OSPAR Commission

for the Protection of the Marine Environment

of the North-East Atlantic

Quality Status Report 2000

Quality Status Report 2000

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More information about OSPAR
The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Union and Spain.

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chapter 1

Introduction

1.1 Aim and scope

The 1992 OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic requires that Contracting Parties shall 'take all possible steps to prevent and eliminate pollution and shall take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected'.

To provide a basis for such measures, Contracting Parties are required to undertake and publish at regular intervals joint assessments of the quality status of the marine environment and of its development, for the maritime area covered by the Convention. These assessments should also evaluate the effectiveness of measures taken or planned for the protection of the marine environment, and identify priorities for action (Article 6 of and Annex IV to the OSPAR Convention).

The 1992 Ministerial Meeting, at which the OSPAR Convention was signed, also issued an action plan for the OSPAR Commission, with a commitment to prepare the first Quality Status Report for the whole North-East Atlantic by the year 2000 (the 'QSR 2000').

To implement these commitments the OSPAR Commission decided in 1994 to undertake the preparation of Quality Status Reports (QSRs) for five regions of the North-East Atlantic: Region I, Arctic Waters; Region II, the Greater North Sea; Region III, the Celtic Seas; Region IV, the Bay of Biscay and Iberian Coast; Region V, the Wider Atlantic. These regions cover the entire maritime area of the OSPAR Convention *(Figure 1.1)*. Earlier work done within the framework of the 1993 North Sea QSR, the Arctic Monitoring and Assessment Programme (AMAP) and the Irish Sea Co-ordination Group was taken into account.

These regional QSRs, which have been published separately, form the basis for this Quality Status Report 2000. This provides a holistic and integrated summary of the status of the entire OSPAR maritime area.

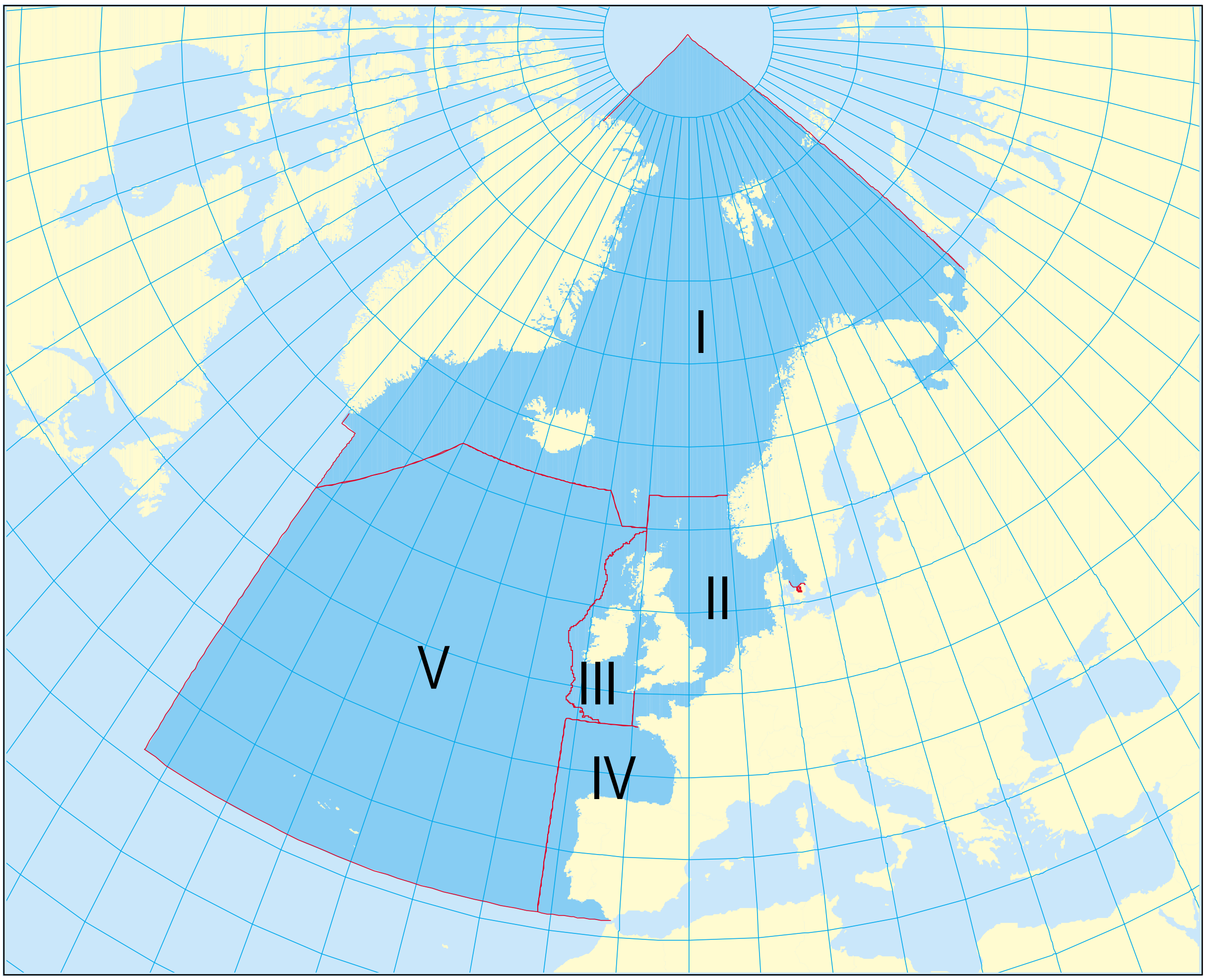
To monitor environmental quality throughout the North-East Atlantic, the OSPAR Commission adopted a Joint Assessment and Monitoring Programme (JAMP). The JAMP builds upon experience gained through amongst others the former Joint Monitoring Programme of the Oslo and Paris Commissions and the Monitoring Master Plan of the North Sea Task Force (NSTF). Under the JAMP umbrella, new guidelines and assessment tools have been developed.

The Ministerial Meeting of the OSPAR Commission in Sintra (Portugal) in July 1998 agreed on strategies aimed at guiding the future work of the Commission. In 1998 and 1999 the Commission adopted strategies for the purpose of directing its work in the medium- to long-term in five main areas, i.e. the protection and conservation of the ecosystems and biological diversity of the maritime area, hazardous substances, radioactive substances, combating eutrophication, and environmental goals and management mechanisms for offshore activities.

Together with the QSR 2000 and the JAMP these strategies form a vital basis for OSPAR's activities.

This report describes the natural features of coastal and offshore environments of the OSPAR area and identifies impacts arising from human activities. In general, the report summarises information available to mid-1998, focusing in particular on environmental changes and the extent to which these result from human activities, natural variability, or both. Another objective was to identify those gaps in scientific knowledge which currently impede the assessment of the environmental significance of certain activities and conditions and consequently to support management and policy formulation. The various natural processes and human-made pressures on the area are analysed and compared taking into account their severity and scale as well as their long-term significance for the environment, human health, resources and amenities. Finally, conclusions are drawn

Figure 1.1 **The OSPAR maritime area.**



Region	Lead country / countries	Other participating countries
I – Arctic Waters	Norway	Denmark (including Faroe Islands) and Iceland
II – Greater North Sea	Netherlands	Belgium, Denmark, France, Germany, Norway, Sweden and UK
III – Celtic Seas	Ireland and UK	
IV – Bay of Biscay and Iberian Coast	France and Spain	Portugal
V – Wider Atlantic	Iceland and Portugal	Belgium, Denmark, France,Germany, Ireland, Netherlands, Norway, Spain, Sweden and UK

The work of the Regional Task Teams was coordinated by the Assessment Coordination Group under the Environmental Assessment and Monitoring Committee.

regarding the priorities for new, or revised, policies and management interventions that would strengthen marine environmental protection.

1.2 The assessment process

Marine environmental assessments are now an integral part of national, regional and global programmes for protecting marine and coastal areas. They provide an opportunity to bring together and assess the results of scientific research and monitoring as well as information on the many different human activities that, either directly or indirectly, can change or damage the natural attributes of the marine environment. In combination, this knowledge can be used to evaluate changes, their causes and implications, and to identify impacts that require the early attention of policy-makers and environmental managers. Assessments are also used to review the effectiveness of existing measures to prevent degradation of the marine environment, to protect valued species and communities and to restore previously damaged habitats and ecosystems.

