the Report.

Having identified the problem, the QSR 2000 shies away from solutions and expressly states that its task is merely to provide a platform for further action. OSPAR's stance is especially 'hands-off' when it comes to managing the region's fisheries as this sector is under the jurisdiction of the EU Common Fisheries Policy, Norwegian and Icelandic management regime, and hence beyond the remit of the OSPAR Convention. But even though OSPAR cannot initiate action, it can and should make recommendations to Brussels, Oslo or Reykjavik. The measure of OSPAR's muscle will be in its ability to translate the priority problems identified by the QSR into concrete action. Compared to the QSR's detailed recommendations to bodies dealing with shipping, the recommendations on fisheries are woefully inadequate.

Mariculture

The severity of impacts arising from practices in the ever growing mariculture sector, such as eutrophication, release of pharmaceuticals, spreading of diseases still appears to be completely underestimated by the QSR 2000. This also applies to genetical and ecological threats to wild fish stocks, especially the wild Atlantic Salmon which is at its historically lowest level.

Hazardous substances

It should be noted that most worsening trends in pollution from toxic, persistent and bioaccumulative substances could only be reversed after a time-lag of about 10-20 years between measures taken and positive trends observed in the environment. The lesson to be learned is to take precautionary action. Although information available is clearly greater for those limited chemicals for which monitoring programmes have been ongoing for many years, it is clear that the QSR could have reflected in more detail the accumulating and, in some cases, extensive knowledge relating to other hazardous substances identified by OSPAR – especially those already included in the List of Chemicals for Priority Action and already singled out as unwanted chemicals by individual Contracting Parties. The same applies to combined effects of hazardous substances with other anthropogenic or natural factors.

Organochlorine pesticides and PCBs, and indeed other hazardous substances, present problems which are by no means restricted to Region II, the North Sea. The focus on these groups, though of vital importance, results in relative lack of attention of research and monitoring studies on other persistent organic compounds.

In some cases a failure to reflect the root cause of problems is observed in identifying priorities for action. The chapter on dredging activities focuses on further assessment, monitoring and mitigation of impacts but does not mention the need to eliminate upstream sources of pollution.

Radioactive substances

The QSR 2000 has recognised that remaining inputs of radioactive substances are largely due to ongoing releases from the nuclear fuel reprocessing plants at Sellafield in the UK and La Hague in France. These discharges of nuclear waste, which spread northwards through the seas of the NE Atlantic, are a completely unacceptable source of nuclear pollution in the region. The QSR claims that a process for reducing discharges, emissions and losses of radioactive substances has started and will continue. Yet, evidence from the UK and France, and the refusal of these countries at this meeting to take action to prevent these discharges, shows that this is not the case. The NGOs welcomed the adoption by Ministers in 1998, of the OSPAR Strategy with regard to Radioactive Substances. And today, we welcome the endorsement of the non-reprocessing option resulting from yesterday's vote. But we deeply regret the resistance shown by the UK and France to implementing it.

Offshore Industry

Pursuit of environmental management mechanisms in the offshore industry is only one priority. OSPAR must continue its efforts to develop existing and, as necessary, new measures to ensure that offshore oil and gas activities do not cause continuing pollution of the marine environment. It should be noted that all other OSPAR strategies apply equally to the offshore sector.

Nutrients and eutrophication

The Report also fails to make the adequate link between increased levels of nutrients from agriculture, sewage and vehicle traffic and the loss of biodiversity, in particular of those rare species and habitats that are adapted to low nutrient levels. By looking into this particular issue the QSR logically should have reached the conclusion that OSPAR needs to exceed their unrealised reduction target of 50%. A number of scientists are suggesting a reduction by 80% for precautionary reasons.

Litter

Although recognised as a longstanding environmental problem in the QSR, OSPAR has failed to bring in any programmes and measures not only to reduce the ecological impact but also to counter the economic and social costs of the litter problem. The IMO is not the only body that can address this problem as North Sea States have demonstrated. They have undertaken efforts in conjunction with the development of a draft EC Directive on port waste reception facilities.

Climate change

Climate change is potentially one of the most significant threats to biodiversity in the North-East Atlantic. It is quite possible, if not likely, that global warming could have such serious consequences that wildlife populations including fish stocks which are already stressed through over-exploitation, pollution and habitat loss are simply not recoverable. OSPAR should consider actions it may take, or which it may urge other international bodies to take, with respect to mitigating climate change and not simply look at monitoring and preparing for the consequences.

Degradation of coastal habitats

Over the next century it is predicted that 50% of the world's coastal wetlands, including in the North-East Atlantic Region, will be lost due to coastal erosion, development and rising sea levels. The report does not give adequate recognition to this particular threat. As these wetlands are the highly productive areas which act as natural flood defences, fish spawning and nursery areas and pollution sinks, OSPAR countries must not allow their continued destruction and loss. If they do, they will fail to meet their international commitments under Annex V of the Convention as well as the global Convention on Biological Diversity.

Science policy

In several areas of the Report, proposed priority actions include strong emphasis on further research and assessment to improve understanding of marine systems. While recognising the vital importance of such research it is essential also to remember that we can never have a complete picture and that action to prevent further degradation of the marine environment must be precautionary and not await the outcome of long-term research programmes.

Copenhagen, 30 June 2000

The sub-headings used in this section are similar to the 13 human-related 'issues' used in the rQSRs: Tourism (and recreation); Fishing; Aquaculture/Mariculture; Coastal Protection and land reclamation; Wave, tide and wind power generation; Sand and gravel extraction; Dredging and dumping (and discharges); Oil and gas (industry); Shipping; Coastal industries; Military activities; and Agriculture.

4.1 Coastal industries

Impacts

Most of the human population in the catchments of the NEASE States is concentrated in coastal areas, many of which are connected with the establishment of coastal industries.

Industrial development has altered, disturbed, and destroyed coastal species and habitats, and other environmental impacts occur from discharges, emissions, and losses to land, air, and water. Many of the chief industrial centres in the NEASE are situated on estuaries and in the vicinity of the main urban areas and ports. Coastal regions, especially estuaries and bays, are under substantial pressure from industrial pollution from metal smelting and processing; chemical, petrochemical and paper-making; oil and gas storage and refining; vehicle factories; shipbuilding; power generation in power plants using coal, oil, gas and nuclear energy; and fish processing. Many of these industries use large amounts of water for cooling, cleaning and rinsing.

In the Greater North Sea area, the most industrialized coastal area in Norway occurs in the innermost part of the fjords, often with larger cities (e.g. Bergen, Oslo) or at localities where hydroelectric power is generated and smelting plants (e.g. for aluminium) are situated. Several oil refineries (e.g. Mongstad) are located in the coastal zone. In Denmark, industrial production is greatest on the east coast of Jutland and near Esbjerg. Most of the German coastal industries are collected near the banks of the rivers Elbe, Ems, Jade and Weser. In the coastal Netherlands, industries are mainly situated on the estuaries of the Scheldt, Rhine/Meuse (Rotterdam area) and near Amsterdam and Ijmuiden. In Belgium, the coastal industry is mainly situated in the Antwerp area, close to the Scheldt estuary. Coastal industries in France are mainly situated on the Calais – Dunkerque coast and the Seine estuary. The main UK industries on the coasts of the North Sea region are situated on the estuaries of the rivers Thames, Tyne and Tees, near Southampton and the Firth of Forth.

In the Celtic Seas area, the largest industrial aggregations occur on the coasts of the northern Irish Sea, the Bristol Channel, the Clyde Sea and the east and south coasts of Ireland. On the eastern side of the Irish Sea, the Mersey estuary and Merseyside forms the main industrial location with two oil refineries and one of Europe's major ports, with shipbuilding, and manufacturing of foodstuffs, chemicals, vehicles, petrochemicals, paper, and metal products. The Cumbrian coast, north of the Mersey, has seen a reduction of its traditional heavy industries, shipyards, and collieries, but includes the nuclear fuel processing plant and nuclear power station at Sellafield. Nuclear power stations are also found at Hunterston (Firth of Clyde), Chapelcross (Malin Shelf), Heysham, Wylfa (Anglesea), and Berkeley, Oldbury and Hinkley Point on the Bristol Channel. A large gas terminal is situated at Barrow-in-Furness. On the western side of the Irish Sea, industry (mainly chemicals, electronics and computer software) is concentrated around Dublin. At several localities around the Bristol Channel (e.g. Port Talbot, Neath, Swansea, Pembroke and Milford Haven Docks), there are oil and other petrochemical refineries, industrial estates, docks and storage facilities, and a high intensity of heavy industry such as metal refining and steel manufacturing. To the north of the Irish Sea, the Clyde Sea coasts (Strathclyde region) include concentrations of industries such as steel manufacturing, power generation, chemical production and information technology. Further north in the Highland region, the fishing industry (e.g. fish processing) forms the main coastal industry. The Western Isles of the UK are mainly rural. In Ireland, besides the Dublin area, Cork Harbour on the south coast contains most of Ireland's heavy industries, including engineering and steel manufacturing, oil refining, and the production of chemicals and pharmaceuticals. The Shannon Estuary on the west coast contains two power stations and an aluminium plant, and large industrial estates with many enterprises are found in Shannon and Limerick. Elsewhere on the coastline, there are fish processing plants around the fishing ports in counties Donegal, Galway, Kerry and Wexford, and concentrations of food processing industries in the southeast.

In the Bay of Biscay area within the NEASE, industries of various types are located along the coasts, and several estuaries (e.g. Loire, Gironde) are under pressure from industrial activities that pollute. The sources of pollution are paper milling, petroleum refining, chlorine production, titanium dioxide production, metal plating, and ferrous and non-ferrous metal industries. Coastal regions outside estuaries are also under similar pressure, e.g. southern Brittany (agro-food industries), and Aquitaine (e.g. paper mills, petroleum industries). The principal coastal cities are Brest, Lorient, Nantes-Saint-Nazaire (with the largest shipyard on the French Atlantic coast), La Rochelle, and Bordeaux.

Many data and energy cables, and pipelines are submerged in the seabed, providing contact between the various industrialized centers as well as connecting with the offshore oil and gas industries. This produces problems for some other users (e.g. bottom trawl fisheries, marine aggregate extraction). Within territorial waters, States can demand that cables and pipelines are removed when no longer in use.

Management and regulatory measures

The management measures required for the regulation of coastal industries are numerous and are mainly connected with the impacts from eutrophication, hazardous substances, shipping, overexploitation of living resources, degradation of habitats, and climate change. These will be dealt with in further detail in the following sections.

Many coastal areas are recognized as important for wildlife conservation and are designated with various levels of legal protection. National legislation, international conventions (e.g. CBD and Annex V of the OSPAR Convention) and EC Directives [especially the Birds Directive (79/409/EEC) and Habitat Directive (92/43/EEC)] provide important instruments that have in many cases fallen behind schedule in their implementation. There is a pressing need to give higher priority to these instruments in order to meet these commitments.

Because of the enveloping and complex effects on the environment and ecosystems arising from coastal industries, there is an overarching need to develop and implement plans for integrated coastal area management, including spatial planning of acceptable and unacceptable activities within specific areas, and setting ecological quality objectives to restore degraded habitats and ecosystems.

4.2 Tourism and recreation

Impacts

Coastal areas provide recreation opportunities that attract local people as well as tourists. During the summer, the population of these areas rises significantly due to tourism. In the NEASE as a whole, tourism has been growing steadily, at rates of about 50-100% per decade since the 1970s in some areas. Without prudent planning controls and development policies, the features that attract visitors such as clean beaches and bathing water, unspoilt landscapes, wildlife refuges, can be harmed by recreation and tourism.

Recreation and tourism cause pressures on coastal ecosystems by excessive influxes of visitors. This is connected with increased vehicle and pedestrian traffic, allowing pets such as dogs and cats to wander unhindered, construction and building (e.g. roads, car parks, golf courses, and accommodation), pollution from the production and disposal of litter and other waste, and the degradation and disturbance of wildlife and their habitats.

Management and regulatory measures

There is a lack of an overall policy and coordinated response mechanism for tourism, including a concerted action within the coastal and water-related tourism and leisure sector to identify and achieve environmental quality objectives. Tourism is an expanding high-growth sector, accounting for about 25% of export of services and 14% of services employment among the rich western countries of the OECD (Organization for Economic Cooperation and Development). Much of this growth is focused on coastal areas. Programmes should be initiated to improve the environmental awareness of those working in the tourism sector and the public at large.

4.3 Coastal engineering and land reclamation

Impacts

Construction engineering activities, connected with coastal protection and land reclamation, frequently cause either permanent destruction of habitats and/or decreases in habitat size and their fragmentation. This type of impact includes extraction of bottom material, dumping and disposal, construction-related changes in current regimes, noise and general disturbance. Although it occurs throughout much of the coastal area of the NEASE, it is most manifest in the southern North Sea, where numerous habitats have been disrupted and degraded by human construction activities, such as the establishment of flood defences (e.g. sluices, dykes, and storm-surge barriers such as in the mouth of the Eastern Scheldt) and general building development. These developments and rising sea level (e.g. from climate change) pose substantial threats affecting the loss of wetlands. These wetlands form important transitional habitats between freshwater and coastal waters, natural defences against wind and tides, and act as sinks for run-off from land-based pollution.

Management and regulatory measures

Future coastal protection policies are needed to provide sufficient protection against rising sea levels in a manner that is compatible with nature conservation. For much of the coastline, there is insufficient information on recent rates of habitat loss in relation to habitat types and areas.

The sustainable management of coastal areas, including the restoration of destroyed and degraded wetlands, should be integrated into a ‘programme of measures’ for achieving ‘good status’ (c.f. EC Water Framework Directive). In many cases the problems have been caused, or seriously aggravated, by many decades of poor land use management.

4.4 Sand and gravel extraction

Impacts

Sand, gravel and calcium carbonate extraction primarily take place in the inshore areas of the southern part of the North Sea, the Celtic Sea and the French Atlantic coast. Sand and gravel are used for building construction, for coastal protection and landfill, and for beach replenishment. The natural sources of calcium carbonate are extracted in the form of maërl banks composed of calcareous algae and shell sands.

Currently about 44 million tonnes per year are extracted from the OSPAR area, of this most comes from the North Sea where extraction increased from 34 to 40 million tonnes per year between 1989 and 1996 and about 4 million tonnes per year from the Atlantic coast of France.

The main impact on the ecosystem is the disturbance and removal of benthic organisms from the extraction site, and damage to sites that act as spawning areas for bottom spawning fish (e.g. herring). Extraction activities can physically alter the seabed profile, increase the instability of shallow banks and increase the possibility for coastal (e.g. beach) erosion. Most States report increasing concerns about the extraction of marine aggregates.

Management and regulatory measures

Various measures have been introduced nationally and internationally to minimize the environmental impacts of such extraction, including the 1992 ICES Code of Practice on Commercial Extraction of Marine Sediments. In the Dutch sector of the North Sea, extraction landwards of the 20 m depth contour is not licensed owing to ecological and coastal defence considerations.

Unacceptable changes through extraction activities, such as large-scale habitat alteration and interference with vulnerable species and habitats, should be precluded. The following aspects of good practice need to be emphasized:

- Careful attention should be given to the location of new dredging areas;
- Consideration of new applications for dredging permission should be based on the findings of an environmental impact assessment and apply the precautionary approach;
- Operators should be required to monitor the environmental impacts of their activities before and after dredging;
- Control of dredging operations should occur through the use of legally enforceable conditions attached to the granting of dredging permission;
- Restriction of dredging to discrete sub-areas (zoning) should be considered;
- Time limits on the duration of dredging permission should be considered in order to provide a balance between commercial realities, monitoring requirements, and the availability of scientific information;
- Seasonal and tidal restrictions for operations should be considered in order to avoid disturbances to vulnerable biota.

There is limited knowledge on the effects of marine aggregate exploitation, especially of shells and maërl. Extraction continues at increasing rates and controls are limited.

The OSPAR Strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area intends to cover the impacts of mineral exploitation on benthic habitats.