The overall assessment in this report is based on the most recent information available from national and international sources, including the Environmental Assessment and Monitoring Committee (ASMO) and the Programmes and Measures Committee (PRAM) of OSPAR and the International Council for the Exploration of the Sea (ICES) and their respective working groups. Scientific and other literature from other international organisations including the European Environment Agency (EEA) and Eurostat were also used. Non-Governmental Organisations with OSPAR Observer status were invited to provide comments; these were taken into account in the development of the report. ICES carried out a scientific peer review of an advanced draft of this QSR.

The information was compiled initially by separate Regional Task Teams (RTTs), consisting of representatives from the relevant countries for the five OSPAR Regions. Inevitably, the amount of information available for each Region differed depending on the extent of past research and monitoring and the availability of resources. Consequently, not all topics are covered to the same depth and level of detail for all parts of the maritime area and conclusions are drawn on the basis of available information.

Although most of the information relates to the 1990s, some topics assessed required the use of earlier data, either because the recent record is sparse or because trend analysis involves consideration of historical conditions. While every effort has been made to ensure the comparability of data from different times and locations, methodologies may differ considerably and some comparisons will, inevitably, be tenuous. Where such uncertainties have been identified, they are indicated in the text.

1.3 Guidance to the reader

The QSR 2000 follows the same arrangements as the regional QSRs in that it consists of the same six chapters. Following this introductory Chapter 1, Chapter 2 gives an overview of the geography, hydrography and climatic conditions of the North-East Atlantic in order to give a baseline for the detailed descriptions of the physical, chemical and biological characteristics of the area presented in following chapters. Chapter 3 provides an outline of the most important human activities that influence the North-East Atlantic. Chapter 4 summarises information on the chemical aspects of the North-East Atlantic, focusing on inputs of contaminants and nutrients, and their concentrations in different environmental media and compartments. Chapter 5 deals with the biological features of the coastal and offshore ecosystems, focusing in particular on the causes, impact and implications of the changes that are occurring to their natural characteristics. Finally, Chapter 6 draws on Chapters 2 to 5 to identify trends, the effectiveness of measures and the major causes of any environmental degradation within the area and the managerial and scientific actions needed to redress this.

The overall assessment found in Chapter 6 identifies, as far as is currently possible, the factors that govern environmental change in the various Regions, leading to a prioritisation of human pressures according to their impacts on the North-East Atlantic. This involved expert judgement for the identification and assessment of a variety of impacts, which differ in nature and importance, and in their spatial and temporal dimensions.

The purpose of the conclusions and recommendations contained in this report is to draw attention to problems and to identify priorities for consideration within appropriate forums as a basis for further work. Within its sphere of competence, the OSPAR Commission will decide what follow up should be given to these conclusions, recommendations and priorities for action. The rights and obligations of the Contracting Parties are not therefore affected by this report.

chapter 2

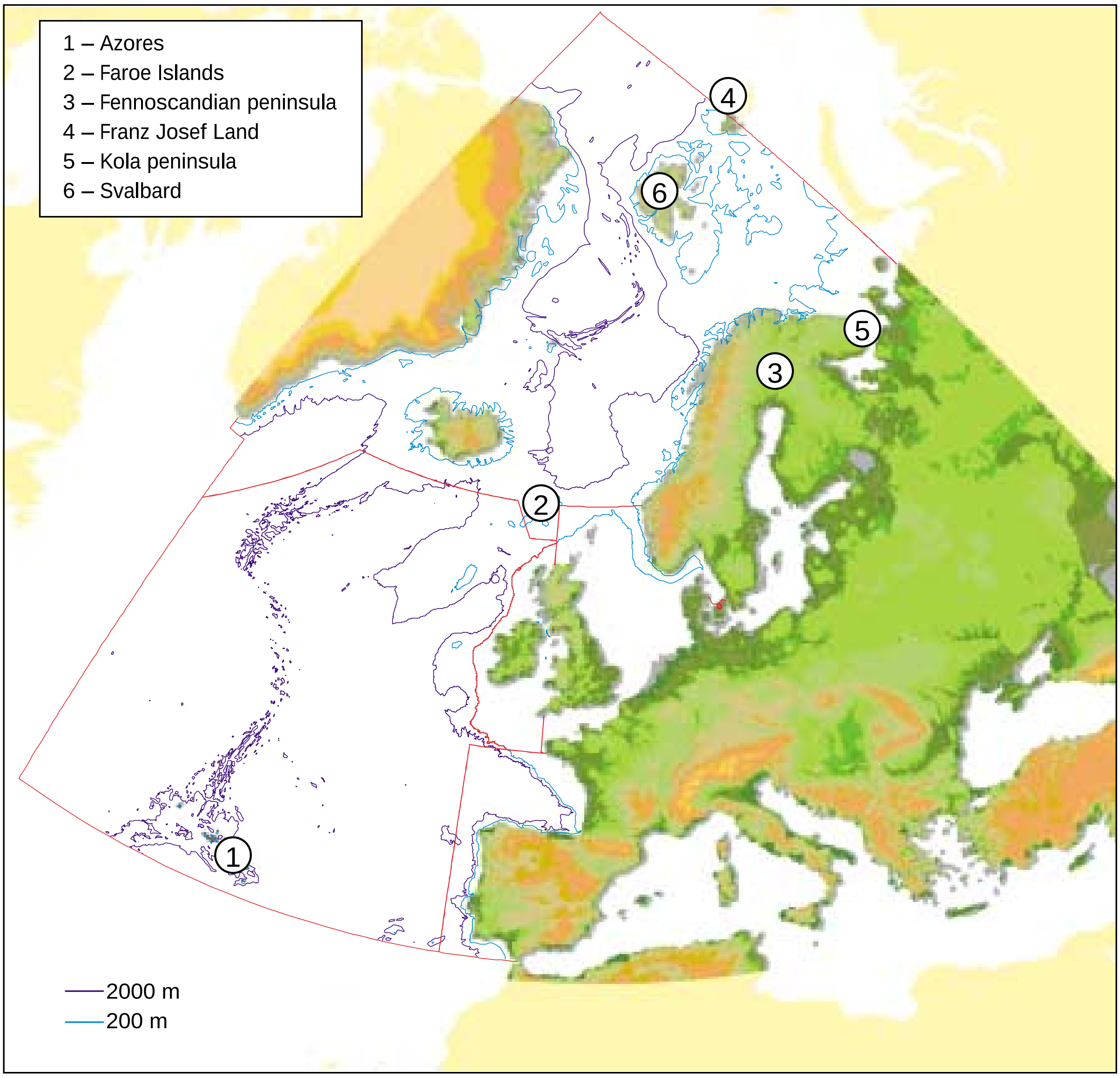
Geography, hydrography and climate

2.1 Introduction

This chapter defines the principal physical characteristics of the OSPAR maritime area. It forms the basis for more detailed descriptions of the chemical and biological properties of the area (in Chapters 4 and 5) and the impact of human activities (in Chapter 3).

The North Atlantic circulation forms part of the global ocean circulation system that has been called the ‘Ocean Conveyor’ by oceanographers. Warm, salty, nutrient-rich surface waters flow north through the Atlantic at a rate more than a hundred times that of the Amazon River. They then sink to the depths of the Greenland and Labrador Seas, and return to the Southern Ocean at two to three kilometres below the surface as ‘North Atlantic Deep Water’. The warm surface waters release heat into the cold northern atmosphere at a rate equivalent to a hundred times the world’s energy consumption sufficient to warm the air over Europe by about 5 °C.

Figure 2.1 **The OSPAR maritime area covers an overall oceanic area of about 13.5 x 10^6 km^2 and has a volume of 30 x 10^6 km^3.**



2.2 Definition of the OSPAR Convention area

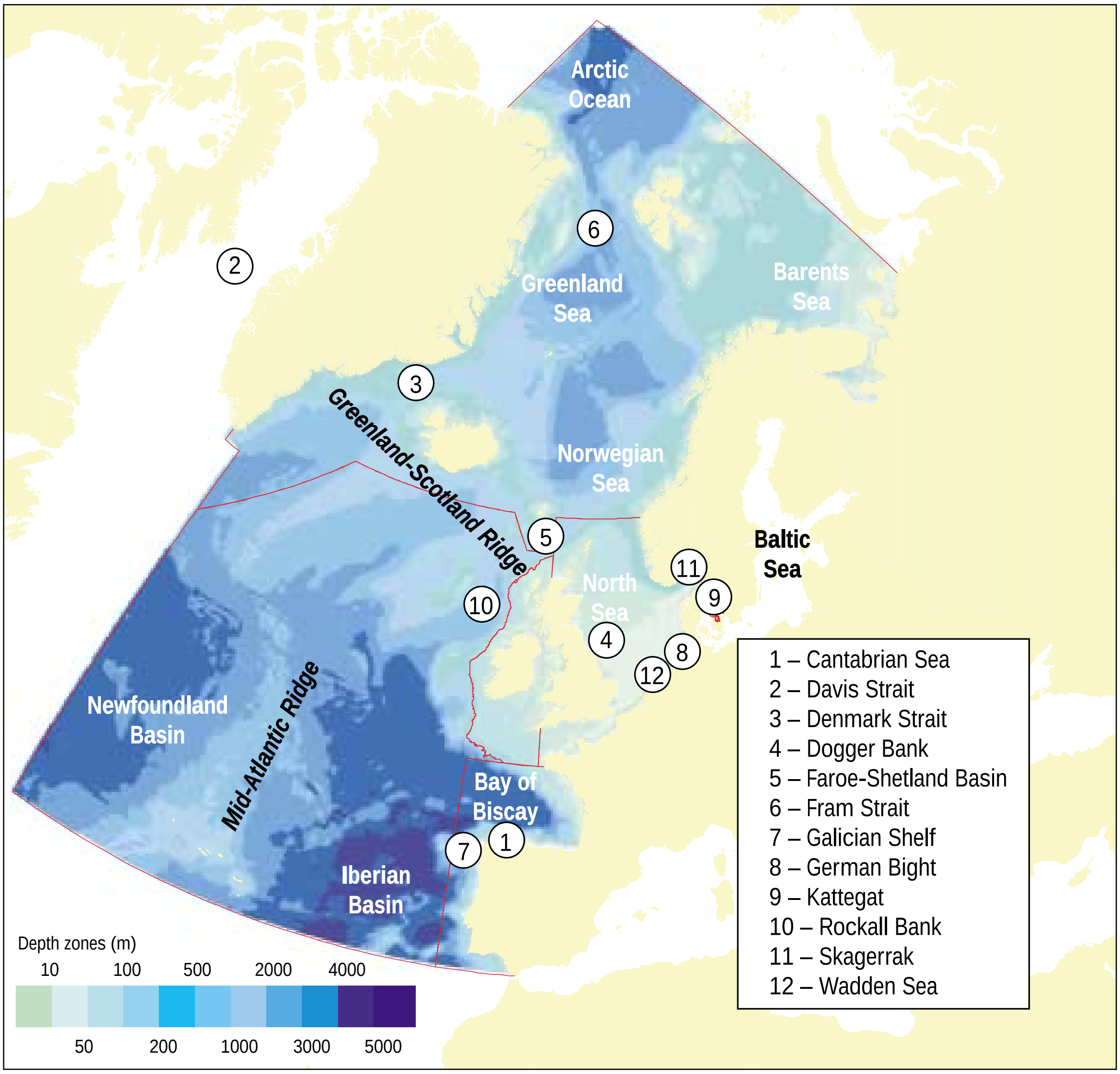
Together, the five regions of the OSPAR Convention area cover most of the North-East Atlantic Ocean *(Figure 2.1)*, having a surface area of about 13.5 x 10^6 km^2 and a volume of approximately 30 x 10^6 km^3. However, because the northern North Atlantic is relatively narrow and shallow, these figures represent only ~ 4% of the surface area and ~ 2% of the volume of the world's oceans. The southern and northern limits of the area are the 36º N parallel and the North Pole respectively. The 42º W meridian, the Atlantic coast of Europe and the 51º E meridian in the Arctic Ocean form the other borders of the area.

2.3 Bottom topography

The major topographical features in the OSPAR maritime area are the Mid-Atlantic Ridge (with the Azores and Iceland as its highest points), and the Greenland-Scotland Ridge (which separates the Atlantic Basin from the Nordic Seas) *(Figure 2.2)*. Water depths range from around 5000 m on either side of the Mid-Atlantic Ridge, to less than 200 m on the continental shelf along the European coast. In some places seamounts occur as submerged single mountains or chains of mountains along the ocean floor.

The most extensive continental shelf areas are found in the North Sea and Celtic Seas. Other shelf seas are found around Iceland, Greenland and in the Barents Sea.

Figure 2.2 **Bottom topography. Source of data: ETOPO5 database, National Geophysical Data Centre, US.**



In contrast, along the Iberian coast and to the west of Norway, the shelf break is quite close to the coastline ***(Figure 2.2)***.

2.4 Geology and sediments

The North Atlantic began to form approximately 200 million years ago as the European and North American plates separated either side of the active mid-ocean ridge The current rate of spreading due to formation of basaltic oceanic crust at the mid-ocean ridge is ~ 2 cm/yr. The OSPAR area can be divided into three distinct geological regimes: the oceanic basin and the continental shelf, separated at the shelf break by the passive continental margin.

In the deep ocean basin an abyssal plain extends either side of the Mid-Atlantic Ridge to the continental margins consisting of a 4 – 6 km thick basaltic basement overlain by 0.1 – 2 km thick accumulations of sediment. The sediment (pelagic ooze) consists largely of the remains of micro-scopic organisms (mostly foraminifera and diatoms) from the overlying waters, as well as minor amounts of windblown atmospheric dust and turbidity currents.

At the continental margins huge wedges of sandy to muddy sediments extend down into the deep-sea basin. These are the result of submarine landslides (turbidity flows). Owing to the intermittent nature of these events, the deposits (which can be up to 10 km thick and 700 km in length) consist of interbedded terrigenous muds and pelagic sediments. These deposits are sometimes rich in hydrocarbons.

The continental crust is generally 30 – 40 km thick, thinning below the sedimentary basins. It has a varied composition of igneous, metamorphic and sedimentary rocks as a result of a succession of separate tectonic periods. Underlying the whole NW European Shelf is the Pre-Cambrian basement (> 600 million yr). Oil is found in the Jurassic sediments of the central North Sea graben and in fractured Tertiary strata of the Faroe-Shetland Basin. Shelf sea sediments are of mainly terrestrial origin. In northern latitudes, including the North Sea and Irish Sea, much of the sea floor sediment is of relict glacial or periglacial origin.

2.5 Description of the coastal margin

A diverse mixture of coastal landscapes is found in the OSPAR area, although generally the western margins are deeply indented with fjords, estuaries and rias and, in northern latitudes, the coast is dominated by high mountains. Around the North Sea and Celtic Sea, the coast exhibits a range of features, including cliffs of varying heights and rock types, bays and estuaries, sandy and shingle beaches, dunes and island archipelagos. Further south, the French coast of the Bay of Biscay is low-lying with lagoons. The Iberian coast comprises alternating cliffs and beaches, while cliffs predominate on the oceanic islands such as the Azores, Iceland and the Faroe Islands.