4.5 Dredging and dumping at sea

In the past, sewage sludge and industrial waste has been disposed of at sea. The disposal of wastes at sea (i.e. dumping) is prohibited by the 1992 OSPAR Convention, with the exception of dredged material, waste from fish processing, inert material of natural origin and, until the end of 2004, vessels or aircraft. The dumping of industrial wastes was phased out in 1993 and sewage sludge dumping ceased by 1998/1999. In 1989, incineration of liquid industrial waste on special vessels in the North Sea was terminated. The dumping of waste from the production of titanium oxide was terminated in the North Sea in 1989 and by Spain in 1993. However, discharges from the titanium oxide industry are permitted under OSPAR and EC (Council Directive 92/112/EEC) regulation, and are mainly confined to French (Seine) and UK (Humber and Tees) estuarine waters. A licence for the disposal of waste at sea is issued only when it can be shown that the material is not seriously contaminated.

The following section provides an overview of the main environmental impacts of these activities and associated management measures.

4.5.1 Dredged material

Impacts

The bulk of the material currently eligible for sea disposal originates from dredging operations. Dredged materials dumped at sea mainly originate from keeping navigation channels clear (e.g. in the vicinity of most of the large ports in the region) or matter removed in coastal construction engineering projects. Dredged material may be used for beach nourishment, land reclamation or salt marsh preservation. The principal dredging operations occur in the vicinity of large ports, but dump areas are found in coastal areas throughout most of the region. However, most of the dredging within the region occurs in the Greater North Sea, where an estimated total of about 85 million tonnes dry weight of dredged material is dumped annually. The annual OSPAR Reports on Dumping of Wastes at Sea provide a summary of the number of permits issued for most of the materials.

Dredging mainly causes physical disturbance and may result in the redistribution and possible change in form of contamination. The disturbance increases suspended matter, which affects primary production and impedes the growth of filter feeding organisms (e.g. bivalves), causes burial of the benthos and changes in the substrate, with potential changes in the localized benthic communities. Contaminants can be resuspended and remobilized from sediments and pass into the food web. For example, most harbour dredgings are contaminated by metals and organic substances that enter the water and are adsorbed onto particulate material settling with the sediments. Contaminated dredgings may impact the biota in the deposition zone. Dredging may also accelerate coastal erosion and change the morphology of natural channels, causing more wide spread habitat changes.

In a number of areas, habitats have been affected under the increasing amount of maintenance dredging for shipping. In the Western Scheldt (Netherlands), due to the progressive deepening of the main tidal channels for shipping, salt marshes and high mudflats are eroding and the extent of shallow water nursery areas for flatfish and shrimp have decreased.

Management and regulatory measures

Maintenance dredging is likely to increase, partly due to the increased incidence of storms that move bottom sediments and reduce shipping channels. Anticipated greater use of larger ships with greater draught is expected to increase the amount of dredging in and approaching ports.

Dredged spoil that is contaminated above specific limits, such as from ports like Rotterdam, is deposited in specially built dumps. Non-contaminated and slightly contaminated spoil is disposed of at dumpsites in estuaries and coastal waters.

Measures to minimize the volume of dredged material are viewed as Best Environmental Practice according to the OSPAR Guidelines for the Management of Dredged Material (OSPAR Reference No. 1998-20). The OSPAR Strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area will address the impacts of dredging activities. However, existing management systems need to be carefully monitored to ensure they are effective.

In general dumping of dredged material is well managed by licenses and controls on contaminant levels but not on loads. There is imprecise information on the actual amounts of contaminants transferred by dredging and the effects of dispersed fine material on benthic habitats. There is also a need to monitor contaminant residues in sediments and biota outside the disposal areas.

4.5.2 Sewage sludge

Impacts

The dumping of sewage sludge increases the fallout of organic material and associated contaminants to the bottom. In already nutrient rich coastal waters, sewage sludge contributes towards eutrophication and thereby affects water quality and changes the pelagic and benthic community structure and productivity.

Management and regulatory measures

Within the OSPAR area, the disposal of sewage sludge at sea was practiced only by Germany, Ireland, and the UK, and has since been terminated.

Sludge from coastal sewage treatment plants are frequently spread on agricultural land and deposited in landfill sites, but with the cessation of the sea disposal-option an increased use of incineration is probable.

Although the dumping of sewage sludge at sea has been effectively stopped through OSPAR mitigation, the impacts of sewage, manure, and nutrients flowing into the sea from mariculture and from land-based sources remain serious. These are *inter alia* described under sections 4.6 (Eutrophication), 4.7 (Mariculture) and 4.8 (Agriculture).

4.5.3 Marine litter and garbage

Impacts

Marine litter is derived from land-based and marine sources, and is found in large quantities on seabeds, in the water and on the shores (Hall 2000). It is a serious problem worldwide and throughout the NEASE. Marine sources of litter are mainly shipping, fishing and mariculture operations, while land-based sources are mainly from garbage sites on or close to shorelines, sewage-derived debris, and items discarded by recreation on beaches and the coastline generally. About 80% or more of this material consists of nondegradable plastic and mainly results from waste from fishing and commercial shipping, and recreation and tourism. The problem is likely to increase as tourism and urban development in the coastal zone increase.

In the greater North Sea, it has been estimated that at least 70,000 m^3 of litter is thrown overboard annually, while at least 600,000 m^3 of litter lies on the seabed. Substantial quantities of litter are regularly observed several hundred km out to sea, for example in oceanic areas of the Bay of Biscay.

The socioeconomic impacts of litter are substantial and include the unsightly aesthetic fouling effects, the substantial costs of clearance, and impacts on the fishing and tourism industries.

The biological effects cause the smothering, entangling and drowning of several biota, especially birds. Birds, turtles, and baleen whales are likely to suffer acute physical injury or obstruction of their alimentary system by ingestion of plastic objects, leading to drowning, starvation, or impaired foraging ability. Litter also spreads toxic substances. Floating and drifting litter can act as a vector for the transportation of non-indigenous species to new areas by ocean currents.

Management and regulatory measures

The MARPOL 73/78 Convention prohibits the disposal of garbage at sea by shipping within three miles of the coast. The discharge of all plastics at sea from ships is prohibited according to Annex V of the MARPOL Convention that entered into force in 1988. A 1995 amendment to this Annex requires all ships of 400 tonnes or more, or transporting more than 15 people, to file a plan for garbage management. Within the NEASE, the North Sea was designated in 1991 as a MARPOL Special Area such that the dumping of all garbage and litter from ships is prohibited. Despite these measures, no discernable improvement has occurred concerning these issues.

At the 2002 5NSC, the Ministers recognized the problems of marine litter and *inter alia* emphasized the importance of mounting clean-up campaigns, public information activities and educational projects. Mechanisms should be set-up as incentives to deliver all ship-generated waste ashore, and to exchange information on the adequacy and use of such facilities, through a harmonized reporting system. A number of initiatives have received attention, including the transport of litter caught in fishing trawls back to port where it can be unloaded free of charge for safe disposal, the experience of the Baltic Sea States in testing the ‘No Special Fee System - 100%’, and the entry into force on 28 December 2002 of the European Parliament and Council Directive 2000/59/EC on Port Reception Facilities for Ship-generated Waste and Cargo Residues. Although information on waste produced from ships and/or delivered is available in some countries, there is currently little use of such data and there is still insufficient knowledge of the amount of litter discharged at sea.

Although litter has been recognized as a long-standing environmental problem, there has been a failure to establish effective programmes and measures to reduce the ecological impact and counter the socioeconomic costs of the litter problem.

The ecological and socioeconomic impacts of litter and waste need to be further quantified in order to adequately consider the effects and necessary measures to conserve species and habitats. Local sources of litter and waste need to be monitored and controlled through effective enforcement measures. Accordingly, comprehensive programmes and measures should be established not only to reduce ecological impacts but also to counter the socioeconomic costs of the problem. Consideration should be given to designating more areas, e.g. the Irish Sea, within the OSPAR maritime area as MARPOL Special Areas for litter and waste in order to help redress the problems.

The ecological impacts of litter will be addressed within the OSPAR Strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area.

4.5.4 Other waste

Dumping of ships in the OSPAR maritime area will be prohibited from 2005.

Dumping at sea of inert material of natural origin (e.g. stone from mines) has taken place on a small scale in national waters by Ireland. Deposition of some inert material from land onto the foreshore occurs in the UK and Norway, but this activity does not constitute dumping under the OSPAR Convention.

4.6 Eutrophication

Impacts

Discharges and emissions from land-based sources (e.g. from industry, households, traffic, mariculture and agriculture) have provided substantial inputs of nutrients to coastal and open waters of the region, via rivers, direct discharges, diffuse losses, and deposition from the atmosphere. The resulting eutrophication[11] is a major environmental issue at national and international levels.

Eutrophication starts with increasing inputs of nutrients resulting in increased primary production in the form of phytoplankton and macroalgal biomass and production, which leads to elevated amounts of organic matter circulating in the ecosystem. This results in several serious and pervasive impacts on ecosystems.

The subsequent breakdown of the produced algal biomass that results from excessive anthropogenic inputs of nutrients requires large amounts of oxygen and may lead, *inter alia*, to depletion of the oxygen content of the water and surface sediments of the seabed. Eutrophication impacts include long-term reduction in light penetration in water with high primary production and increased turbidity, leading to a decrease in the depth distribution of perennial macrophytes (e.g. bladderwrack *Fucus vesiculosus*) that are attached to the seabed and an increase in short-lived filamentous and epiphytic or drifting algae. Blue mussels and green and brown filamentous algae have replaced bladderwrack in many places, starting to cover shallow soft bottoms and change the nutrient flux at the sediment-water interface by decreasing the oxygen content. The increased occurrence of filamentous green algae tends to smother macroalgae, with major ecological consequences, and 'slimy' green algae reduce amenities for tourism and recreation purposes. Increased levels of nutrients lead to the loss of rare species and habitats that are adapted to low nutrient levels. When combined with physical disturbance of the seabed (e.g. bottom trawling, sand and gravel extraction, dredging), eutrophication may cause persistent degradation of benthic habitats and their associated community structure.

Coastal areas serve as important spawning, nursery, and feeding areas for many fish species. Besides being economically very important, the status of fish stocks impact aquatic birds and marine mammals. Moderate levels of excess nutrients may be beneficial for fish stocks in systems with low nutrient levels, but increased enrichment may result in harmful effects. Attention has been drawn to the impacts of fishing in nutrient enriched ecosystems, in which the combined impact of increasing fishing intensity and nutrient run-off on marine food webs, and bottom oxygen depletion, leads to a decline in mean trophic level as measured by the increasing relative biomass of small pelagic fish caught compared with demersal fish (Caddy 2000). In the North Sea and adjacent shelf seas, a decrease in many demersal fish and a relative flourishing of pelagic fish has occurred with increasing eutrophication and high fishing effort (Boddeke & Hagel 1995; Hopkins *et al.* 2001).

Eutrophication has not been considered a serious problem on the open shelf and deep waters off the continental shelf. However, within the coastal zone, embayments and estuarine areas having little water exchange are prone to eutrophication, particularly in the southeastern part of the North Sea area. The specific regional impacts of eutrophication particularly include the increased production of phytoplankton in the coastal areas of the eastern part of the North Sea, and the linking of nutrient inputs to the extended duration of blooms in the Wadden Sea and changes in the structure of the plankton and benthos communities in the German Bight. In the Celtic Seas, the Mersey Estuary and Liverpool Bay area, and Belfast Lough show signs of eutrophication, and reductions in nutrient inputs appear necessary to restore conditions. Concern

[11] Eutrophication is defined by OSPAR as the undesirable effects resulting from anthropogenic enrichment by nutrients.

has been expressed over the occurrence of areas of anoxic sediment ('black spots') and accompanying mortality of benthos in the Wadden Sea in 1996. Some hydrodynamically confined areas on the coast of North Brittany are sometimes affected by 'green tides' that deposit thousands of tonnes of 'sea lettuce' (*Ulva*) on the beaches.

Some improvements have been detected in the German Bight and Danish waters for the concentration of phosphorus, and some improvements with respect to nuisance algal blooms, as well as oxygen deficiency and benthos/fish kills are observed in several areas of the North Sea. However, trends of decreasing oxygen concentrations have been documented for the deep waters of the Kattegat and the basin waters in Swedish and Norwegian fjords.

Management and regulatory measures

Since the 1987 Second International Conference on the Protection of the North Sea, the North Sea States have agreed to remain committed to reaching the 50% reduction targets on phosphorous and nitrogen set by their Ministers. Agreement has occurred to strengthen implementation of existing measures on all sectors, putting special emphasis on agriculture policies, as soon as possible. OSPAR was invited to adopt a strategy to combat and prevent eutrophication, and national and international bodies were urged to integrate this strategy in their activities. It was also agreed that the concept of balanced fertilization should take account of the principles of the OSPAR Strategy to Combat Eutrophication.

In 1993, OSPAR Contracting Parties identified their problem areas with regard to eutrophication. A second more rigorous assessment of eutrophication status is currently underway within OSPAR through the adoption in 1997 of a Common Procedure for the Identification of the Eutrophication Status of the OSPAR Maritime Area. The Common Procedure comprises two phases, starting with a simplified Screening Procedure to identify areas of obvious 'no concern' (non-problem areas), followed by a Comprehensive Procedure applied to all remaining areas. The intention of the Common Procedure is to characterize, with respect to eutrophication, the various parts of the OSPAR Maritime Area either as problem areas, potential problem areas or non-problem areas. In implementing the Common Procedure, OSPAR will develop and adopt common assessment criteria and will assess the results of OSPAR Contracting Parties' application of the Procedure.

In 1998, OSPAR adopted its Strategy to Combat Eutrophication, with the main objective of achieving by 2010, and maintaining, a healthy marine environment where eutrophication does not occur. The Strategy comprises and integrated target- and source-orientated approaches. The target-orientated approach prepares the setting of ecological quality objectives, followed by quantification of necessary reductions in input of nutrients to meet the objectives. The source-orientated approach focuses on the immediate implementation of all agreed measures. The Strategy also provides for the development and implementation of additional measures that are necessary to meet the quality objectives.

OSPAR has developed Guidelines for Harmonised Quantification and Reporting Procedures for Nutrients (HARP-NUT) in close cooperation with the EC and European Environment Agency. The guidelines describe procedures for the quantification and harmonized reporting of total phosphorus (P) and total nitrogen (N) losses from anthropogenic diffuse sources and natural background losses into primary surface water recipients.

The results of the Screening Procedure were presented to OSPAR in 2000. The Screening Procedure identified the obvious non-problem areas with regard to eutrophication. All other areas will be subject to the Comprehensive Procedure (OSPAR Agreement 2001-5) (Figure 9). Starting in 2002, the OSPAR Contracting Parties will use these criteria in their application of the Comprehensive Procedure. The repeated application of the Comprehensive Procedure will identify any change in the eutrophication status of a particular area.