2.6 Estuaries, fjords, rias and wetlands

Many rivers do not discharge directly to the sea, but flow out through an estuary. In Greenland and Norway in particular glaciers formed deep fjords during the Quaternary period. Further south in the OSPAR area, for example in south-west Ireland and on the north-western Spanish coast, drowned river valleys, or rias, were formed by rising sea levels. Wetlands, areas of land either

Figure 2.3 **Catchment areas of the OSPAR Regions and the Baltic Sea. The inset shows the major rivers discharging to the Russian Arctic (see Table 2.1).**

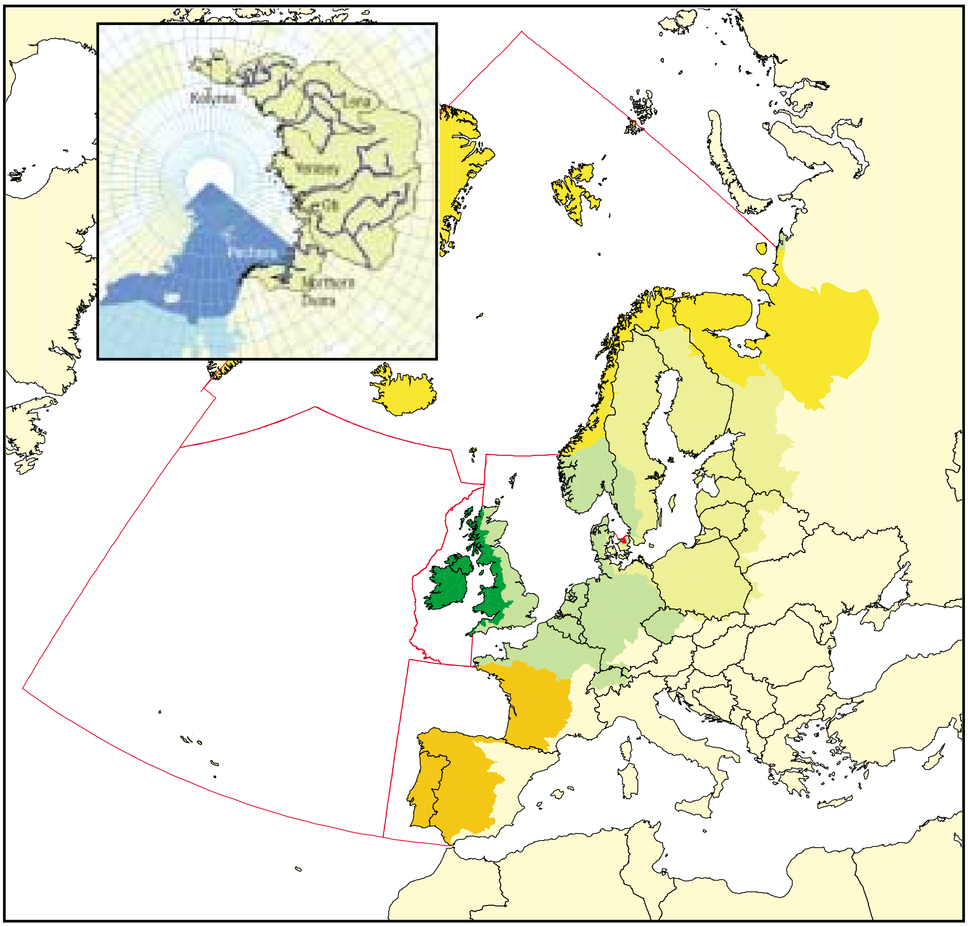


Table 2.1 Catchment areas and river run-off.

	Catchment area (km^2 x 10^3)*	River run-off (m^3/s)†
Region I		
Greenland‡	600	16 000
Iceland	103	5 400
Norway > 62° N	190	8 700
Russia and Finland	914	9 500*
SUB-TOTAL:	1 807	39 600
Region II		
Baltic Sea	1 650	14 900
North Sea	850	9 500
SUB-TOTAL:	2 500	24 400
Region III		
Ireland	68	900
western UK	110	1 600
SUB-TOTAL:	178	2 500
Region IV		
France	260	2 200
Iberian Peninsula	395	3 450
SUB-TOTAL:	655	5 650
Region V		
Azores	2.3	Low
SUB-TOTAL:	2.3	Low
TOTAL: Convention Area	5 142	72 150
3 Siberian Rivers		
Lena	2 486	16 656
Ob	2 990	12 857
Yenisey	2 580	19 866
TOTAL: 3 Siberian rivers	8 056	49 379

* approximate; † mean values for different base periods; ‡ the data for eastern Greenland are taken as being two-thirds of the totals for the whole of Greenland. The catchment area for Greenland as a whole is ~ 900 x 10^3 km^2, and the modelled average run-off according to Janssens and Huybrechts (in press) is 23 920 m^3/s (run-off from ice sheet: 8800 m^3/s; basal melting from ice sheet: 320 m^3/s; iceberg calving: 9800 m^3/s; run-off from ice-free land: 5000 m^3/s).

seasonally or permanently waterlogged, occur predominantly around the North Sea coast and on the west coast of France. Wetlands are highly productive areas. An estuarine circulation pattern, with lighter brackish water flowing seawards at the surface and intruding salt water below, is a common feature of all these areas.

2.7 Catchment area and freshwater run-off

The catchment areas and run-off of rivers discharging into Regions I to V *(Figure 2.3)* are given in *Table 2.1*. The total catchment of the Convention area covers approximately 5 140 000 km^2, made up of:

- Region I: the Norwegian coast north of 62° N, the Fennoscandian and Kola peninsulas and Arctic islands (including Svalbard), Iceland, Greenland and the Russian rivers Pechora and Dvina;
- Region II: catchments draining directly into the North Sea and, indirectly, through the Baltic outflow from a large Baltic catchment;
- Region III: the western part of the United Kingdom (including Northern Ireland) and Ireland;
- Region IV: the Franco-Iberian area; and
- Region V: the Azores.

Mean total river run-off into each Region ranges from a negligible input to Region V to ~ 25 000 m^3/s to Region III, but may vary considerably between years. Much of the Arctic region is covered by permafrost and ice and run-off to these areas is relatively low. However, huge amounts of freshwater enter the sea by calving from glaciers from the Greenland ice sheet. Data are also included in *Table 2.1* for run-off from the major Siberian rivers – Lena, Ob and Yenisey – which drain into the Arctic and can have a considerable influence on the hydrography and ecosystems of Region I.

2.8 Water masses

Sea water properties can vary significantly and play a major role in the hydrography of the oceans *(Box 2.1)*.

In Region I, different water masses represent surface and upper layer waters. These include two warm, high-

Box 2.1

A water mass is defined as a large body of water with a distinctive set of properties, typically identified by its temperature and salinity. A newly formed water mass will mix and sink to a given equilibrium depth, depending on its density relative to that of the surrounding waters.

Water density is determined by water temperature and salinity. Atmospheric cooling or heating may change the temperature of the water mass, while precipitation, evaporation, run-off and ice melt can modify its salinity. If the density of a water mass is increased, it sinks, often along a front. As it sinks, it mixes with surrounding water until it reaches a depth where its density is equal to that of the surrounding water.

Vertical mixing can occur in a variety of ways. For example, winds play a key role and, if they are directed along the shore, may generate coastal upwelling. On the shelf, tidal movements are important in mixing bottom waters and, depending on the depth and strength of the currents, can influence the development of thermally stratified waters.

salinity water masses, which enter from the Atlantic. On entering the Nordic Seas, these waters have temperatures ranging from 7 °C to 10 °C and salinities mainly between 35.1 and 35.4. Within the region, the Atlantic water is cooled and diluted and may change considerably in character. ‘Norwegian Coastal Water’ enters the region from the south-east; its salinity increases to a maximum around the Lofoten Islands. While there is a general northward temperature decrease, the seasonal temperature fluctuations are large. ‘Polar Water’ is formed in the Arctic Ocean where it occupies the 30 – 50 m thick surface mixed layer. ‘Arctic Surface Water’ is observed in the upper layers of the central Greenland and Iceland Seas. The Polar Front separates the warm Atlantic water from the cold northern water masses.

In Region II, water originates from the North Atlantic and from freshwater run-off in different admixtures. The salinity and temperature characteristics of different parts of the region are strongly influenced by heat exchange with the atmosphere and by local freshwater supply. The deeper waters of the North Sea consist of relatively pure water of Atlantic origin, also partly influenced by the surface heat exchange (especially winter cooling) and, in certain areas, slightly modified with admixture of less saline surface water.

Region III waters vary from being oceanic at the shelf break to the west, through the relatively shallow semi-enclosed Irish Sea, to estuarine and fjordic inlets on its eastern boundary. In very general terms, the overall movement of water masses is from south to north, with oceanic water from the North Atlantic entering from the south and west of the region. This moves northwards through the area, to exit either into Region I to the north or, after flowing around the north of Scotland, into Region II. The general pattern of salinity distribution indicates that the water is mainly of Atlantic origin.

The major part of Region IV corresponds to the continental margin of the southernmost part of the Convention area. Most of the water masses found in the region either have a North Atlantic source, or result from interaction between waters formed in the Atlantic with water of Mediterranean origin. Winter vertical convection is also likely to give rise to water mass formation in the upper ocean levels (0 – 500 m) beyond the continental slope north of 40° N, particularly at the western Bay of Biscay, in a process subject to significant interannual variability.

Region V is the region where cold, low salinity water masses coming from the polar seas and the warm, salty waters originating from the south are transformed by mixing and cooling. Many of the water masses found in the Atlantic contain high concentrations of dissolved oxygen and are rich in nutrients. Throughout the deep waters of the North-East Atlantic, concentrations of dissolved oxygen never fall low enough to limit aerobic biological activities.

Most areas of the OSPAR region are vertically well mixed in the winter months of the year, down to a depth of more than 600 m in the eastern Atlantic. In spring, as solar heat input increases, a thermocline (a pronounced vertical temperature gradient) is established over much of the region, separating a heated and less dense surface layer from the rest of the water column. These waters are said to be stratified. In shallow shelf areas, with strong tidal movements, the waters remain mixed throughout the year.

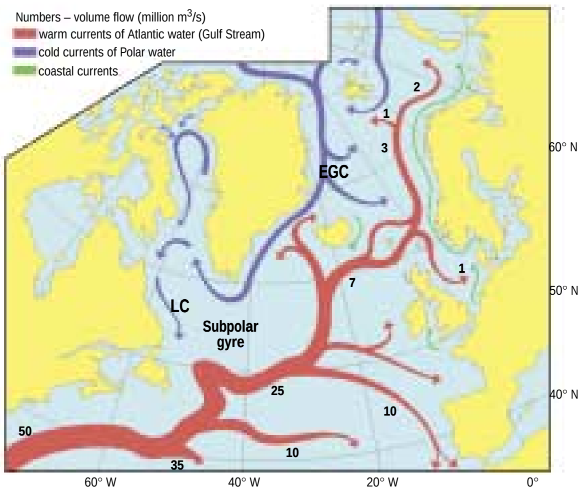
The distinction into stratified and permanently tidally mixed areas is of considerable importance to the structuring of both pelagic and benthic ecosystems. The stability induced by the establishment of the spring thermocline allows phytoplankton to remain near the surface where both high light and nutrient levels are found. After the spring bloom, nutrients become limiting above the thermocline. As a result, phytoplankton production is reduced in the summer. Where the thermocline outcrops at the surface, the boundary between the different water masses is known as a tidal front and is a region of intense biological activity. In oceanic waters to the south of the OSPAR area, there is a deep, permanent thermocline.

2.9 Circulation and volume transport

Within the OSPAR area, warm Atlantic surface water flows in a north-westerly direction towards the Norwegian Sea as the North Atlantic Current (NAC). An eastward-directed flow in the Azores Current (AzC) roughly coincides with the southern boundary of the OSPAR maritime area. As extensions of the Gulf Stream, these two currents form the southern edge of the subpolar gyre and the north-eastern edge of the subtropical gyre respectively. On the margins of Europe a warm northward-flowing Eastern Boundary Current (EBC) is found intermittently. A western boundary current flows south from the Fram Strait as the East Greenland Current (EGC) and, its extension, the Labrador Current (LC). The northward transport of warm surface waters towards the Arctic Ocean is balanced by a southward return flow of intermediate and deep water from the Nordic Seas via the Denmark Strait and from both the Faroe–Shetland Channel and the Labrador Sea. Mean flows for these currents derived from modelling and observational studies are given in *Figure 2.4*.

The NAC and AzC, together with the dominant mid-latitude westerly winds and a mean meridional density gradient, combine to push oceanic water against the European coast. This effect, influenced by the Coriolis force, generates the northward-flowing EBC. Although the EBC does not appear to be continuous, it is evident from southern Portugal to northern Norway. It may also reverse its surface mean flow to the south in the summer upwelling period, especially off the coast of the Iberian Peninsula.

Figure 2.4 **Mean surface currents.**



The water circulation of the European shelf seas is dominated by tidal and wind generated currents. In the North Sea the residual circulation is anticyclonic (anti-clockwise), passing out along the Norwegian coast after mixing with the outflow from the Baltic in the Skagerrak *(Figure 2.5)*. This low salinity outflow continues to the north towards the Arctic and into the Barents Sea. Elsewhere on the narrow shelves of the eastern margin of Europe and in Region III, the shelf currents are predominantly from south to north. Coastal upwelling that occurs typically between April and October off the Iberian Peninsula complicates the coastal currents in Region IV. In Region I, currents exhibit complex patterns, particularly around the Region's islands. Off Iceland, the coastal current circles in a clockwise direction.

2.10 **Waves, tides and storm surges**

2.10.1 Waves

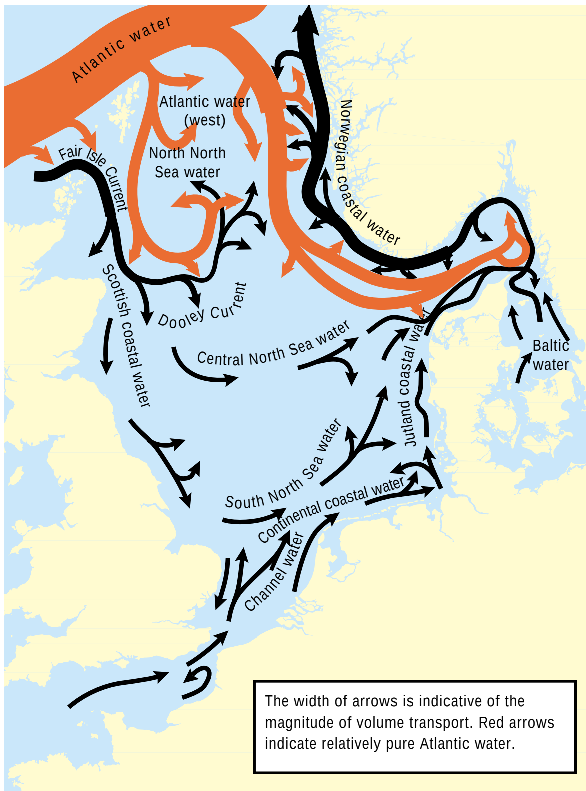
In the open ocean, the wave climate is conditioned by changing wind regimes. Ocean currents and, in shallow waters, strong tidal currents may modify wave fields. In shallow waters, wave activity may also contribute to the mixing of water masses by weakening or destroying stratification. Statistical studies have shown that North Atlantic storms in both open ocean and coastal areas are not increasing in intensity. Although there has been a noticeable increase in mean significant wave height in the North Atlantic, this appears to be correlated with the increasing intensity of the North Atlantic Oscillation (NAO) seen in recent decades. Therefore, the increase in mean significant wave height appears to be positively correlated with the atmospheric zonal mean flow strength, rather than with storm intensification.

2.10.2 Tides

Tides are semi-diurnal throughout the area. In the Atlantic, their amplitude is small relative to those occurring in many of the continental shelf regions. In addition to regular sea level changes, tides also induce oscillating currents over the same period, and these too are strongest on the shelf regions.

Tidal ranges are greatly amplified near the coasts of semi-enclosed seas. The best examples are in the North Sea and the Irish Sea, where heights of up to 8 m or more can be observed. Strong oscillatory currents are often associated with these high tidal ranges and vigorous mixing and sediment resuspension is common in such areas. Tides can generate a net residual flow, and may dominate the circulation of certain coastal regions. Where they are strong enough, the tidal currents can keep the water column mixed in zones marked by tidal fronts. Tidal circulation and fronts affect the distribution of biota and the transport, dispersion and aggregation of pollutants.

Figure 2.5 **A schematic diagram of the general circulation in the North Sea. The width of the arrows is indicative of the magnitude of volume transport. Source: after Turrell *et al*. (1992).**



2.10.3 Storm surges

A storm surge is an unusually high stand of sea level produced when strong winds blow water shoreward and when the ocean surface rises in response to low atmospheric pressure. Partially enclosed shallow water areas are particularly vulnerable to storms surges, which may increase sea level by several metres. Operational numerical models are used in the North Sea to produce reliable forecasts of storm surges.