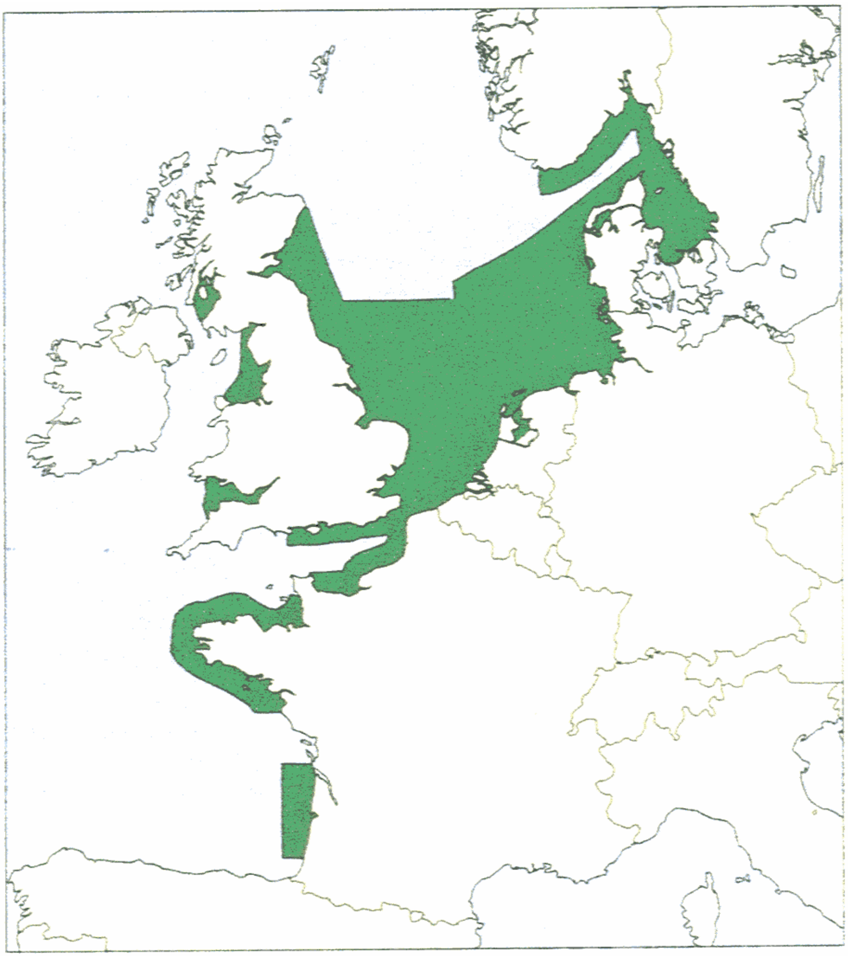


Figure 9. Locations where the OSPAR Comprehensive Procedure for eutrophication will be applied. After OSPAR QSR 2000.

The Comprehensive Procedure will also be applied to a number of Irish estuaries. In applying the Screening Procedure (not completed in all areas) not all local areas of possible concern have been identified: these areas will also be considered by OSPAR Contracting Parties under the Comprehensive Procedure.

In 2001, OSPAR developed an integrated set of Ecological Quality Objectives for nutrients and eutrophication effects (EcoQO-eutro). The EcoQOs-eutro were selected from the common assessment criteria and their respective assessment levels to be used within the Comprehensive Procedure. The elaborated EcoQOs-eutro are considered as an integrated set to serve as a tool for establishing whether the measures for the nutrient reduction at source are sufficient in order to achieve by the year 2010 a healthy marine environment where eutrophication does not occur. The elaborated integrated set of EcoQOs-eutro comprises targets for maintaining the levels of nutrients, phytoplankton (chlorophyll a and eutrophication indicator species), oxygen, and benthos (affected by eutrophication).

Regarding the reduction of anthropogenic nutrient inputs to the North Sea, most States have achieved the 50% reduction target for phosphorous whereas the reduction of nitrogen is still substantially behind schedule for achieving the 50% target. This is *inter alia* due to delays in implementing EC Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources and to regional delays in implementing the EC Council Directive 91/271/EEC concerning urban waste water treatment or delays in equivalent national measures. Accordingly, at the 2002 5NSC, the North Sea Ministers agreed to take further action to achieve full implementation of the Nitrates Directive, the Urban Waste Water Directive, and the Water Framework Directive or equivalent national measures in order to meet the target of the OSPAR Strategy to Combat Eutrophication.

Predictive methods suggest that the environmental conditions in the OSPAR maritime area may improve up to 25-30% due to a 50% reduction of inputs of nutrients for many coastal waters. However, predictions that are more precise will be needed for the situation following the implementation of the agreed measures. A number of NGOs are calling on OSPAR Contracting Parties to meet and exceed their 50% reduction targets for nutrient inputs, and independent scientists are now arguing that an 80% reduction is necessary in order to safeguard species and habitats.

Ten years after the adoption of Council Directive 91/271/EEC on Urban Waste Water Treatment, the vast majority of Member States show major delays and shortcomings in its implementation. Almost all Member States are very slow in providing the European Commission with information about the treatment of city sewage.

The new EC Water Framework Directive, that is applicable in all EU and EEA countries, focuses *inter alia* on the management of water quality and eutrophication in coastal and transitional waters on a river/catchment area basis.

Management and measures concerning eutrophication from agricultural sources are examined in section 4.8.

4.7 Fisheries and mariculture

4.7.1 Fisheries

Impacts

Fisheries affect the marine ecosystems and the fish stocks are affected by the ecosystems. Fisheries management must, according to recent international agreements and codes, consider the effect of fisheries on the marine ecosystem (e.g. FAO 1995; UN 1995; Hopkins 1999).

The effects of fishing have been comprehensively reviewed (e.g. Dayton *et al.* 1995; Lindeboom & de Groot 1998; Kaiser & de Groot 1999; Hall 1999; Nilsen *et al.* 2002; Huse *et al.* 2003). Fisheries mainly affect the marine ecosystem through:

1. Removal of biomass as food—changing the food base for other biota.
2. Removal of biomass of predators—removing predators and thus reducing predation pressure in the system.
3. Removal of target species leading to changed abundance and population structure of these populations. This effect has been the main concern so far of fisheries management. However, the change in target populations is a concern not only in relation to the immediate resource base for fisheries, but also in relation to changes in the species composition and structure of the ecosystem.
4. Removal of non-target species.
5. Discarding unwanted catches - creating a food source that would otherwise not be available at that time and place.
6. Mechanical effects inflicted by the fishing gear on the bottom environment, which result in changes in benthos communities.
7. These more direct impacts on the ecosystem will result in more general changes in the structure of the ecosystem such as changes in biodiversity, in the trophic structure or the size composition of organisms in the system.

The present exploitation rate on many fish stocks in the NEASE is excessively high and is not sustainable. The OSPAR QSR 2000 for the North-East Atlantic maritime area as a whole identified 40 of the 60 main commercial fish stocks as being ‘outside safe biological limits’ or in other words as currently being unsustainable, severely depleted, or in danger of becoming so. Updates by ICES ACFM (ICES 2001b, ICES 2002a) have not shown a tangible improvement in the proportion of the stocks identified as being outside safe biological limits, the majority of which are found in the NEASE either as resident stocks or stocks migrating in and out of the region. The differences between current fishing mortalities and those corresponding to recommended optimum rates are also very large. The yield from many target fish stocks would be significantly higher with a lower fishing mortality and different exploitation pattern.

Heavy exploitation of commercial fish species and the related ecosystem impacts of fishing occur throughout nearly all of the continental shelf areas of the NEASE, with the most extensively overfished areas occurring in the southern and southeastern North Sea including the Channel, in the Irish Sea/Bristol Channel, and around Brittany and Aquitaine. However, excessive exploitation rates of deep-water fish stocks are also found in the deeper areas either bordering or intruding into the continental shelf.

By-catch and discarding of unwanted fish are recognized as causing major problems by seriously reducing the numbers of juveniles before they have matured to the spawning stock (diminution of both 'capital and interest' in banking terms), and in reducing the fish that are available to feed larger fish such as cod. There is a general lack of data on the amount and species composition of by-catches and discards. Recorded fish landings are generally viewed as undependable, with substantial levels of misreporting occurring in many fisheries.

Based on recent reviews within the NEASE area (ICES 2000b; Nilsen *et al.* 2002; Huse *et al.* 2003), unsustainable fishing may be summarized as causing the following specific impacts:

a) Many stocks of target demersal fish (e.g. gadoids and flatfish) and deep-water fish species are outside safe biological limits, in breach of the precautionary principle;
b) Decrease in the abundance of larger fish, resulting in a shift towards smaller fish communities;
c) High exploitation rates allow relatively few juvenile fish to survive to spawning age;
d) Particularly vulnerable species of demersal fish have become seriously depleted (e.g. many sharks, skates and rays), with some having become locally extinct (e.g. common skate in the Irish Sea and the North Sea);
e) Fishing effort has increasingly been directed to lower levels in the food chain, such as smaller plankton eating fish and benthos feeding fish;
f) Depleted stocks of larger piscivorous fish (e.g. cod) that have reduced the predation on stocks of small pelagic fish and allowed the expansion of pelagic and industrial fisheries;
g) Death and injury of marine mammals (especially harbour porpoise) seabirds, and turtles as by-catch in gill and static nets, and longlines;
h) Increased food supply (offal discards, and reduced competition) for some opportunistic species of seabirds, zoobenthos, and fish;
i) Increased competition from marine mammals, and seabirds and shorebirds, with fisheries for fish and shellfish food species;
j) Death, injury, and disturbance from bottom gears (e.g. beam trawls, ottar trawls, shellfish dredges) of vulnerable benthic species and the degradation of habitats (e.g. large bivalve molluscs, biogenic reefs with cold-water corals and serpulid worms);

Management and regulatory measures

In the North-East Atlantic, and especially in the NEASE within this area, the poor performance of fisheries management has been identified as the cause of the majority of commercial fish stocks being 'outside safe biological limits' as well as the cause of serious damage to biodiversity and the marine ecosystems (OSPAR QSR 2000; Nilsen *et al.* 2002).

In the NEASE, management of the fisheries is regulated within EU waters under the EC Common Fisheries policy, and within Norwegian waters by national policy and legislation. Additionally, the North-East Atlantic Fisheries Commission (NEAFC) aims at promoting conservation and optimal utilization of straddling fish stocks in the North-East Atlantic area.

The fundamental problem for fisheries management is to achieve an appropriate balance between fishing effort and the available fish resources. At present, managers apply a system of catch quotas and total allowable catches (TACs) as the main instrument used to control fishing mortality rates, as well as other measures such as restricting the number of fishing vessels, their fishing capacity, fishing time and area of operation at sea. A control and enforcement system monitors fishing activities at sea as well as the catches on landing. TACs have not been effective in reducing fishing mortality on demersal stocks and have been only partly effective on pelagic stocks, even in those cases where TACs have been set according to the biological advice. Supplementary effort reduction measures have not been put in place to prevent stocks from falling outside safe biological limits. Many of the management measures employed have not been successful, and the present control system is flawed with the misreporting of catches and other fisheries statistics resulting in serious problems for fish stock assessments.

The precautionary approach and environmental objectives need to be integrated into fisheries policy and management in order to halt overfishing, ensure the recovery of depleted fish stocks and minimize the impact on vulnerable species and their habitats. Although the precautionary approach has been applied to an increasing number of the main commercial fish stocks in the NEASE since about 1998, it has not been implemented for a large number of other fish stocks and many fish stocks are not regulated by TACs. Full application of the precautionary principle for all management measures concerned, including those related to the conservation of non-commercial items, still requires considerable development.

There is a need to establish longer-term objectives for the management of the fisheries in the region. In general, management measures should aim at building diverse fish communities with larger numbers of bigger and older individuals and hence larger spawning stocks, especially for larger species (Nilsen *et al.* 2002).

For the implementation of long-term management plans in accordance with the precautionary approach for commercially harvested stocks, precautionary limit and target reference points are required and indicators for sustainable development of marine capture fisheries must be identified and implemented (FAO 1995; FAO 1999). However, for several stocks there is insufficient data available to establish precautionary reference points. According to the EC's Biodiversity Action Plan for Fisheries and in line with the precautionary principle, rules for exploitation of such stocks need to be established, which should take into account the history of exploitation, yield and the likely biological outcomes of exploitation. Although progress has been made in developing limit reference points for fish stocks, fisheries management and the fishing industry have resisted the implementation of target points for stocks so far.

Several changes will contribute to significant reductions in the effects of bottom trawls on the benthos and reduce the ecosystem effects of fishing. ICES has advised the European Commission that the most serious effects could be mitigated, without unduly reducing the possibilities of catching commercially important species, through the following priorities: 1) a major reduction in fishing effort; 2) establishing closed areas (*e.g.* spatial and real time closures), 3) making gear substitution, 4) modifying gear, 5) habitat restoration; and 6) governance changes (ICES 2000b). A number of changes to fisheries management systems are under review that would greatly facilitate major reductions in the effects of fishing on marine ecosystems, e.g. proposals from IMM 1997 and revision of the EC CFP. ICES has emphasized that the precautionary approach requires that immediate action be taken, to ensure that conservation is not compromised while greater knowledge bases are being built. So the following specific immediate actions have been recommended: a) prevent expansion of areas impacted by bottom trawls; b) prevent increase in numbers of bottom trawlers; c) strengthen interactions with groups working on conservation of the marine ecosystem; and d) improve the ability to detect and measure impacts.

Many scientists and NGOs are promoting marine protected areas - particularly the idea of 'no-take zones' for fisheries as a fundamental support to existing management measures. These should help facilitate recovery plans by safeguarding critical areas for commercial species and the ecosystems upon which they depend.

Scientific advice forms an important basis for the management of fisheries. However, the scientific justification for measures is in many cases challenged, often by reference to lack of data or knowledge in contradiction of the precautionary principle. Reference to socioeconomic conditions is frequently given as another reason for not implementing necessary management measures.

Further integration of fisheries and environmental policies

The requirement for the integration of fisheries and environmental policies received particular attention at the Intermediate Ministerial Meeting on the Integration of Fisheries and Environmental Issues and the 5NSC, both held in Bergen Norway in 1997 and 2002 respectively. A number of policy guidelines and commitments were made (see below). These commitments must speedily and progressively become reality. However, the first step is to remove the main obstacle to environmental integration, which continues to be the excessive fishing pressure. Technological improvements to remove or reduce the environmental impact of fishing will not be sufficient if this is not addressed as the first priority. It is important to note that the current scientific knowledge provides sufficient basis to advance the development of environmental protection within fisheries management. In this respect, measures have been promoted in the EC Biodiversity Action Plan and the Norwegian Environmental Action Plan for 2000 to 2004.

Important European Community policy documents that have appeared since 1999 on this issue include:

a) Fisheries Management and Nature Conservation in the Marine Environment (COM(1999)363);
b) Application of the Precautionary Principle and Multi-annual Arrangements for Settings TACs (COM(2000)803);
c) Elements of a Strategy for the Integration of Environmental Protection Requirements into the Common Fisheries Policy (Doc. No. 7885/01 Pêche 78, Env 188);
d) Conclusions from the Council of the 18 June 2001 on a Biodiversity Action Plan for Fisheries (COM(2001) 162 Vol. IV);
e) Sixth Environmental Action Plan of the European Community, 2001-2010;
f) Sustainable Development Strategy (Gothenburg Summit, June 2001).

Thus, the Community is working towards a comprehensive environmental integration, of which the main elements have been identified as:

1. The progressive adoption of an ecosystem approach to fisheries management;
2. The incorporation into the Common Fisheries Policy (CFP) of the environmental principles defined in Article 174 of the Treaty as i) the precautionary principle, ii) the principle of prevention, iii) the principle of correction at source, and the polluter pays principle;
3. Carrying out of specific management action, mostly described in the Biodiversity Action Plan for Fisheries.

In Norway, work has started for developing integrated ecosystem based management of the coastal and offshore areas, including:

- The Environmental Action Plan for the 2000-2004, in which general environmental goals and specific targets are set for fisheries, aquaculture and coastal management, as well as the actions necessary to achieve these goals. Annual reports are submitted to the Norwegian Parliament;
- The 2001 White Paper on Biodiversity, outlining a management system for biodiversity that will also be of importance to the fisheries sector;
- A new Marine Law (‘Havlov’) aims to improve the focus on environmental considerations in the fisheries;
- The capture fisheries and aquaculture industries are developing an environmental strategy for the sector.