2.11 Transport of solids

Input of suspended particulate matter (SPM) to the marine environment occurs mainly from rivers and, to a lesser extent, from the atmosphere and from sea-ice. Particle sizes of SPM range from sand (millimetres) via silt to clay (micrometres). In general, the finest particles travel the greatest distances, depending on the dynamic intensity in the conveying medium. Consequently, coastal and shallow water sediments are normally coarser than those found far away from the coast. There may be exceptions to this rule in semi-enclosed narrow bays, like fjords, or on tidal flats, where the dynamic activity of the water is low.

The supply of SPM from land depends both on the existence of soils subject to erosion in the hinterland and on the climatic situation. Therefore, under present climatic conditions, it would appear that SPM enters the OSPAR area mostly in its mid-latitudes, rather than in the drier south.

The mineral nature of the SPM is an important factor for the transport and fate of contaminants in the marine environment. Certain minerals, such as the clays, have a high adsorption capacity for a number of both organic and inorganic contaminants, whereas more silty and sandy fractions consist of inert minerals, which have a negligible adsorption capacity. This adsorption capacity/affinity strongly influences contaminant transport.

2.12 Meteorology

The atmospheric circulation is characterised by a westerly airflow associated with a meandering upper troposphere jet stream. Embedded within this belt of westerly winds are numerous cyclones, which develop along the zones of strongest temperature gradients, the Polar Front, and generally traverse the area from south-west to north-east. The cyclonic activity in the atmosphere is much stronger in winter than in summer.

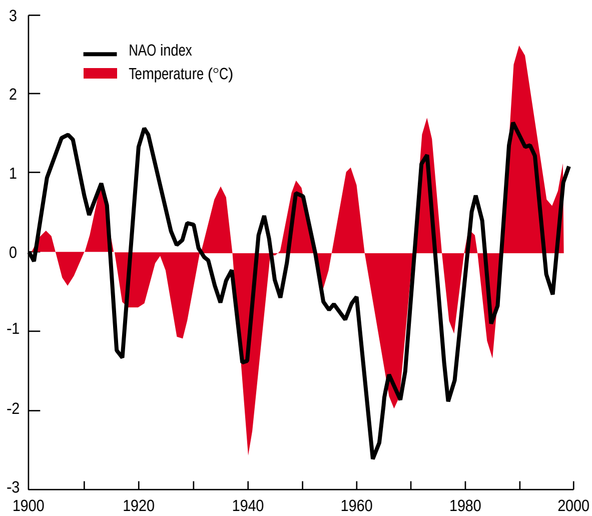
The NAO index is defined as the difference in atmospheric pressure at sea level between the Azores and Iceland and describes the strength and position of westerly airflows across the North Atlantic. Fluctuations in the strength of the westerly winds over the North Atlantic are believed to play a major role in controlling oceanic ecosystems and ultimately North Atlantic fish stocks.

When the NAO index is high, the westerly winds over the North-East Atlantic are strong and numerous cyclones bring wet weather (particularly over the western parts of the British Isles and Scandinavia). In winter, high NAO values result in very mild weather over the eastern OSPAR area and north-western Europe, while summers often become unsettled and chilly. When this pressure difference is unusually small, anticyclones dominate large parts of this area and winter becomes colder. Further to the west, closer to southern Greenland, there is a tendency towards opposite reactions to the variations in the NAO. Thus high values on the NAO index are most often characterised by cold weather with outflow of very cold air from the Arctic region. Periods of low NAO values can be very mild in south-western Greenland, when warm air masses penetrate northwards into the Davis Strait.

2.13 Climate variability and climate change

The NAO index undergoes long-term cycles with varying periodicity. These oscillations have been linked to fluctuations in wind speed, sea temperature, heat fluxes, wave heights, storm tracks, and patterns of evaporation and precipitation. The relatively high NAO index over the past fifteen years *(Figure 2.6)* has been associated with milder

Figure 2.6 **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, for the period 1900 to 1999. Source: after Rodwell *et al.* (1999).**



Normalised, smoothed time series of the observed North Atlantic Oscillation index and north European surface temperatures. The NAO index is calculated as the normalised difference in December to February mean sea level atmospheric pressure between the Azores (Ponta Delgada 26° W 38° N) and Iceland (Stykkisholmur, 23° W 65° N). North European surface temperatures (averaged over the box 5 – 50° E, 50 – 70° N) are taken from a blended data set of land (Jones *et al.*, 1999) and sea surface (Parker *et al.*, 1995) temperatures. The smoothing filter passes variations with periods greater than 6.5 years. Figure produced by M.J. Rodwell is an extension of that given in Rodwell *et al.* (1999).

than normal winters in Europe, and high sea surface temperatures, especially in winter. When considering the NAO index for the present decade, particularly within the context of this century, the 1960s were generally low-index years while the 1990s were high-index years.

The energy release by the North Atlantic warms the air over Europe. North-western Europe and the northern North Atlantic region, in particular, have a climate that is some 5 – 10 °C warmer than the zonal mean. This gives a climate, which is very benign relative to the same latitudes elsewhere. Yet this has not always been the case. Past climatic records reveal that there have been several occasions when, for reasons not yet firmly established, the climate of Europe suffered major cooling events that occurred very rapidly (10 to 100 years). The global thermohaline circulation (or 'Ocean Conveyor), and its switching on and off in the North Atlantic, has been suggested as the source of these rapid and potentially disastrous fluctuations. A variety of historic records suggest that such a rapid shift could happen again, particularly if atmospheric levels of carbon dioxide increase steeply.

The UN Intergovernmental Panel on Climate Change (IPCC) has drawn a number of conclusions concerning the impact of climate change over Europe and the North Atlantic (IPCC, 1997). They noted that most of Europe experienced temperature increases this century larger than the global average together with enhanced precipitation in the northern half and decreased precipitation in the southern half of the region. Projections of future climate, not taking into account the effect of aerosols, indicate that precipitation in high latitudes of Europe may increase, with mixed results for other parts of Europe. The effects of aerosols mainly exacerbate the current uncertainties about future precipitation.

The IPCC further noted that water supply might be affected by possible increases in floods in northern and north-western Europe and by droughts in southern parts of the continent. A warmer climate could lead to reduced water quality, particularly if accompanied by reduced run-off. Warmer summers would probably also lead to increased water demand. Expected changes in snow and ice will impact upon European rivers, affecting, for example, summer water supply, shipping and hydropower.

The IPCC report also notes the ecological importance of coastal zones. Some coastal areas are already beneath mean sea level, and many others are vulnerable to storm surges. Areas most at risk in Europe include the Dutch and German coastal zones. Storm surges, changes in precipitation, and changes in wind speed and direction add to the concern of coastal planners. In general, major economic and social impacts can be contained with relatively low investment. This is not true, however, for a number of low-lying urban areas vulnerable to storm surges, nor for ecosystems, particularly coastal wetlands, which may be even further damaged by protective measures.

There is some evidence of a change in the climate of the OSPAR area, or, at least, of some changes in the ocean circulation and water mass characteristics. The amount of Atlantic water in the Arctic Ocean has increased during recent years, the temperature in the deep water of the Norwegian Sea has increased and there are indications of changes in the Iceland–Scotland Ridge overflow. The Annual ICES Ocean Climate Status Summary shows relatively high temperatures in the North Atlantic during the 1990s. Most areas show a warming trend, although the temperature has been going down in the subpolar North Atlantic, between Greenland and Iceland (Read and Gould, 1992).

There is a poor understanding of observed ocean climate variability, because of the complex interaction of forcing parameters. A better understanding of the cause of ocean climate variability is of major importance in predicting future climate impacts. Also the impacts of the climate change are rather uncertain. Some climate change models are predicting a global sea level rise. A mean sea level rise of 50 cm during the next 100 years has been forecast, putting low-lying coastal areas and wetlands particularly at risk from flooding.

chapter 3

Human activities

3.1 Introduction

This chapter is devoted to the various human activities that influence the coastal and offshore environments of the North-East Atlantic. The changes that are occurring especially to coastal marine ecosystems are largely a function of human intervention and an assessment of these changes needs to be made in relation to those activities that have large-scale and persistent consequences for habitats, biological diversity and productivity. In attempting to assess the causes of environmental change, it is particularly important to understand how these activities (i.e. the sources of change) are themselves changing with time.

At present, a balanced description of human activities affecting the marine environment is difficult. Most countries do not routinely compile demographic statistics, and related land-use (industrial and tourist) data, specifically for the coastal zone (e.g. within 10 km of the sea) and trends are therefore difficult to assess accurately. In addition, there is a lack of harmonised data on economic parameters associated with human activities. Although efforts have been made to gather the most readily available data for the current assessment, the information presented is far from balanced and complete and there are considerable disparities between countries and regions. Nevertheless, this chapter gives an indication of the general patterns of the human activities across the maritime area.

Many of the coastal states bordering the North-East Atlantic are densely populated, highly industrialised or use land intensively for agriculture. As a consequence, the region is affected by many human activities that result in inputs of nutrients and harmful substances, and the introduction of hazardous substances through rivers, the atmosphere and direct domestic and industrial discharges.

The OSPAR countries make use of the seas for fishing activities, offshore oil and gas exploration, the laying of pipelines, extraction of sand and gravel, dumping of dredged material, the laying of cable routes and energy cables and as transport routes. There is growing traffic between European States and other parts of the world, and the North Sea is one of the most frequently traversed sea territories in the world.

Many coastal zones are intensively used for recreation. In several regions there is increasing competition for the use of certain facilities and amenities on, or adjacent to, the coasts. There is growing demand for housing, commercial sites, rented accommodation and improved services. There is also an expanding market for clean beaches, watersports, angling, ecotourism and unspoilt coastal landscapes. These interests are not always compatible.

Most States in the North-East Atlantic have declared an Exclusive Economic Zone (EEZ), making use of the UN Convention on the Law of the Sea (UNCLOS), which distinguishes between three categories:

- the 'territorial seas' (mostly 12 nm), subject to coastal state jurisdiction;
- the EEZ extending up to 200 nm offshore (350 nm including the continental shelf); in the EEZ the coastal state has the exclusive right of exploitation and fisheries and is responsible for regulating pollution from seabed installations, dumping, and other activities; and
- the 'high seas' beyond the EEZ, neither subject to national jurisdiction nor sovereignty.

International conventions and regulations, such as the International Convention for the Prevention of Pollution from Ships (MARPOL) and the London Convention, apply both within and outside of the EEZs.

Measures and regulatory framework for the protection of the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected are described under Section 3.16. Adopted measures concern hazardous substances known for their environmental risk and mentioned in the various OSPAR Strategies, such as polychlorinated biphenyls (PCBs), and heavy metals, radioactive substances and nutrients. Another OSPAR Strategy concerns the protection and conservation of ecosystems and biological diversity of the maritime area. Measures have been adopted to address several industrial sectors and diffuse sources (e.g. inputs of phosphorus and heavy metals have been substantially reduced, but other substances (e.g. nitrogen) have not been substantially reduced). Traffic separation schemes have been established in order to reduce the risk of accidents. Fisheries have been regulated through the application of technical measures and Total Allowable Catches (TACs).

The framework for environmental protection of the Convention area has developed extensively during the past twenty years through initiatives by the European Union (EU) and the International Maritime Organization (IMO). Furthermore, initiatives were taken in accordance with the OSPAR and preceding Oslo and Paris Conventions, and through the Bonn Agreement, the Helsinki Convention, the International Conferences on the Protection of the North Sea and the Trilateral Wadden Sea Conferences. There are no special agreements between East Atlantic and West Atlantic coastal states.

Table 3.1 Estimated population size and density in the catchment areas of the OSPAR Regions.

	Population size (millions)	Population density (inh/km^2)
Region I		
Faroe Islands	0.04	
Finland (1997)	0.009	2
Greenland (1995)	0.004	
Iceland (1996)	0.27	2.4
Norway (1996)	1.1	7
Russia (1989)	1.2	
Region II		
Belgium	10.1	333*†
Czech Republic (1996)	10.3	131*†
Denmark	2.2	122*†
France	25.3	107†
Germany	72.5	229*†
Liechtenstein (1996)	0.031	194*†
Luxembourg (1996)	0.4	161*†
Netherlands	15.6	381†
Norway	3.3	14*†
Sweden	2.4	20*†
Switzerland	5.7	171*†
UK	36.4	280
Region III		
Ireland	3.6†	52†
UK	22.3	203
Region IV	47.2	71
France	16.7	64
Portugal	9.5	106
Spain	21.1	67
Region V		
Azores – Portugal	0.24	103

* relates to the whole country not just the catchment area; † data from 1996 Fischer Weltalmanach (1999) (all other data from the regional QSRs).

3.2 Demography

The human population in the catchments of the five OSPAR Regions ranges from 240 000 in Region V (Azores only) to 184 million in Region II *(Table 3.1)*. Population densities vary from 2.4 inh/km^2 (Iceland, northern Norway, Scottish Highlands) to 381 inh/km^2 in the Netherlands *(Table 3.1)*. Populations in coastal areas often show considerable seasonal variation due to tourism. The human population in Regions III, IV and V tend to concentrate in coastal towns creating growing competition and conflict between the exploitation of natural resources, and the consequent development, and the need for nature conservation. The same is also true for Region I, but because of the low population density the pressure on the coast is not nearly as high as in Region II. Population density and land cover in coastal areas are shown in *Figure 3.1*.

The mean annual population growth between 1990 and 1996 recorded in Iceland was 1% and in Norway 0.5%. In 1996 the population in the EU grew by more than 1 million people (0.3%) to a total population of 373 million *(Figure 3.2)*. Since the mid-1980s, immigration has influenced population growth in the EU; approximately 80% of the growth in 1995 was due to immigration.

Extrapolating present trends in birth rates, death rates and migration, results in the population of the OSPAR Member States (with exception of Finland, Luxembourg and Switzerland) reaching a maximum of about 312 million in 2025 (Eurostat, 1997).

3.3 Conservation

3.3.1 Ecological conservation

Modifications to coastal areas resulting from human activities have been accompanied by changes to and losses of habitats and ecological disturbance. In recognition of this, OSPAR Contracting Parties are signatories to several international conventions concerning the conservation of coastal and offshore environments, and all OSPAR Contracting Parties have established conservation areas within the framework of international conventions or national regulations *(Table 3.2)*. Some offshore areas and some species (e.g. whales and migratory birds) are also protected by conventions. In 1998, the OSPAR Convention was expanded by a further Annex to include protection and conservation of ecosystems and biological diversity.

Table 3.2 International conventions for ecological conservation.

	Region
The Bird Directive focuses on the preservation, maintenance and re-establishment of a sufficient diversity and surface area of appropriate habitats to classify Special Protection Areas (SPAs)	SPAs have been designated or are still being designated in all OSPAR Regions
The Habitats Directive concerns the conservation of natural habitats as well as wild plants and animals and plans for the designation of special areas of conservation (SACs) before 2004. These zones will be coupled with specific plans for management and restoration. Under this directive all whales and turtles are fully protected	SACs have been designated or are still being designated in all OSPAR Regions
The Ramsar Convention protects wetland areas of international importance, particularly those containing waterfowl habitat	several areas and sites in Regions I, II, III and IV are protected by this convention
Biosphere Reserves are areas of terrestrial and coastal ecosystems which are internationally recognised within the framework of UNESCO's Man and the Biosphere (MAB) Program. Each Biosphere Reserve is intended to fulfil three basic functions: conservation, development and logistics	several areas in Regions II, III and IV are parts of the MAB
The Bonn Convention on Migratory Species (1979) protects migrating species by a number of subsidiary agreements: **the Agreement on the Conservation of Seals in the Wadden Sea** *(1990)* (as a consequence of the 1988 seal epidemic the Wadden Sea States gave special protection to the common seal population); **the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS)** (all small cetaceans are protected)	
The African Eurasian Waterbird Agreement for the protection of migrating waterbirds aims at protecting the most important breeding, feeding, resting and overwintering areas in the African-European region	

Figure 3.1 **Population density and land cover in coastal areas. Source: EEA (1999).**