In conclusion, on the basis of the proposals in the reports and declarations from the QSR 2000, IMM97, and 5NSC, action on the following issues needs to be given serious attention by the appropriate authorities in order to sustain the fisheries and protect environmental resources and ecosystem function:

- Fisheries management and environmental policies must be further integrated, within the framework of the ecosystem approach in a holistic, multiannual, and strategic context. The current state of scientific knowledge, coupled with a sound application of the precautionary principle, allows the immediate setting of several environmental protection measures. These measures include: a) the introduction and promotion of fishing methods that have a reduced physical impact on the seabed and habitats, b) the introduction and promotion of the use of selectivity devices that minimize by-catches of non-target species, c) introduction of limits on by- or incidental catches, especially for species listed in environmental legislative instruments, and d) establishment of temporal and spatial closures to enhance the protection of juvenile fish and vulnerable species or habitats;

- Reduction without delay of excessive fishing effort, fleet overcapacity and overcapitalization, and subsidies in the fishing industry at sea and on land;
- Development and implementation of recovery plans and outline measures for the fish stocks that are outside SBLs in order to stop the decline of fish stocks and the associated crises for the fishing industry that rely on the sustainability of the stocks. A multispecies approach should ensure that a recovery plan for one target species does not impact on another species (e.g. by displacement of effort from a closed area). The importance of linking environmental and economic aims, combined with the necessary political and technological elements, is emphasized;
- For the implementation of medium and long-term management plans in accordance with the precautionary approach for commercially harvested stocks, establishment of precautionary limit and target reference points for biomass and mortality are required. However, for several stocks there is insufficient data available to establish precautionary reference points. According to the Biodiversity Action Plan for Fisheries and in line with the precautionary principle, rules for exploitation of such stocks should be established, which should take into account the history of exploitation, yield and the likely biological outcomes of exploitation. TAC regimes and other management measures should be extended to species that are unregulated at present;
- Addressing the particular vulnerability of deep-sea species, *inter alia* by establishing a management regime for deep-sea fisheries in the North East Atlantic and implement it on the basis of ICES advice and following a precautionary approach;
- The benefits for fisheries and/or the marine environment of the temporary or permanent closure or other protection of certain areas (e.g. MPAs, 'no-take zones', undisturbed areas of significant size). Due to the lack of progress made towards establishing such areas, it is necessary to *inter alia* establish legal means in order to close areas at short notice (e.g. due to concentrations of juvenile fish), and to identify additional areas to be closed permanently or temporarily to fishing activities for the protection of juvenile fish, and vulnerable species and habitats;
- Concern about the high incidence of by-catch and discards in the fisheries requires that adequate data and information—including monitoring and reporting—on by-catch and discards are necessary in order to allow improvement of the selectivity of fishing gears, improvements towards a sustainable management of fisheries and an enhancement of the basis for the multispecies and ecosystem approaches. Measures should be considered for harmonization of regulations for by-catch and discards, joint and coordinated control measures both at sea and at landing of catch, and permanent or closure of areas with a high incidence of by-catch and/or discards;
- Investigations of the ecological and economic effects of, and practicability of, applying a discard ban. The establishment of a discard ban for certain fisheries should be evaluated;
- Providing high priority to research and studies providing a better understanding of the structure and function of marine ecosystems, contributing to the operational application of an ecosystem approach to fisheries management;
- The risks posed to certain ecosystems and habitats (e.g. seamounts, hydrothermal vents, sponge associations, deep-water coral communities);
- Adverse environmental impacts of certain fishing gear, especially those causing excessive catches of

non-target organisms and habitat disturbance. Currently an objective official procedure for assessing the environmental impact of fisheries in general is not available;

- Implementation of national plans of action in the context of the FAO International Plans of Action for the Management of Fishing Capacity, the Reduction of Incidental Catch of Seabirds in Longline Fisheries, for the Conservation and Management of Sharks, and to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing;
- The establishment of Regional Advisory Committees, comprising relevant stakeholders, to provide joint advice for decision-making on the management of fisheries at the appropriate spatial scales;
- The current process of reforming the EC Common Fisheries Policy presents a major opportunity to integrate environmental protection requirements into the principles, objectives and operation procedures of fisheries management;
- Eco-labelling schemes offer a market- and information-based tool to promote sustainable fisheries practices.

4.7.2 Mariculture

Impacts

Mariculture activity in the NEASE is substantial and increasing rapidly (OSPAR QSR 2000) The bulk of the production results from the farming of salmonids in large cages in sheltered bays, inlets and fjords, as well as the intensive and extensive cultivation of shellfish (mainly bivalve molluscs). Mariculture sites are mainly located around most of Ireland with the exception of most of the central Irish Sea areas, on the coasts of western Scotland and southwestern Norway, and from the North Sea Danish coast along the eastern side of the Channel to the coasts of Normandy, Brittany and Aquitaine.

Finfish mariculture mainly started in the 1970s and has become a particularly important industry in Norway, Scotland and Ireland, reaching a current production in the NEASE of more than 350 thousand tonnes. The main species, farmed in sea cages, are Atlantic salmon and rainbow trout. For salmon, the increase in the production has been about 20% per year for Norway and Scotland, with there being a tendency towards larger cage farms. The density of farms is frequently high, e.g. in the Malin Sea area alone about 430 Scottish sites annually produce about 80 thousand tonnes of salmon.

Marine shellfish culture - mainly comprised of blue mussels and oysters in approximately equal proportions with some scallops, and negligible amounts of crustaceans - currently amounts to about 431 thousand tonnes in the region. Shellfish culture is a very high value activity.

There is considerable interest from the industry to increase production from both intensive as well as extensive (e.g. sea ranching) forms of mariculture. The potential to do so is substantial, both from the currently cultured species and from extending the range of species farmed to include, for example, cod, halibut and turbot, and several shellfish species such as European abalone (*Haliotis tuberculata*). The demand for cultured fish and shellfish tends to increase as the stocks and fisheries catches of wild species have declined.

The environmental impacts of mariculture represent a substantial threat to the environment and ecosystems (Wildish & Héral 2001; GESAMP 2001), and are mainly:

- The discharge of waste nutrients and organic material, and their interaction in the wider marine environment;
- Effects of other discharges from aquaculture, *e.g.* medicines and chemicals;
- Disease and pathogen impacts on wild and farmed stocks;
- Escapes from fish farms and potential effects on wild populations;
- Sustainability of feed supplies, particularly from capture fisheries.

All types of mariculture are liable to produce excessive amounts of nutrients and deposit organic material (e.g. overfeeding and wastage of food and production of faeces) in their vicinity, particularly in areas where there is poor flushing of the surrounding waters. This can lead to eutrophication (section 4.6.). For example, it has been estimated that about 7,500 tonnes of nitrogen and 1,240 tonnes of phosphorous were annually liberated into the marine environment from mariculture in Scotland in the late 1990s, comparable to the annual sewage inputs of about 3.2 million people in the case of nitrogen and about 9.4 million people in the case of phosphorous (MacGarvin 2000).

The proportion of escaped cultivated fish in Atlantic salmon populations has been high in coastal areas (ca. 30-50%) and in wild brood stocks in rivers. These proportions are highest in areas with high mariculture activity. As the number of cultured salmon in the NEASE is about 150 times the number of wild salmon, even a relatively small proportion of refugees represent serious threats (e.g. impairing gene pools, transferring parasites and diseases, competing for food and habitats) to wild populations that currently are at historically low levels.

There is often a high prevalence of pathogens and diseases in mariculture compared with wild stocks. Thus, inadequate control of mariculture stock movements facilitates the spread of internal and external parasites and diseases. Although disease control has markedly improved in fish farms in recent years, problems remain with some diseases, notably sea lice. Sea lice control has remained a general problem in commercial salmon cultivation, and is viewed as a threat to wild stocks of salmon and sea trout. In some coastal areas, the total number of sea lice on farmed salmon greatly exceeds that on wild salmonids. There is thus a need to control sea lice in salmon farms, both for husbandry purposes and to minimize the impacts on wild salmon and sea trout.

Other impacts of mariculture include the use of toxic and persistent chemicals, e.g. pesticides, antibiotics leading to resistant bacteria, impregnation of nets with copper. However, the ratio between the tonnage of fish treated with antimicrobials and the tonnage produced has declined by a factor of about 100 to small values since a maximum was reached in 1992.

The increase in finfish farming using fishmeal and fish oils from capture fisheries has caused concern regarding ‘fishing down the food chain’ when the majority of the major piscivorous fish stocks have been severely depleted.

There is increasing concern over the environmental impacts of intensive shellfish farming, notably benthic impact. In terms of water quality, it is generally accepted that shellfish aquaculture can be of benefit to the coastal system, particularly through biofiltration contributing to the minimization of eutrophication effects through the grazing of phytoplankton and sedimenting material with consequent improvements in water clarity. Thus, the grazing activity of shellfish can mitigate against other coastal activities that contribute towards nutrient enrichment. Combining the culture of filter-feeding bivalves and finfish is being investigated in this context. The deposition of faeces can impact on the benthos in a similar manner to the deposition of faeces and waste food from salmon farms, particularly where currents are weak.

Management and regulatory measures

The 1995 FAO Code of Conduct for Responsible Fisheries addresses the main issues of Aquaculture Development in Article 9, which was followed up by the publication of the 1997 FAO Technical Guidelines on Aquaculture Development drawing attention to various aspects of good practice in the industry.

Sustainable development of mariculture requires that the environmental impact of the industry be limited as much as possible. The environmental impacts of mariculture are recognized, but there has been a lack of international cooperation at the regional level to ensure that equivalent and effective measures are put in place to redress the root causes. Although various national measures have been established to attempt to redress the environmental impacts of mariculture, these are highly variable from country to country and not effectively coordinated on a regional basis.

Furthermore, the issue of the environmental impacts of mariculture has not yet received the full focus of intergovernmental conferences in the region as has fisheries and pollution. Connected with this, there is also a general scarcity of official information flowing into appropriate international bodies. For example, the OSPAR QSR 2000 noted that the lack of informative reporting by countries on the implementation of PARCOM Recommendation 94/6 concerning Best Environmental Practice for the Reduction of Inputs of Potentially Toxic Chemicals from Aquaculture Use had hindered an assessment of the measure. At present, there appears to be a lack of either a clear mandate and/or a will by regulatory intergovernmental bodies in the region to place the issue of environmental impacts of mariculture on the high-level agenda. The impacts of this sector, as with other human activities, need to be addressed in an integrated and comprehensive manner within the new EC Water Framework Directive.

Nevertheless, there is evidence that the various national regulatory authorities are tackling the impacts, most notably significantly reducing the use of chemicals and antibiotics. The use of in-feed treatments for disease or parasite infections has become more difficult to sustain because of the risk for transfer of such chemicals to wild biota, e.g. fish feeding on excess pellets and waste material. However, there has been a consistent pattern of reduction in the use of antibiotics in Norway, Ireland and Scotland, even though the production of fish has increased considerably. Nevertheless, the authorities are increasingly requiring that environmental impact assessments be conducted before licenses are granted for the cultivation of fish and shellfish. There is also a need for environmental monitoring programmes to be developed and implemented in and around mariculture sites in order to assess and control the various environmental impacts.

A number of national environmental monitoring programmes have been developed since the early 1990s for caged finfish (e.g. LENKA and MOM programmes in Norway; and monitoring programmes in Scotland and Ireland). However, these vary considerably concerning the range of parameters measured. Accordingly, there is a need to develop an internationally agreed set of statutory environmental quality objectives, and associated remedial measures, for the mariculture industry. The main elements of appropriate programmes should involve adjusting the local environmental impact of a fish farm to the holding or carrying capacity of a site. Parameters for investigation include tonnage produced, current speeds determining flushing, sedimentation rate, chemical condition of the sediment, benthic infaunal community, with consideration of impacted zones from local, intermediate, and regional levels. A general principle of the benthic monitoring is that an allowable zone of impact is acceptable and that outside this zone, typically in the region of 100 m from the farm, the benthic conditions must not differ from ambient conditions. Within the impacted zone, anoxic and afaunal conditions are not acceptable. While monitoring programmes are expensive, they are considered to be a necessity for regulatory purposes and to convince the public that the fish farming industry does not have a significant adverse impact on the environment as a whole.

Environmental monitoring programmes similar to those for fish farms currently do not exist for shellfish aquaculture, although the need to develop appropriate programmes has been identified, particularly in France, Scotland, and Ireland. There is general agreement that the focus of monitoring the impacts of shellfish farming on the environment should be on the benthos.

Several environmentally positive initiatives are being undertaken at the national level, including:

- Marine fish cultivation in recirculating systems;
- For land-based operations, depuration treatment of wastes is now widely applied with reservoirs where phytoplankton blooms occur that allow associated production of bivalve molluscs;
- Combining culture of filter-feeding molluscs (e.g. blue mussels) with fish to reduce eutrophication effects;
- Fallowing strategies in fish cage farming are increasingly being applied, firstly to break disease cycles, and secondly to allow a period of recovery of the benthic environment;

- Applying minimum distances between mariculture installations, to minimize the cumulative effects on the water column, on the benthos, and to reduce the risk of spreading parasites and diseases.

4.8 Agriculture

Impacts

Agricultural land accounts for more than 42% of the total land area of Europe, with highly productive agricultural systems in western Europe comprising intensive areas of field-crop farming (e.g. grains, cereals, vegetables), animal production (e.g. pigs, cattle), and fruit farming (OSPAR QSR 2000). The areas of intensive field-crop farming are dominated by large holdings concentrated around the North Sea in eastern England, northern Germany, and much of the Netherlands. Areas of very intensive agriculture specializing in animal production and/or fruit and vegetable farming are found in the coastal and areas of western Denmark, parts of Germany, the Netherlands, northern Belgium and Brittany (France).

Emissions and inputs from agriculture are a significant source of pollution in both the ocean and the atmosphere. There are considerable environmental impacts associated with agricultural activities, causing soil erosion, and a range of inputs and emissions of nutrients, methane and ammonia, and various contaminants in the form of pesticides including insecticides, nematocides, fungicides and herbicides (e.g. atrazine, carbofuran, TPT, DDT, dieldrin, aldrin, and lindane). However, the main types of pollution resulting are from nitrates and phosphates, ammonia, methane, pesticides, and run-off from silage and slurry/manure. Several of the atmospheric emissions contribute towards increased levels of 'greenhouse' gases and climate change. Losses of nutrients in the form of nitrates and phosphates from over-dosing with fertilizers and run-off from silage and slurry are a major source of eutrophication in coastal waters. There is also growing competition for water resources between agricultural systems, other users, and ecosystems.

The demand for water to support irrigated agriculture has led to the degradation and demise of wetlands and their associated wildlife for decades. Additionally, the drainage of wetlands in coastal areas for agriculture purposes has resulted in major reductions in the biodiversity of wetland fauna and flora.

Agricultural activities, particularly those associated with emissions to the air and water, can have significant effects many kilometres from their place of origin. There may also be inter-related impacts. For example, pollution that directly affects aquatic populations can indirectly influence recreational activities, and may have economic effects in the form of remedial water treatment and cleanup costs.

Despite various regulatory and management measures, agriculture from crop cultivation and animal husbandry remain the largest anthropogenic source of nutrients entering the sea in the NEASE.

Further information on the impacts of eutrophication and hazardous substances is provided in sections 4.6 and 4.9, respectively.

Management and regulatory measures

Due to significant impacts from inputs and emissions to the atmosphere, surface waters, ground waters, and finally into the marine environment, control of run-off and emissions from agriculture is a critical element in the immediate and long-term strategy to conserve marine biodiversity (OSPAR QSR 2000).

With the exception of Norway, the farming and agricultural production of the region is regulated according to the EC's Common Agricultural Policy (CAP). The CAP has resulted in the subsidized (35% of gross farm revenue between 1999-2001, source OECD) and considerable overproduction of food. As part of the proposals for the current reform of the CAP, the European Commission has recommended to 'decouple' subsidies and production and to direct a substantial proportion of the about EUR 40 billion CAP-spending towards environmental and rural development projects.

The EC Directive on the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC) provides for establishing codes of good agricultural practice, designation of vulnerable zones, and for programmes of action to reduce nitrate inputs to such vulnerable zones to be in place by the end of 1998. However, implementation of this Directive has been substantially delayed and accordingly the benefits have yet to be realized. Reductions in fertilizer use should also occur due to the EC 'set-aside' scheme and other measures aimed at reducing surplus production. Additionally, the EC Directive 79/117/EEC prohibiting the placing on the market place and use of plant protection products containing certain active substances, the EC Directive 91/414/EEC concerning the placing of plant protection products on the market, the EC Directive 96/61/EC concerning integrated pollution prevention and control, and the EC Directive 98/8/EC concerning the placing of biocidal products on the market, apply to agricultural activities. Furthermore, the implementation of the EC Water Framework Directive (2000/60/EC) is expected *inter alia* to provide another link between the management of activities in catchment areas and their effects in coastal waters.

The OSPAR Strategy to Combat Eutrophication includes a commitment to dealing with source-oriented approaches, including the promotion of good agricultural practice and ecologically based agriculture.

In order to further combat eutrophication from agriculture, the North Sea Ministers in 2002 (NSC 2002) have emphasized the following specific measures:

- Directly limiting fertilization to such amounts as required, given available nutrients in the soil and given the established nutrient demand of the crop, based on realistic and verifiable yield expectations for local conditions;
- Stimulating and promoting this approach in practice, training, education and advisory programmes and in research;
- Making every endeavour to reduce nutrient surpluses where coastal and marine waters are found to be eutrophic, or may become eutrophic, or where groundwater contains/could contain more than 50 mg/litre nitrate or where at lower concentrations there is a significant and upward trend;
- Promoting, where it embraces the above-mentioned management practices, organic farming and other strategies towards sustainable agriculture;
- Significantly reducing the use of fertilizers based on a broader and deeper application of agri-environment measures according to Council Regulation (EC) 1257/1999 on support for rural development from the European Agricultural Guidance and Guarantee Fund (EAGGF), or equivalent measures;
- Making use of strengthened 2nd nitrates action programmes or equivalent monitoring programmes;
- Making extensive use of the measures under the EU Agenda 2000 and further supporting an increased commitment to environmental measures in the review of the CAP, as well as including strengthening the integration of environmental objectives for the marine environment in the further development of national agricultural policies;
- Providing appropriate treatment facilities to remove nutrients, taking into account the catchment areas of eutrophic water bodies and water bodies that may become eutrophic if protective action is not taken, and paying special attention to fulfilling the requirements on nitrogen removal.

4.9 Hazardous substances

Impacts

The main efforts concerning preventing pollution from hazardous substances have been directed at substances that are persistent, liable to bioaccumulate and toxic (PBTs) or which have harmful properties giving rise to an equivalent level of concern (e.g. endocrine disrupters and substances that can damage immune systems) (Nilsen et al. 2002). In this context, chemicals that are both very persistent and very bioaccumulating (VPVB) are also being addressed. Both of these groups are of particular concern, since they will accumulate in the marine food chain and because, once discharged, they are practically impossible to remove from the environment. Some of the so-called Persistent Organic Pollutants (POPs) may be subject to long-range transport. Mixtures of such substances are also of concern, even at low concentrations due to their harmful, sometimes synergistic, effects on biota.

4.9.1 Metals

Heavy metals are naturally occurring and do not degrade, thus man made pollution above background levels in the environment can cause serious effects.

Dissolved copper can affect trophic levels such as phytoplankton, while cadmium, mercury, and lead can be toxic at levels that are only moderately above background levels. Filter-feeders and sediment feeders (e.g. shellfish), and top predators are at risk due to bioaccumulation. The effects are generally localized and are mostly found in estuaries and the coastal zone. In such affected areas, concentrations of metals in water and sediments may exceed ecological assessment criteria (EACs[12]) indicating concern for affects on plants and animals. Concentrations of cadmium, lead, mercury, copper and zinc exceed environmental quality standards (e.g. EACs) in the sediments and/or water of several estuaries and coastal areas, close to current or past inputs, in all countries in the NEASE. Several heavy metals travel long distances in the atmosphere causing transboundary pollution in other areas, e.g. the Arctic. Although inputs of metals to the NEASE have generally decreased, residues in the marine environment remain high and cause serious concern at regional and local scales.

4.9.2 Organic substances

In addition to the perverse intrinsic properties mentioned above, there is clear evidence that a range of natural and man-made substances (e.g. TBT and several other organometallic compounds, PCBs, dioxins, and certain pesticides, pharmaceuticals and industrial chemicals) can impair the reproductive process (e.g. through interfering with hormonal systems and causing 'imposex'[13] in snails and whelks) in aquatic organisms. These so-called 'endocrine disrupters' can have effects at very low ambient concentrations that are substantially less than those that are mutagenic and acutely toxic. Imposex disturbances have been registered in estuarine and coastal areas throughout the NEASE that have the greatest concentrations of shipping-related activities and the highest levels of TBT in sediments and biota.

PCBs (polychlorinated biphenyls) emitted and deposited since about the 1930s, are a diffuse source of pollution despite a ban on their production, use and marketing in the NEASE. PCBs are chemically stable and heat resistant, and the slow rates of decay and dissipation in the environment result in persistent residues. Accordingly, PCBs are easily bioaccumulated in the tissue of organisms and concentrated up the food chain. High levels have been found in many biota, particularly in the fatty tissues of piscivorous birds and marine mammals. PCBs can disturb behaviour, reproduction, and immune systems in seabirds, fish, and mammals (e.g. harbour seals in the Wadden Sea). PCBs can act as cancer promoters and cause birth defects. Concentrations in mussels exceeding the EAC have been reported at several localities throughout the NEASE. Despite these serious concerns, there is insufficient sampling and information to assess temporal and spatial trends in PCB residues in the marine biota (OSPAR QSR 2000).

PAHs (polycyclic aromatic hydrocarbons) found in the marine environment and biota arise from the domestic and industrial burning of fossil fuels, oil spills, emissions from offshore installations and shipping exhausts. Sediments are the most important reservoir of PAHs in the sea, with concentrations in sediments often exceeding EACs in a number of estuaries in the North Sea. PAHs are not as liable to bioaccumulate or biomagnify as organochlorine compounds (e.g. PCBs). However, PAHs can form carcinogenically active metabolites and accumulate in sediments. There is a risk of liver tumours and related pathogenic conditions

[12] Ecological Assessment Criteria: concentrations of specific substances in the marine environment below which no harm to the environment or biota is expected. EACs refer primarily to acute toxicity, and their derivation does not include bioavailability under field conditions, the degree of bioaccumulation, carcinogenity, genotoxicity, and hormone balance disturbances (e.g. endocrine disruption).

[13] Imposex is the development of the sexual characteristics of the other sex.

occurring in North Sea flatfish due to pollution from PAHs and possibly chlorinated hydrocarbons (see section 3.4). Recent data shows that the toxicity of PAHs to marine biota may be increased due to exposure to ultraviolet light, drawing attention to a potential effect of ozone reduction in the atmosphere.

Organochlorine pesticides (e.g. DDT) and their metabolites found in the marine environment mainly arise from diffuse water and atmospheric inputs resulting from use in agricultural activities, and from transboundary pollution outside the NEASE. Most of these can affect the nervous system and the liver, and several interfere with reproduction. Although use of most such pesticides has been phased out, concentrations of DDE (a breakdown product of DDT) still exceeds EACs in mussels and fish in some areas. In general, levels of organochlorine pesticides in the marine environment are decreasing and restricted to local situations. However, the identification of elevated toxaphene residues in biota (e.g. fish liver, marine mammal blubber) in the North Sea and the Irish Sea/Bristol Channel has raised concern.

A large number of chemicals that are either known to be hazardous or for which the intrinsic effects are largely unknown are still entering the marine environment. Additional persistent organic substances, identified for action by OSPAR, are not yet included in any OSPAR long-term monitoring programmes. These substances include brominated flame retardants, chlorinated paraffin's, synthetic musks, additional known endocrine disrupters, and dioxins that are not manufactured but are produced as combustion by-products, or during the production of certain chlorinated chemicals and pulp bleaching.

Management and regulatory measures

The presence of high concentrations of metals and man-made substances in seafood has for a long time been recognized as posing threats to human consumers. Accordingly, countries have established monitoring programmes for contaminants in seafood to ensure human safety. However, only in some cases has the impact of contaminants on populations and communities of marine biota been measured directly in the OSPAR area. The effects on biota can be expected in areas where EAC limits in sediments and water are exceeded, especially if the registered concentrations are above the upper EAC limits. Such areas have been registered for the water and sediment compartments. However, it is emphasized that the system of EACs is currently sparse, e.g. only provisional EACs exist for heavy metals in sediments, and EACs for biota are still lacking.

Although there is evidence of decreasing levels of input of many of the traditional hazardous substances, attention has been drawn to the discharge into, and detection in, the NEASE of a large number of more recently produced man-made compounds for which the ecological effects are largely not known (Nilsen *et al.* 2002). Although the use of most organochlorine pesticides was phased out sometime ago (e.g. DDT since 1979 under Council Directive 79/117/EEC), they are still manifest in the marine environment due to their extreme persistence, illegal use or use in other regions.

In 1998, OSPAR adopted a Strategy with regard to Hazardous Substances (OSPAR Ref. No. 1998-16). The aims of this Strategy are to prevent pollution in the maritime area by continuously reducing discharges, emissions and losses of hazardous substances in order to eventually achieve concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances. A timeframe has been set to move towards the cessation of discharges, emissions and losses of hazardous substances by 2020. This Strategy has also been incorporated into the OSPAR Strategy for the offshore oil and gas industry.

The main elements of the 1995 Esbjerg Declaration's (NSC 1995) one generation cessation target[14] were taken onboard in OSPAR's Strategy with regard to Hazardous Substances, the EC Water Framework Directive and the EC's new Chemicals Policy. There have been substantial reductions in discharges and

[14] One generation target: the agreed objective of achieving the cessation of discharges, emissions and losses of hazardous substances by the year 2020.

emissions of many priority substances since 1985, but there is still a long way to go to reach a complete cessation or phase out. The "one generation" target has been given increased importance due to its recognition within OSPAR and the EU. Progress also includes further achievements in meeting the 50% and 70% reduction targets established or confirmed by the London (1987), Hague (1990) and Esbjerg (1995) Declarations, and additional limitations on the marketing and use of some of these substances. In the NEASE, 50% reduction targets have been met for a large number of the particular substances. For some substances, the targets have not been reached by 2002 by all countries, particularly for copper, nickel, zinc, TBT-compounds, trichlorethylene, and the pesticides dichlorvos, malathion, and trifluralin. Where information is available, it is concluded that most countries have achieved the 70% reduction targets for mercury, lead, cadmium, and dioxins.

In 2000, a concept similar to the one generation target was integrated into the EC Water Framework Directive (2000/60/EC). The directive introduces the concept of a combined approach, whereby the reduction (and for some substances cessation) of discharges, emissions and losses of hazardous substances is achieved through a mutually reinforcing combination of (i) setting environmental quality objectives and (ii) adopting control measures on emissions and products. The one generation cessation target concept addresses specifically a group of chemicals designated as "priority hazardous substances". The directive requires the cessation or phase-out of discharges, emissions and losses of these substances within 20 years of the adoption of the relevant measures. A list of priority substances, including the "priority hazardous substances", has recently been adopted, together with a time schedule for the development of cost effective and proportionate control measures for these substances and a system for updating the list. The adoption of the one generation target for the "priority hazardous substances" identified under the Water Framework Directive will ensure that the resulting measures from the directive will be legally binding.

A new EC Chemicals Policy has been outlined in a recent white paper (COM(2001) 88). The new policy intends that, within one generation (2020), chemicals are only produced and used in ways that do not lead to a significant negative impact on human health and the environment, which is also in line with the Water Framework Directive and with commitments undertaken in international forums. The white paper also proposes a common regime for the registration, evaluation and authorization of new and existing substances and foresees a shift in the burden of data generation and evaluation from regulators to producer and user industries. A new legal instrument is planned to support the policy.

OSPAR and the EC have developed prioritization mechanisms for selecting the substances of greatest concern to the aquatic environments (e.g. List of Chemicals for Priority Action), and both have priority lists containing about 30 chemicals for which measures are being developed with the aim of meeting the one generation target or the corresponding aims of the Water Framework Directive, respectively. PBT-substances are also addressed under various EC priority lists on dangerous substances and pesticides. OSPAR has been requested to develop an effective and efficient monitoring and assessment process for the chemicals selected for priority action, in order to demonstrate publicly, clearly and transparently whether and how progress towards the cessation of discharges, emissions and losses is being achieved. The monitoring and assessment process should draw on the experience gained in the implementation of the Water Framework Directive and with the application of the newly developed Harmonized Quantification and Reporting Procedure for Hazardous Substances (HARP-HAZ prototype). It should provide for periodic assessment of progress for the chemicals selected for priority action towards the "one-generation" target, and the publication of such assessments.

EU/EEA Member States are required to ensure that all large industrial installations comply with the Integrated Pollution Prevention, Control (IPPC) Directive involving *inter alia* the development of BAT reference documents (BREFs), and an integrated permitting system for large point sources will be introduced by 2007.

The principle of substitution of hazardous substances with safer and preferably non-hazardous alternatives or the use of alternative processes has been established as an important tool for risk reduction and risk management. However, new initiatives on substitution are needed to address concerns about products, processes and diffuse sources. In order to make rapid progress, it is important to involve all other stakeholders including the industries concerned, environmental non-governmental organizations and representatives of consumers. Additionally, information must be made available to all users, especially consumers, on the hazards and risks to human health and the environment from hazardous substances, and to the presence of such substances in consumer products so that an informed choice may be made on purchase and use. Furthermore, integrated product policies (IPP) should be established to minimize hazards and risks throughout the production, use and disposal of products (including waste minimization and increased re-use or recycling. Safer alternatives to hazardous substances should continually be sought, and vigorous efforts should be made to facilitate the identification and development of such safer, and preferably non-hazardous alternatives where they do not currently exist. Important implemented IPP instruments are eco-labelling systems and support for the develop of eco-designed products.

It is anticipated that the EU should use the criteria and principles established for hazardous substances in the evolving EC Chemicals Policy in its forthcoming review of pesticides legislation. The LRTAP POPs protocol and the Stockholm Convention on Persistent Organic Pollutants should be ratified as soon as possible, and these instruments should be applied to pesticides as well as to other chemicals that meet the criteria established in these instruments. The application of OSPAR Recommendations 2000/1 (agricultural use of pesticides) and 2000/2 (amenity use of pesticides) by pesticide-users should be promoted in the EU/EEA States, recognizing the contribution to be made by organic agriculture to reducing pesticide use. The EU should accelerate and complete the review within the framework of Directive 91/414/EEC of the 19 pesticides given in Annex 2, Appendix 1 of the Esbjerg Declaration that have been detected in or pose risk to the marine environment.

The HARP-HAZ reporting format used for the 2002 5NSC allowed improved reporting on emissions to air and discharges to water from an extensive number of diffuse and point sources (Nilsen *et al.* 2002). An advantage of the new reporting procedures is the provision of substance-specific source profiles (patterns) for the various reporting years and allowed the identification of the remaining sources. However, there is a clear demand for data on sources for emissions and releases of substances to improve the standard of reporting on the one generation target. The implementation of the Convention on Access to Information, Public Participation in Decision Making and Access to Justice in Environmental Matters (Århus Convention), on the right to environmental information, will place emphasis on the need to know concerning the pressure on the environment from hazardous substances.

4.10 Radioactivity

Impacts

Present day levels of radioactive substances found in the marine environment are influenced by current management but also by past disposal practices. The sources of such radioactivity include managed discharges from nuclear power and reprocessing facilities, fallout from atmospheric nuclear weapons testing, fallout from accidents such as from Chernobyl, and other processes involving the use of radioactivity (e.g. nuclear medical diagnosis and therapy) (Nilsen *et al.* 2002). A wide variety of naturally occurring radionuclides has also been released into the marine environment by human activities such as oil exploration, phosphate production and land-based mining. Ionizing radiation also results from naturally existing background sources (e.g. the Earth's crust, cosmic rays).

4.10.1 Artificial radionuclides

Before 1967, a number of shallow marine sites were used for the disposal of relatively small amounts of radioactive wastes in a manner that was not coordinated. Subsequently, disposal of such wastes at sea was coordinated by the Nuclear Energy Agency (NEA) in deeper waters until a global moratorium on radioactive waste disposal at sea was brought about in 1983 by the London Convention. All Contracting Parties to the 1992 OSPAR Convention now accept a legally binding ban on the dumping of radioactive substances, including wastes, through the coming into force of OSPAR Decision 98/2.

A 1985 OECD report on the main dumpsite at sea concluded that it posed negligible human radiological risk. However, the lack of baseline data on benthic organisms makes it hard to draw conclusions about environmental impacts. Several OSPAR Contracting Parties have expressed concern about the termination of surveillance of the former radioactive dumpsite.

Fallout of caesium-134 and caesium-137, mainly from the 1986 Chernobyl accident, contributed to radionuclide contamination in the NEASE region.

Currently the main sources of anthropogenic radionuclides in the region are discharges from nuclear power and reprocessing plants at Cap de La Hague in France on the Channel coast and Sellafield in the UK on the Irish Sea coast (OSPAR QSR 2000; Nilsen *et al.* 2002). Considerable public interest surrounds the levels of the radionuclides discharged from such installations. Discharges of radionuclides are transported from the Irish Sea and the Channel into the North Sea. Concentrations of artificial radionuclides in sediments and biota are generally low except near the discharge outlets. However, discharges of some radionuclides have been detected at low concentrations in seaweeds, shellfish and other wildlife as far away as in the Norwegian Coastal Current, the Barents Sea and beyond.

The discharges of most radionuclides from Sellafield and La Hague have been reduced significantly in recent years but there have been important exceptions. Between 1993 and 1996, discharges of iodine-129 (^{129}I) from La Hague increased from 0.65-1.69 TBq following commissioning of a new reprocessing operation. At Sellafield, releases of the actinides and ruthenium have decreased, but between 1993 and 1996 there have been increases of technetium-99 (^{99}Tc) from 6-150 TBq and ^{129}I from 0.16-0.41 TBq. Re-mobilization of the actinides and caesium-137 (^{137}C) from seabed sediments in the Irish Sea has resulted in continued export of these radionuclides through the North Channel into the North Sea.

With the exception of one year, the discharges of total alpha activity from nuclear installations in the OSPAR States (mainly situated around the North Sea and the Celtic Seas) during the decade ending 1999 have shown a decreasing trend falling to an approximately constant level of 10% of that discharged at the start of the period. During the same period, a clear decreasing trend was not observed for the discharge of total beta emitting radionuclides (excluding tritium, ^{3}H). Tritium releases, although quite large, are of minor radiological significance.

4.10.2 Natural radionuclides

Inputs of natural radionuclides mainly originate from anthropogenic activities, such as mining and ore processing, and burning coal, oil and natural gas in power plants, and the production of phosphate fertilizers. The latter is the most important non-nuclear industrial process resulting in the discharge of radionuclides into the marine environment, due to the discharge of phospho-gypsum waste into the sea in the OSPAR countries. Discharges of phospho-gypsum have tended to decrease in recent years and this is expected to continue due to the reduced production of phosphoric acid by European countries as well as the increased land-based storage of waste products.

Management and regulatory measures

Generally, as noted in the OSPAR QSR 2000 for Region II, inputs of radionuclides from land are considered to be in the 'lower intermediate impact category' in terms of the full range of human pressures on the North Sea and their respective priorities. All discharges comply with the regulatory requirements, and the doses for critical human groups are significantly lower than the limits allowed in EU legislation. This legislation builds on recommendations from the International Commission on Radiological Protection (ICRP).

International radiological protection has historically focussed on the protection of man with the view that if man is adequately protected then other living organisms are also likely to be sufficiently protected. However, there has been increasing focus in recent years on protection of the marine environment from possible detrimental effects of ionizing radiation, with questions arising as to whether the principle of protecting man is sufficient for protection of the environment. Currently the impacts of radionuclides on marine wildlife have not been assessed, and there are no internationally accepted radiological criteria for the protection of marine flora and fauna.

In 1994, OSPAR agreed - through PARCOM Decision 94/8 - that greater emphasis should be devoted to assessing biological and ecological effects in the marine environment arising from existing and foreseen discharges of radioactive substances. OSPAR adopted in 1998 a Strategy with regard to Radioactive Substances that provides for progressive and substantial reductions of discharges, emissions and losses of radioactive substances, and a programme for a more detailed implementation of the strategy. The strategy requires *inter alia* that national plans are implemented with a view to organize a progressive decline in discharges. Within the framework of the OSPAR strategy, it is important to develop environmental quality criteria for the protection of the marine environment (including fauna and flora) from adverse effects of radioactive substances with a view to reporting on progress by 2003. In this context, it is pertinent to note that the ICRP has established a working group to consider a need for guidelines and criteria to focus on the environment, and is in the process of reviewing its position on environmental protection.

Concern has been expressed about potential accidents during the transport of radioactive material by sea, and the need to protect the environmented, human health, and to address socioeconomic implications (e.g. NSC 2002). The 2001 General Conference of the International Atomic Energy Agency has called for further efforts to examine and improve measures and international regulations relevant to the international maritime transport of radioactive materials. The importance has also been stressed of having effective liability and indemnification mechanisms in place.

4.11 Oil and gas industry, and offshore installations

Impacts

Impacts on the environment from the oil and gas industry, and offshore installations in the NEASE region are numerous (Patin 1999; OSPAR rQSR II 2000; OSPAR rQSR III 2000; OSPAR rQSR IV 2000; Nilsen *et al.* 2002), and arise from transportation, placement of structures on the seabed, discharges to the sea, emissions to the atmosphere, accidental spills of oil and chemicals, and acoustic disturbance.

The growing demand for oil and gas has lead to substantial oil and gas activities in the NEASE, especially in the North Sea and Irish Sea areas. However, there are currently no oil and gas activities in the Bay of Biscay part of the NEASE.

The major developments in the offshore oil and gas industry have mainly taken place in the northern North Sea in Norwegian and UK waters, while gas production primarily occurs in the shallower southern regions in the Danish, Dutch, and UK sectors, as well as in Norwegian waters. A network of pipelines connects the major fields to the markets. In general, the larger oil fields have been developed with concrete and steel platforms as production facilities. Smaller finds are often developed as satellites to larger fields, with smaller platforms or with sub-sea installations.

In the first half of the 1990s, the number of offshore platforms and oil production almost doubled, mainly due to increased activity in the Norwegian and UK sectors. There are several gas and oil production platforms in the Wadden Sea.

In the Celtic Seas, offshore gas production started in 1985, but the Kinsale and Ballycotton fields are not expected to last more than about a decade. Exploration drilling occurs in the Irish Sea, Celtic Sea, and Bristol Channel. In 1990, oil was discovered in Liverpool Bay. After oil discoveries west of Shetland and developments in technology needed to exploit deeper water areas, there has been renewed interest in exploration off the west of the Hebrides. Oil exploration and production continues to move into previously unexploited deeper areas off the continental shelf.

In the early stages in the development of an oil field, the source of most significant environmental impact is discharges of drill cuttings to the seabed. Later, production discharges to the sea and atmosphere become the major impact sources. Decommissioning of installations may pose particular problems concerning the disposal of platforms, sub-sea structures, pipelines and cables.

The earliest impacts of oil and gas activities were detected on the seabed near the platforms, due to discharges of drill cuttings contaminated with oil-based drilling fluids. Cuttings piles under older installations, resulting from drilling with oil-based drilling fluids, may continue leaking oil and chemicals many years after the cessation of drilling.

Recently, produced water from oil and gas production has caused grounds for concern as it constitutes the largest and increasing source of oil-related inputs as reservoirs in many oil fields produce higher amounts of water in ageing. Produced water contains *inter alia* salts, hydrocarbons, heavy metals, together with production chemicals and well completion and well cover chemicals. Compared with drilling discharges, knowledge about the environmental impact of produced water is very limited. There is a particular concern that PAHs may accumulate in organisms such as mussels up to 10 km from the nearest produced water discharge sites.

For zoobenthos, the general response patterns to the effects of drilling discharges are quite well known and appear to be universal. At modest contamination levels, subtle changes in the macrofauna community patterns (e.g. species composition and abundance) may be detected. With stronger impact, there is a decrease in species richness and diversity. Certain sea urchins and brittle stars characteristic for large areas of the North Sea are highly sensitive to drilling-related contamination, and tend to disappear with increased proximity to drilling installations. Other opportunistic species prosper in the absence of competition from the more sensitive species, and increase the abundance of macrofauna, but further reduce biodiversity, close to installations. Subtle macrofauna changes have been detected up to 5 km or more from platforms.

Monitoring of both chemical concentrations and biological effects at offshore sites should continue to build a better database on long-term ecological change in the peripheral zone round the platforms.

The nature and scale of impacts from the process of flaring need to be established.

There are at present no official and quality assured data on the use and discharges of the most harmful chemicals (as defined by OSPAR) from offshore activities, although preliminary data were presented at the OSPAR Offshore Industry Committee (OIC) meeting in 2001.

The environmental problems connected with discharges of oil, heavy metals and PAHs are further described under section 4.9 (Hazardous Substances) and section 4.12 (Shipping).

Management and regulatory measures

Reducing discharges of oil on cuttings and in produced water, and the discharge of chemicals

At the 1995 4NSC, the Ministers expressed continued concern for the effects of oil discharges on the marine environment and asked that reduction efforts should be continued.

PARCOM Decision 92/2 on the use of Oil-Based Muds has had a significant effect on phasing out the input of oil from this source. Oil-based drilling fluids are, however, still used but since January 1997 oil-contaminated cuttings are now either brought ashore for treatment or injected into suitable seabed formations.

OSPAR Decision 2000/2 on the Harmonized Mandatory Control System for the Use and Reduction of the Discharges of Offshore requires pre-screening, ranking, and risk assessment of chemicals and the substitution of certain chemicals by less hazardous alternatives.

OSPAR Recommendation 2001/1 anticipates a national total reduction of discharges of oil in produced water by a minimum of 15% by 2006 compared with the reference year 2000. By the end of 2006, no individual offshore installation should exceed a performance standard for dispersed oil of 30 mg/litre for produced water. Prior to the introduction of OSPAR Recommendation 2001/1, the input of oil from produced water was predicted to continue increasing even if the oil content is currently well below the performance standard of 40 mg dispersed oil/litre adopted by OSPAR in the early 1980s and is generally below the revised standard of 30 mg dispersed oil/litre that will come into force in 2006.

OSPAR Decision 2000/3 on the Use of Organic-Phase Drilling Fluids (OPF) and the Discharge of OPF Contaminated Cuttings, entered into force formally in 2001, and prohibits the discharge of oil-based muds and cuttings contaminated with oil-based mud residues. Cuttings may only be discharged when the concentration of residual drilling fluid is less than 1%. There are no practical techniques available offshore for attaining this level. Furthermore, there is a presumption against discharging cuttings contaminated with synthetic drilling fluids. The Decision defines ‘exceptional circumstances’ whereby a discharge is permitted and Contracting Parties are obliged to inform OSPAR of such discharges.

OSPAR is collecting information on concentrations of aromatic hydrocarbons in produced water, techniques for the analysis of aromatic hydrocarbons, and Best Available Techniques (BAT) and Best Environmental Practice (BEP) for the reduction of these substances in produced water. The aim is to propose performance standards in 2003 and a timeframe for meeting the performance standards.

Cuttings piles are believed to contain a mixture of all the chemical and additives discharged with the cuttings over time. There is currently a strong initiative from the authorities and oil industry in the UK and Norway to generate information necessary for an environmentally sound management of these deposits.

The decommissioning of offshore installations

As an increasing number of installations will reach the end of their productive life in the near future, their removal and the handling of the waste deposits on the seabed is imminent.

OSPAR Decision 98/3 on the Disposal of Disused Offshore Installations prohibits the dumping, and leaving wholly or partly in place, of disused installations within the OSPAR Maritime Area. However, subject to agreed assessment and consultation procedures, derogations to the general ban are possible for the footings of a large steel installation, concrete installation or other installation in exceptional circumstances.

The 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention 1972), *inter alia* stipulates that platforms or other man-made structures at sea may be considered for dumping. The 22nd Consultative Meeting of Contracting Parties to the London Convention 1972 (September 2000) adopted Specific Guidelines for Assessment of Platforms or Other Man-

Made Structures at Sea, which also require the assessment of disposal options other than dumping at sea.

Implementing management systems

In 1999, OSPAR adopted a Strategy on Environmental Goals and Management Mechanisms for Offshore Activities in order to prevent and eliminate pollution and take the necessary measures to protect the maritime area against the adverse effects of offshore activities, so as to safeguard human health and to conserve marine ecosystems and restore marine areas that have been adversely affected.

Health, Safety and Environmental (HSE) Management Systems have become an integral part of the daily operation of the offshore industry. The model of the HSE management systems under implementation in the North Sea is consistent with that contained in the International Organization for Standardization's (ISO) 14,000 series and the Eco-Management and Audit Scheme (EMAS).

Besides highlighting management measures, vigorous efforts should be made to develop existing and as well as new measures to ensure that offshore oil and gas activities do not cause continuing pollution of the marine environment. It is anticipated that all other appropriate OSPAR strategies apply similarly to the offshore sector.

4.12 Shipping

Impacts

The environmental impacts of shipping include large-scale coastal developments for port facilities, dredging and disposal of sediments for navigational purposes, the transfer of non-indigenous species by ballast water discharge and hull fouling, the release of oil, the inputs of hazardous substances through tank-cleaning, burning of fuel releasing waste products such as sulphuric and nitrous oxides and carbon dioxide, losses of antifoulants (e.g. TBT) containing biocides, discharge of wastewater and garbage, collisions, loss of ships through mechanical failure or bad weather, the loss of cargo (50% of goods carried at sea can be described as dangerous), and dumping of litter (OSPAR QSR 2000; Nilsen *et al.* 2002).

Maritime accidents may result in harm and death to marine life, especially seabirds and benthos in shallow water and shore areas, and occasionally to humans. About 50% of goods carried at sea can be described as dangerous. Unintentional pollution at sea may cause explosions, collisions, groundings, and damage and breakdowns to ships. Of the shipping accidents involving pollution of the sea recorded in the OSPAR area, it has been estimated that more than 50% occurred in the North Sea.

In the main ports of the NEASE, an estimated 500,000 vessel movements occur annually. Most of Europe's largest ports are situated on the North Sea coasts (e.g. Hamburg, Bremen, Amsterdam, Rotterdam, Antwerp, Le Havre, and London), and the North Sea has some of the world's busiest shipping routes.

After a stakeholder consultation process conducted in 2002, the European Commission has published a survey of several major pollutants emitted from ships in EU waters. The survey reveals that NO_x and SO_2 levels could reach a volume equal to over half of all land-based emissions by 2010, and that the majority of NO_x, SO_2, CO_2, hydrocarbons and particulates emissions are concentrated in the North, Baltic and Mediterranean Seas. The survey findings will be used in the preparation of an overall strategy for the reduction of air pollution from ships, including proposals for legislation.

Ship's traffic continues to increase both globally and regionally as world trade and the supporting industries expand. For example, in the decade before 1995, worldwide transport of crude oil increased by about 60% in tonnage and by about 85% in tonne-miles. Of the crude oil transported by sea, about 26% was either destined for or shipped from northwestern Europe. Substantial increases in other shipments, such as of commodities by bulk carrier, also occurred in the area. For example, container transfer in the main North Sea ports has increased by over 100% in the last decade.

About 50% of the North Sea's shipping movements consist of ferries and roll-on/roll-off vessels on fixed routes.

Management and regulatory measures

In the OSPAR maritime area as a whole, in accordance with agreements and legislation, discharges of oil from bilges and engine rooms should not give rise to visible oil at the sea surface. The so-called North West European Waters - comprising the North Sea and the seas around Ireland and their approaches - received the status of a Special Area under MARPOL Annex I (oil) in 1999, prohibiting the discharge of oily cargo residues into the sea from oil tankers. The IMO agreed in 2002, subsequent to an application by the 9th Trilateral Governmental Conference on the Protection of the Wadden Sea, to the designation of a Particularly Sensitive Sea Area (PSSA) in the Wadden Sea. The IMO guidelines allow the declaration of a PSSA for sea areas that need special protection because of their ecological importance and their sensitivity to threats from shipping. PSSA status is meant to avoid or reduce accidents, intentional pollution and damage to habitats. Because PSSAs are marked on sea charts, the crews of ships are expected to be particularly careful. Upon request by the countries concerned, the IMO can also decide on special measures, e.g. restricted areas, traffic separation areas, coastal traffic and deep water areas, special rules for waste disposal, compulsory pilotage, mandatory reporting or ship traffic management.

There is a need for full implementation of the provisions of the International Convention on the Control of Harmful Antifouling Systems on Ships adopted in 2001. Due to the serious effects of tributyltin (TBT) causing imposex of whelk populations, a mechanism for a general ban on the use of organotin compounds (e.g. to counter hull fouling) has been decided through the IMO. A ban on any new application of TBT as a protective coating will be mandatory (IMO Resolution) by January 2003, with a total ban on the use of TBT by January 2008. The control on other TBT applications has been improved through the revision of the EC's Council Directive 76/769/EEC. Furthermore, the European Commission adopted in 2002, effective 1 January 2003, an EU ban on the application of TBT-based antifoulants in advance of the entry-into-force of the IMO Convention that would ban the application and use of all organotin-based antifoulants globally. However, the EU action will cover only a small proportion of the commercial vessels that operate in Community waters. The alternatives to TBT need to be carefully evaluated regarding both their toxicity and their capabilities to prevent fouling and potential introductions and transfers of alien species. A strategy needs to be developed for the further reduction of the harmful effects of other antifouling systems.

Through the IMO framework, traffic separation schemes (e.g. shipping corridors in several regions of the North Sea) have been introduced to reduce the risk of accidents.

The IMO has adopted *voluntary* guidelines under a) Resolution A.774(18) entitled 'International Guidelines for Preventing the Introduction of Unwanted Aquatic Organisms and Pathogens from Ships Ballast Water and Sediment Discharges', and b) Resolution A.868(20) the voluntary IMO 'Guidelines for the Control and Management of Ship's Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens'. Resolution A.868(20) provides a useful global instrument for ballast-water management purposes.

IMO is now working towards completion of a self-standing International Convention for the Control and Management of Ships' Ballast Water and Sediments and associated guidelines. The Convention is expected to be adopted in 2003 and will be *mandatory*, i.e. legally binding. The developing IMO Convention will apply to all ships engaged in *international traffic* that carry ballast water. However, ships vary in their capability to undertake ballast management measures, and those that rely on ballast exchange at sea may be unable to complete the process during the voyage or in the prevailing weather conditions. A ship on a coastal voyage may encourage the spread of non-indigenous organisms by exchanging ballast water near to shore. There is a need for additional national and regional measures such as monitoring programmes, information exchange, early warning systems, combating actions, control and enforcement. Research should be actively supported on the development of treatment technologies, decision support systems, and other issues related to preventing the spreading of non-indigenous organisms via ships ballast water and sediments.

As a substantial 'pool' of alien species is already present in the NEASE, effective measures are required to limit unintentional and unwanted introductions into regional or local waters. According to a 1997 OSPAR IMPACT report (OSPAR 1997) only one out of 12 Member Countries has some kind of practice in place to minimize the risk of unintentional introductions via ship's ballast water, and for that country under 25% of the ports known to receive ballast water have either local policies or require compliance with the IMO Guidelines. Regarding minimizing the risk of negative effects of introductions via aquaculture, only six countries reported that the ICES Code of Practice (ICES 1995) is applied while two countries reported that although the Code is applicable the extent to which it is actually used is uncertain. Most countries do not have explicit national ballast water requirements.

There is a need to raise awareness of liabilities connected with shipping in order to better protect environmental damage from accidents at sea (Nilsen *et al.* 2002; NSC 2002). This includes actively supporting the 1996 HNS[15] Convention together with the Protocol of 1996 to Amend the Convention on Limitation of Liability for Maritime Claims, 1976. However, there is a need to actively review, strengthen and introduce further appropriate compensation and liability regimes. This includes further developing the International Fund for Compensation for Oil Pollution Damage (IOPC), in order to establish appropriate compensation for the cost involved in restoring environmental damages.

Greater cooperation is necessary at the national and EU levels to enforce the internationally agreed rules and standards for the prevention, control and reduction of pollution from ships and the need to increase detection of illegal discharges, as well as the need to improve the investigation and prosecution of offenders. This includes initiatives to create a network of investigators and prosecutors to improve the understanding of cooperation in the different stages of the enforcement process.

Support should be given to revising Annex II (chemicals) to MARPOL 73/78, including strengthening of the discharge requirements for all generations of chemical tankers.

The European Commission aims to develop a community strategy to reduce air pollution from ships.

Although a decision has been made to designate the North Sea as a sulphur-emission control area under MARPOL Annex VI, there is a need to participate more actively in international forums (e.g. IMO) on mitigating the impact of shipping on climate change. This includes rapidly bringing into force MARPOL Annex VI and working to strengthen the global cap for sulphur content in marine fuel oil towards 1.5%, and strengthening the IMO NO_x requirement. Regional mechanisms, including economic instruments, should be developed and implemented to reduce air pollution from shipping as a supplement to the IMO regime on air pollution.

Potentially polluting wrecks should be cleaned-up or removed, particularly where they hamper or endanger other legitimate uses of the sea. In this context, IMO is working to finalize the development of an International Convention on Wreck Removal aiming at its adoption in 2004/2005. There is a need to making ship recycling an environmentally sound activity, and to adopt appropriate international safety and environmental measures regarding dismantling and recycling of ships (e.g. IMO, Basle Convention).

New approaches and mechanisms are needed to minimize the impact of shipping on the environment, including further developing the concept of vessels designed, constructed and operated in an integrated

[15] HNS: International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea 1996.

manner to eliminate harmful discharges and emissions throughout their working life (the IMO "Clean Ship" approach).

Economic or other incentives should be introduced in order to improve the environmental performance of shipping, by rewarding quality ships and as far as possible harmonize such incentive schemes, and to promote this concept internationally (e.g. within IMO). Programmes should be initiated to improve the environmental awareness of the maritime community, for example by introducing marine environmental awareness courses.

4.13 Military activities

Impacts

In peacetime, military operations account for only a small part of sea-borne and coastal activities (OSPAR QSR 2000). Three types of military activities, mainly conducted by the various navies, may affect the conservation of marine environments and coastal zones: port activities, construction and maintenance of the fleet, disposal of weapons and munitions, and manoeuvres and firing exercises.

Substantial quantities of arms and munitions - including considerable quantities of chemical warfare materials - have been disposed of at sea in the NEASE at the end of World Wars I and II (Anon. 1989; NSTF 1993; OSPAR QSR 2000). Examples of such disposals occurring shortly after two World Wars are found at the location 'Paardenmarkt' off the Belgian coast, in the Skagerrak, in the Channel, and off the southeast coast of the UK. Munitions (e.g. phosphorous incendiary devices) disposed of in a deep trough (Beaufort's Dyke) in the North Channel between Northern Ireland and Scotland are washed up on beaches along the east of Ireland, the Isle of Man, and the west of Scotland and present a hazard to the public. It is not possible to determine what materials and quantities were deposited in or around the designated disposal area.

Military activities in peacetime can disturb wildlife and interfere with other uses of the involved areas. However, some military areas that are less disturbed may become wildlife havens or conservation areas.

Management and regulatory measures

OSPAR is considering measures to deal with dumped munitions.

4.14 Climate change

Impacts

A number of events underline the earth's changing climate. The 2001 Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has, for example, emphasized that the rate and duration of warming in the 20th century was greater than in any of the previous nine centuries, and the average surface temperatures have increased by 0.6^{o}C during the 20th century with the last two decades having been the warmest for the past 1,000 years. The IPCC emphasizes that increases in human emissions, such as greenhouse gases, are contributing substantially to global warming. These changes place human systems as well as the natural environment and biodiversity under stress (IPCC 2002).

The sea level is rising, precipitation patterns are changing and extreme weather events such as floods, droughts, soil and coastal erosion, and heat waves are becoming more common. The Arctic ice is rapidly melting. Work by the IPCC using circulation models predict that by 2100 the surface air temperatures of the North-East Atlantic will have increased by about 1.5^{o}C. Sea level will have risen between 0.25 – 0.95 m, mean precipitation will have risen and there will be an increased frequency and intensity of extremes such as storms. Prognoses suggest that precipitation in European high latitudes will increase, and water supply may be affected by floods in northern Europe and by droughts in southern Europe.

Climate change may affect exposures to air pollutants by affecting weather, anthropogenic emissions, and biogenic emissions and by changing the distribution and types of airborne pollutants. Local temperature, precipitation, clouds, atmospheric water vapor, wind speed, and wind direction influence atmospheric chemical processes, and interactions occur between local and global-scale environments. If the climate becomes warmer and more variable, air quality is likely to be affected. However, the specific types of change (i.e. local, regional, or global), the direction of change in a particular location (i.e. positive or negative), and the magnitude of change in pollution levels that may be attributable to climate change are a matter of speculation, based on extrapolating present understanding to future scenarios.

UV-B radiation levels are predicted to increase due to reduction in the thickness of the ozone layer, and may cause damaging effects on all biota including humans.

The predicted large-scale impacts of climate change on the oceans are expected to affect the structure and productivity of ecosystems at all trophic levels. Impacts include the distribution and biomass of plankton and commercially important species such as fish, with significant impacts on the higher trophic levels of living marine resources as well as human societies that rely on these resources. These changes may be further compounded by inappropriate exploitation practices, e.g. overfishing, and other environmental stresses that reduce the renewable resources of ecosystems. Diverse and productive coastal systems are likely to suffer from sea level rise, storminess, as well as temperature changes. Such physical effects will particularly produce erosion of coastlines and increased impacts on the wetlands of low lying parts of the coasts such as seagrass and saltmarsh areas and mudflats, magnified by sea defences around many estuaries hindering coastal habitats to move back as sea levels rise. Global warming will have serious consequences on wildlife, including fish stocks, which are already seriously stressed through over-exploitation, pollution and habitat degradation and loss.

The NEASE faces substantial risk with respect to climate change because its oceanographic characteristics are closely coupled to fundamental ocean atmosphere interactions (e.g. NAO, Gulf Stream variability, and formation of cold deep-water in the Nordic Seas) that result in pronounced manifestations of climate change, including storm surges and erosion of coastal ecosystems (see section 2.1).

Management and regulatory measures

The 1992 UN Framework Convention on Climate Change (UNFCC) is concerned with ecosystem management and aims to reduce greenhouse emissions to allow ecosystems to adapt naturally to climate change. Parties are committed *inter alia* to promote sustainable management and to cooperate in the conservation of sinks and reservoirs of greenhouse gases such as the oceans and coastal and marine ecosystems.

In 2002, the Kyoto Protocol measures were approved by all of the States in the NEASE, committing them to cutting greenhouse gas emissions by eight percent during 2008-2012 from 1990 levels. Including the NEASE States, 178 States have agreed to tackle climate change through this agreement.

Climate change, caused by the emission of global warming gases, is potentially the most significant threat to biodiversity at both the global and regional scales. However, there is a general lack of understanding concerning the relationships between trends in climate and changes in physical oceanography and how this influences patterns of water movement and the renewable biological production of marine plants and animals.

Much greater focus needs to be applied to examining regional climate change scenarios and assessing the biological, landscape and habitat, and socioeconomic impacts of climate change at the regional scales.
National and regional environmental awareness campaigns should be developed in order to help deliver reductions in emissions.

5. OVERALL ASSESSMENT AND GAPS ANALYSIS

5.1 The main human pressures in the NEASE and their location

Identifying and grading the importance of impacts

The OSPAR rQSRs have based their assessment on 13 similar ‘issues’: Tourism (and recreation); Fishing;

Aquaculture/Mariculture; Coastal Protection and land reclamation; Wave, tide and wind power generation; Sand and gravel extraction; Dredging and dumping (and discharges); Oil and gas (industry); Shipping; Coastal industries; Military activities; and Agriculture. However, the approach to establishing Overall Assessments in the QSR 2000 has been variable with respect to classifying and ranking the human impacts (pressures) in Regions II (Celtic Seas), III (Greater North Sea), and IV (Bay of Biscay and Iberian Coast) (**Table 7**). This is especially apparent concerning the three or four main terms used to classify the importance or severity of the impacts or pressures. For the Greater North Sea, the assessment progressed further than in the other two regions in identifying a list of 32 human pressures (**Table 8**). In addition, the '*human activities contributing to climate change*' were also recognized as a pressure, but the QSR for the Greater North Sea considered it inappropriate to compare this item directly with the other human pressures in view of the broad scope of its causes and effects. Although one may understand the difficulties that are highlighted, it is important that this view does not result in a complacent downgrading of the risk from one of the most important human-induced threats to biodiversity.

Table 7. Comparison of threats identified by the OSPAR Quality Status Report 2000 for the Celtic Seas, the Greater North Sea, and Bay of Biscay and Iberian Coast.

Celtic Seas	Greater North Sea	Bay of Biscay & Iberian Coast
	Climate change	
High Importance • Fishing • Endocrine disrupters • TBT • Coastal development • Climate change	**Highest Impact** • Fisheries: effects on target species, seabed disturbances, discards and mortality of non-target species • Nutrients: inputs from land • Trace organic contaminants: TBT & other antifoulants by shipping	**High Importance** • Fishing • Climate Change
Medium Importance • Sewage • Litter • Microbiological contamination • Mariculture • Biotoxins • Metallic contaminants • PAHs • Oil spills • Ballast waters • Ships on passage	**Upper Intermediate Impact** • Oil and PAHs: from maritime (offshore oil & gas industry, shipping) & and land sources • Other hazardous substances (other than oil & PAHs) by offshore oil & gas industry • Heavy metals: inputs from land • Biological impacts: non-indigenous species via shipping; microbial pollution & organic material from land; introduction of cultured specimens, non-indigenous species and diseases by mariculture	**Medium Importance** • Microbial pollution • Marine biotoxins/harmful algal blooms • TBT • Coastal development • Litter
Other Important Issues • Organochlorine pesticides • PCBs • Eutrophication • Deoxygenation • Radioactivity	**Lower Intermediate Impact** • Litter & disturbance: litter from fisheries and shipping; physical disturbance from offshore & gas industries • Dredging & dumping: dispersion of substances; (chemical) ammunition by military activities; physical disturbance • Engineering operations: mineral extractions (e.g. sand, gravel & maërl); coastal zone constructions including artificial reefs • Mariculture: inputs of nutrients & organic material; inputs of chemicals including antibiotics • Radionuclides	**Other Important Issues** • Heavy metals • Dredging • Biodiversity • Non-indigenous species • Organic contaminants • Eutrophication/deoxygenation

Celtic Seas	Greater North Sea	Bay of Biscay & Iberian Coast
• Munitions • Military activities • Dredged material • Sand, gravel and maërl extraction • Offshore developments	**Lowest Impact** • Litter & disturbance: physical disturbance by shipping & recreation (e.g. noise, visual), military activities (e.g. seabed, noise, visual), & engineering operations (e.g. electromagnetic disturbances by power-cables)	

For the Greater North Sea, the originally identified 32 pressures (c.f. Table 8) have been combined to 13 for simplicity and relative comparability of presentation with the other two regions.

Table 8. Overview (unranked) of 32 human pressures affecting the ecosystem, including sustainable use, identified from the OSPAR QSR 2000 for the Greater North Sea.

Category	Human Pressures
Fisheries	• Removal of target species by fisheries • Seabed disturbances by fisheries • Effects of discards and mortality of non-target species by fisheries
Trace organic contaminants	• Inputs of trace organic contaminants (other than oil and PAHs) from land • Input of TBT and other antifouling substances by shipping trace organic contaminants
Nutrients	• Inputs of nutrients from land
Oil and PAHs	• Input of oil and PAHs by offshore oil and gas industry • Input of oil and PAHs by shipping • Inputs of oil and PAHs from land
Other hazardous substances	• Input of other hazardous substances (other than oil and PAHs) by offshore oil and gas industry • Input of other hazardous substances (other than oil, PAHs and antifouling) by shipping
Heavy metals	• Inputs of heavy metals from land
Biological impacts	• Introduction of non-indigenous species by shipping • Introduction of cultured specimens, non-indigenous species and diseases by mariculture • Inputs of microbiological pollution and organic material from land
Litter and disturbance	• Input of litter specific to fisheries • Input of litter by shipping • Physical disturbance (e.g. seabed, visual, noise, pipelines) by offshore oil and gas industry • Physical disturbance (e.g. noise, visual) by shipping • Input of litter by recreation • Physical disturbance (e.g. seabed, noise, visual) by military activities • Physical disturbance (e.g. noise, visual) by recreation • Power cables (electromagnetic disturbances) by engineering operations • Dumping of inert material (e.g. wrecks, bottles)
Dredging and dumping	• Dispersion of substances by dredging and dumping of dredged material • Dumping of (chemical) ammunition by military activities • Physical disturbance by dredging and dumping of dredged material
Engineering operations	• Constructions in the coastal zone (incl. artificial reefs) by engineering operations • Mineral extraction (e.g. sand, gravel, maërl) by engineering operations
Mariculture	• Input of chemicals (incl. antibiotics) by mariculture • Input of nutrients and organic material by mariculture
Radionuclides	• Inputs of radionuclides from land

The potential list of 32 pressures is extensive, although the correctness of the list is open to discussion at this relatively early stage in the evolution of such assessments. However, the intention is commendable as a contribution to elaborating a credible list of pressures that allow the individual entities to be transparently relatable to specific sources of harmful human activities. This will facilitate 'cause and effect' regulatory actions through establishing threshold levels that are in accord with sustainable development. These human pressures have direct and indirect impacts - alone and/or together - on the constituent species, habitats, and associated environment. Human pressures often interact with each other to compound the problems that interfere with the structure and functioning of the ecosystem and its biodiversity. Thus, they all pose significant threats to biodiversity, although some are clearly graded as more serious than others.

Besides emphasizing the variability in the approach taken in the component regional QSRs, the results also underline that the degree of human impact varies between the various areas of the NEASE. However, it should also be emphasized that some of the variation is connected with a lack of quantitative data being provided by national authorities, which may contribute to ambiguous conclusions and difficulties in establishing appropriate levels of concern. Nevertheless, while recognizing this, it is important not to be distracted by such variability and uncertainty, and thereby loose focus of the main issues and concerns on a shelf-wide basis. This being said, appropriate solutions must be found to these problems at the most relevant geographical scale for the stakeholders actually involved in the specific human activities that cause the pressures.

The following part of the report synthesizes the main issues/pressures on a NEASE-wide basis, while also eventually focusing on the areas and localities in the NEASE where these impacts are most prevalent. For more detail, the reader should refer back to the relevant parts of sections 3 and 4 of the report.

Fisheries

The impacts of fisheries have been ranked as amongst those of the highest importance and concern in the NEASE. These impacts occur at all levels in the ecosystem from benthos to mammals, and are mainly operative in open sea areas. The main impacts cause the mortality and removal of target fish and shellfish species, from seabed disturbance and habitat degradation by towed demersal gear, and from the by-catch and discarding of non-target species. The majority of target fish stocks are outside Safe Biological Limits. The OSPAR Quality Status Report 2000 (OSPAR QSR 2000) emphasizes that "*fisheries management and environmental policies must be further integrated, within the framework of the ecosystem approach.*" (§ 6.2.1).

Besides fisheries, mariculture represents a significant pressure on the coastal and nearshore marine environments due to the rapid expansion of the sector. Mariculture is regulated together with fisheries under the CFP.

Climate change

The impacts of human-induced climate change are recognized as being of the highest importance and concern in the NEASE. These impacts are pervasive and have the potential to cause serious effects on the production, distribution, and migration or dispersal patterns of plankton, fish, seabirds and shorebirds, and marine mammals. Furthermore, climate change is likely to cause increased flooding and erosion of diverse low-lying coastal habitats. Climate change can be expected to alter the dispersal and the biological effects of pollutants, including by elevating temperature-related metabolic processes in animals and plants. Elevated ambient temperatures will also favour the wider establishment of more cosmopolitan non-indigenous species in temperate and boreal regions.

Nutrients

The main human pressure for nutrients may cause eutrophication, and occurs from land-based inputs, and changed nutrient ratios primarily affect the coastal zone. Nutrient-related problems are of serious and widespread concern in the southern North Sea and parts of the Irish Sea, in particular in many estuaries and fjords/loughs, the Wadden Sea, the German Bight, the Kattegat and the eastern Skagerrak. The impacts of eutrophication include increased phytoplankton production, and reduction and decay of the sedimented biomass resulting in periodic oxygen depletion and subsequent mortality of benthic and sessile organisms, as well as changes in the abundance and diversity of various plant and animal communities. Due to the storage of nutrients in the sediments, recovery times can be in the order of decades.

Hazardous substances

The impact of the following hazardous substances poses serious concerns in the NEASE:

Trace organic contaminants

Trace organic contaminants occur throughout the region. The main human pressures concerned with trace organic contaminants are inputs (excluding oil and PAHs) from land, and input of TBT and other antifouling substances used by shipping. Inputs of trace organic contaminants from land include all pathways (e.g. riverine, direct, atmospheric, sewage and sludge formerly deposited, and the dumping of dredged material). The sources can be inside or outside the region with dispersion covering the whole area. Recovery times are long, in some cases about a century. The ecological effects include disturbed hormone metabolism and impaired reproduction in several biota.

Oil and PAHs

The main human pressures regarding oil and PAHs include inputs from the offshore oil and gas industry as well as by shipping, together with input from land. Significant reductions have occurred for refineries and the offshore oil and gas industry, although inputs from produced water from the latter have increased progressively in recent years. PAHs are widespread, particularly in the North Sea and Irish Sea, and input levels are unquantified. Oil pollution causes mortality and fouling of fish, birds and benthos from contact with the toxic fractions of petroleum, or chronic biological effects (e.g. impaired reproductive success) as toxic chemicals concentrate through the food web. Oil spillage frequently results in economic losses affecting a fishery, recreation and tourism. Exposed shorelines, shallow reef environments, estuaries and wetlands are particularly susceptible to damage and degradation from oil spillages.

Heavy metals

Airborne and waterborne sources provide inputs of heavy metals. Some sea-based activities also provide inputs, such as exploitation of offshore resources (e.g. sand and aggregate extraction) and dumping of dredged materials. Discharges and emissions have been reduced in many places for cadmium, mercury, lead and copper, resulting in reductions of concentrations in water, sediments and some biota. However, as heavy metals do not degrade, anthropogenic contributions may cause serious biological risks for marine life in estuaries and the coastal zone. Areas where heavy metal concentrations are highest may frequently be ecologically significant as habitats, breeding, and foraging grounds. Cadmium, mercury and lead accumulate at all trophic levels and end up in fish, birds, marine mammals and humans in the upper levels of the food chain, while copper can affect phytoplankton species composition and productivity. Recovery times are often of the order of decades. Thus, particulate bound metals are trapped in sedimentation areas where they pose a risk to bottom living species, and metals present in buried sediments may become resuspended and mobilized.

Other hazardous substances from sea-based sources (other than oil, PAHs, and antifouling substances)

Inputs of these substances occur from the offshore oil and gas industry, particularly via drilling discharges and produced water. Inputs from shipping consist of elemental phosphorous, pesticides and lipophilic substances originating from the cleaning of tanks, burning fuel, discharges of wastes and loss of cargo. Many of these substances are slowly degraded in the environment, and accordingly often bioaccumulate in the food chain with serious effects.

Litter

Discharges of marine litter and garbage, from shipping, tourist and recreational activities represent the main sources of serious impacts in the NEASE. The impacts include declines in the general environmental quality and aesthetic values or amenities of both nearshore and offshore areas, as well as the seabed, with lethal and sub-lethal effects (e.g. drowning, smothering) on numerous biota and their habitats.

Other biological impacts: non-indigenous organisms and microbial pollution

The main human pressures causing serious biological impacts - in addition to those mentioned above - in the NEASE are the introduction and transfer of non-indigenous species and genetically modified organisms via shipping and mariculture, and inputs of microbiological pollution from sewage-related land-based sources. These biological impacts pose serious detrimental ecological and economic effects, mainly due to the risks of parasites and pathogens/diseases, changes of species composition, the introduction of toxic algal species, and genetic changes to indigenous populations (e.g. wild Atlantic salmon). Attention has been focused recently on the risk of genetically modified organisms (GMOs) escaping into the natural environment.

Degradation and loss of habitats and ecosystems

The above-mentioned impacts, together with coastal development and engineering, lead together to the degradation and eventually loss of ecosystems and their component habitats. Such effects lead to modification/loss of biodiversity involving natural productivity, genetic diversity, changes in community structure and ecosystem stability, susceptibility to disease, changes in migratory species populations and migratory patterns, loss of carbon sinks and release of carbon to the atmosphere, increased vulnerability to opportunistic non-indigenous invasive species, impacts of estuarine system changes on adjacent coastal marine ecosystems, and changes in natural storm barriers and reduced protection from erosion.

5.1.1 Coastal zones

The most serious environmental effects on species and habitats are found in the coastal and nearshore areas. These are generally characterized by reduced water circulation and exchange, heavy inputs from rivers, stratification of the water column, and ecologically sensitive littoral zones of importance to flora and fauna throughout the region. Many of these geographic areas and localities exhibit high levels of environmental and biodiversity impact based on their having much greater concentrations of human population and industries in the land-catchment that drain into semi-enclosed and/or sensitive sea areas, together with a high density of polluting and extractive activities (e.g. dredging, sand and gravel extraction, fisheries). These areas include first and foremost the North Sea, and especially the southern North Sea and Channel, and the Irish Sea.

Many estuaries and areas with restricted water circulation are under pressure due to high population density and industrial and/or port-related activities. Human impacts in estuaries situated in industrialized and highly populated areas frequently include health problems for organisms due to pollution, eutrophication and physical disturbance by dredging.

The waters off the west coasts of Scotland and Ireland, and the French Atlantic coast, are relatively unaffected by pollution arising from within the region. The main needs are to ensure that the rapid growth of mariculture does not cause serious pollution and interactions with wild stocks, and that tourism and recreational activities are carefully regulated and abide by good environmental guidelines to limit impacts on wildlife and habitats.

Sensitive coastal habitats, such as transitional areas between saltwater and freshwater, intertidal areas, wetlands and salt marshes, are continuing to vanish due to draining, erosion and the construction of coastal defence structures and other installations. These coastal regions, especially sandy areas, are frequently severely disturbed by tourism and recreational activities.

5.1.2 Open sea areas

The impacts of human activities in the open sea are generally less than in coastal areas, although pollution from coastal sources also often transported to open sea areas. In the open sea the main impacts are from the effects of fisheries, and inputs of pollutants from the offshore oil and gas industry. An important and increasing part of this pollution is through the discharge of produced water, but oil (including PAHs) and phenolic compounds, potential endocrine disrupters, and chemicals used in the production process are discharged.

Persistent pollutants also reach high levels in the open sea at localities where they are concentrated, such as sedimentation areas exemplified by the Dogger Bank, the Skagerrak and the Norwegian Trench.

5.2 Gaps in knowledge and management

Sections 3 and 4 of this report draw attention to numerous gaps or shortcomings in knowledge, as well as recommendations for establishing new management and regulatory measures. The current section complements the more detailed information made in the above-mentioned sections. By their nature, they are more general and aim to highlight a number of selected areas regarding 'gaps' that require future consideration and action.

In spite of major efforts on behalf of the scientific community and environmental and fisheries managers, there are still gaps in:

a) knowledge and understanding regarding the environment and ecosystems;
b) the manner in which human activities affect the various biological components of ecosystems, and
c) the appropriate way to manage and regulate the human-related root causes of overexploitation, pollution and habitat degradation.

Science, monitoring and assessment

In accord with the emphasis on implementing the ecosystem approach to management, more studies should be promoted on ecosystem functioning and the sources of natural and anthropogenic variability, as well as on investigations into the impact of human activities on coastal and marine habitats. The long-term monitoring and forecasting of human impacts on the marine ecosystem needs more support, including identifying trends in marine ecosystems based on key species and by monitoring the state of conservation in selected sensitive areas. Regarding monitoring activities of marine biodiversity, a more balanced and cost effective reallocation should be considered from the current focus on single species stock-assessments of commercially important fish towards wider integrative multispecies-assessments involving both commercially important target species and other important components in the ecosystem (e.g. benthos, seabirds, marine mammals, non-indigenous organisms, and habitats). It is emphasized, however, that these needs are for *applied science* conducted in order to support the effective implementation of the ecosystem approach to management, and not to delay management measures in the absence of sufficient knowledge.

Research and management policy programmes should be developed for all activities affecting the marine environment, including the obligatory establishment of environmental assessments for specific areas of concern related to significant effects of human activities. There is also a need to assess the effectiveness of different management regimes with a view to improving their general performance and adaptive management. These should encourage closer collaboration between socioeconomics and the chemical, physical and natural science disciplines. Tools need to be developed for the assessment of substances and effects of concern, taking into account the merits of integrating biological effects and chemical monitoring approaches. Greater emphasis should be given to developing biomarker techniques, sustainability indicators and ecological quality objectives, and designing more efficient monitoring and assessment programmes with the aim of providing clearer results in terms of status and trends. More attention needs to be given to measuring the levels and the biological effects of contaminants (e.g. hazardous substances and radionuclides) in key biota (e.g. benthic animals and plants), besides the current weighting on levels in seawater and sediments. Experimental work on resident biota in different coastal ecosystems should be encouraged to establish reference levels for marine contaminants.

Because of its pervasive effects at all levels in the ecosystems, much greater emphasis needs to be given to investigating climate change and its wider reaching effects (both present and likely scenarios) on hydrometeorology and marine biodiversity at the regional and local levels.

Despite these gaps, it is important that the need for more knowledge should not be used as an impediment to taking management action (c.f. the precautionary approach).

The need for improved governance and spatial management

In order to achieve a better appreciation of the benefits of sustainable biodiversity, there is a need to appropriately consider the socioconomic and ecological interactions involved as outlined in the ecosystem approach to management. There is a need to comprehensively integrate socioeconomic analyses with a view to conducting scenarios of impacts (e.g. gains and losses) affecting the relevant stakeholders (e.g. shipping, aquaculture, land-based and offshore industries, fisheries, environmental sectors) as parts of the 'whole picture'. This has been promoted as part of the integrated ecosystem approach to management, for example in the Large Marine Ecosystem (LME) programme. The ecosystem approach can be facilitated through an integrated approach to planning and management of human activities within the framework of integrated coastal zone management.

Within the general framework of integrated coastal zone management, policy and management guidelines must be established (e.g. Codes of Good Practice) for the allocation of specific coastal areas and resources to various economic development needs. An important aspect of this is spatial planning including zonation, whereby appropriate consideration is given to deciding on what human activities are applicable in different localities or areas in the context of biodiversity conservation. It is important to proceed with ecosystem-based management in a spatially specified manner, in order to organize management and regulatory measures according to the regionally and locally most pressing needs. Greater emphasis must be placed on conducting environmental impact assessments (EIA) and strategic environmental assessments (SEAs) as processes whereby the potential impacts of a proposal on the social, biological, chemical and physical environment are assessed and justified, and the means sought to minimize or eliminate negative effects.

Inclusive stakeholder forums need to be established at all levels of governance related to biodiversity conservation, involving representation of relevant parties and for confidence building, information exchange, capacity building and 'outreach' activities (e.g. training courses, workshops and seminars). Institutional reform should be prioritized involving co-responsibility for management. In particular, integration of fisheries (including mariculture) and environmental issues must be actively promoted at national and international levels, by effectively applying the precautionary principle and the ecosystem approach to management. Increased use should be made of marine protected areas (MPAs) as tools for the integrated management of coastal zones, their living resources and the protection and conservation of biological diversity. National and international programmes need to be established that aim at the recovery of degraded coastal habitats. The ecosystem approach should be implemented at the appropriate geographical and spatial scales, with candidate sub-regions within the NEASE for management purposes including: The Atlantic Frontier; The Celtic Sea and Iberian Shelf; The Irish Sea; The North Sea with sub-areas comprising the northern and southern North Sea, Norwegian Trench, Skagerrak, Kattegat, and Channel. The integrated ecosystem approach should also be used as a mechanism to raise public awareness about the important but non-monetary values of the marine environment including its biodiversity.

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