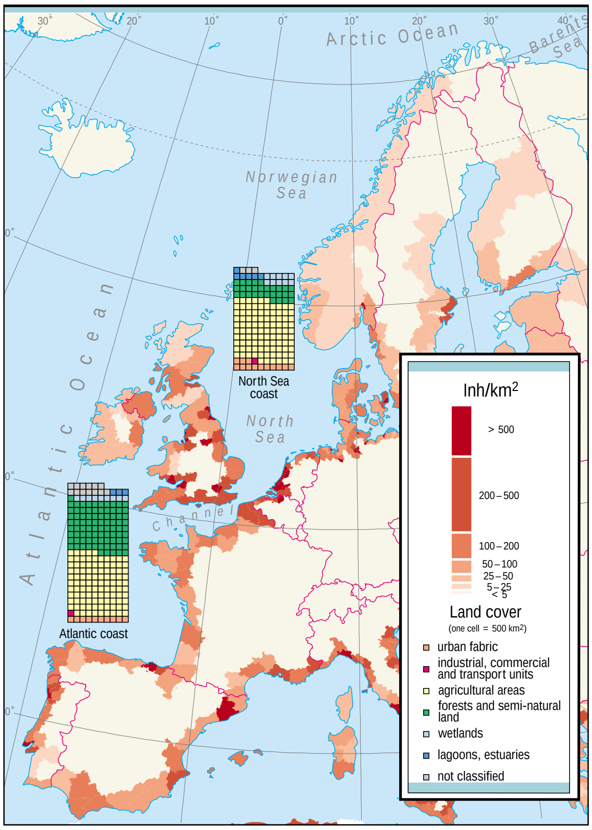
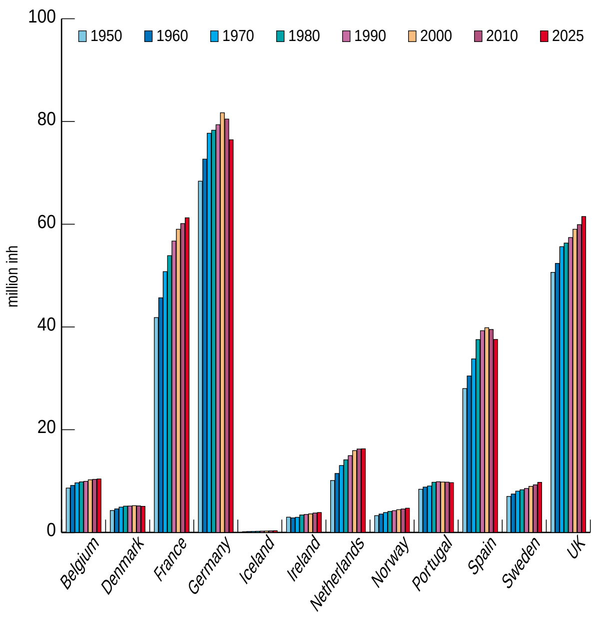


Figure 3.2 **Population change between 1988 and 1996. Source: Statistisches Bundesamt (1995).**



Both national legislation and EC directives are important instruments in protecting marine ecosystems. Examples are the EC Directive on the conservation of wild birds (79/409/EEC) and the EC Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC). Within that framework a coherent ecological network of habitats shall be established (NATURA 2000). Additionally, countries have developed a number of national designations. In Iceland and Norway where these EC directives do not apply, nature protection areas are predominantly land-based, although some coastal areas are protected or have been identified for protection.

3.3.2 Archaeological conservation

Numerous old wrecks and other features of archaeological importance such as ancient tombs and buildings can be found on the coasts of the OSPAR area. They have little significance for the ecology of the area but they are part of its marine heritage, may attract scholars and tourists and are worthy of protection. Examples are the submerged villages off the south-east coast of England and the numerous archaeological remains.

Numerous old shipwrecks can be found on the seabed around the coastline of all Regions (3000 off the coast of Northern Ireland alone). Many vessels foundered during the Fifteenth Century in the Azores (800 wrecks) and between the Sixteenth and Nineteenth Centuries around Spain and Portugal.

Archaeological remains and shipwrecks are subject to the risks of disturbance and destruction by mineral extraction, navigational dredging, pipe laying and pollution. Special legislation for protecting marine archaeological relics exists in all Regions. The European Convention on the Protection of the Archaeological Heritage (1992; ratified by Norway 1995) regulates sites of cultural heritage significance, both on land and in the sea. Moreover, a draft convention on the underwater cultural heritage is under discussion within the UN system.

3.4 **Tourism and recreation**

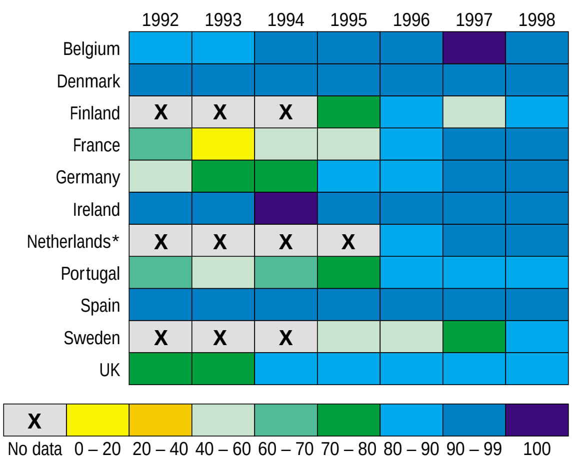
Coastal areas provide many opportunities for leisure and recreation that attract both local people and tourists from inland and abroad. Camping and bathing, sailing, recreational fishing, surfing, scuba diving and bird- and whale-watching are among the most popular activities. The number of tourists shows a distinctly seasonal pattern. For example, in the Wadden Sea area 75 to 90% of all overnight stays are booked for the period April to October. In several areas the tourist season is increasingly concentrated in the summer months.

In all OSPAR Regions tourism has been growing steadily. For example, in Norway the number of overnight stays in hotels increased during the mid-1990s by 20 to 25%. In the Republic of Ireland it is estimated that since the 1970s the number of day trips to the coasts has increased by almost 600%. Tourist accommodation in the Azores has increased by 83% since 1980. Tourists visiting Iceland increased by about 62% over the period 1990 to 1998. The number of car ferries operating in the area and their carrying capacities have been expanding rapidly and these facilitate the tourist trade.

In the absence of stringent planning controls and sensitive development policies, the attributes of coastal areas that are most attractive to visitors such as unspoilt landscapes, clean uncrowded beaches, sea water fit for bathing and wildlife refuges, can be harmed by the sheer number of visitors, construction, and excessive vehicle and pedestrian traffic.

In the past, bathing water at many coastal sites was contaminated by bacteria and organic material, often as a result of contamination by sewage. As an EC report has shown *(Figure 3.3)*, there has been much improvement recently in bathing water quality primarily through the provision of new or improved wastewater treatment plants. Designated beaches are monitored regularly during the bathing season and the number of beaches complying with the mandatory requirements of the EC Directive (76/160/EEC) is steadily increasing.

Figure 3.3 **Bathing Water Directive compliance in EU countries during 1992 to 1998 (percentage of beaches complying with at least the mandatory values of the Directive). Source: after EC (1999).**



* For 1992 to 1995 insufficient data were available for compliance. This information differs from the EC report where percentages of compliance were presented.

3.5 Fisheries

Fishing has great economic and social importance for most OSPAR countries, and technical developments have led to more efficient exploitation of commercial fish stocks. It is very important that fishing is managed in a sustainable way to avoid overexploitation of the fish stocks and to rebuild those stocks that are believed to be overexploited today. Many target species are now not within their 'Safe Biological Limits' (see footnotes to *Table 5.1*). Fishing also results in the mortality of non-target species and towed fishing gears can impact on benthic communities and cause physical disturbance of the seabed.

3.5.1 Fish

The landings of the main commercial fish species are outlined in *Figure 3.4* and *Table 5.1*.

Norway and Iceland are among the largest fishing nations in the world, with a yearly catch of 2 600 000 and 1 500 000 – 2 000 000 t, respectively. In the Norwegian Sea the catches from the Russian fleet increased from 440 000 t in 1994 to 1 300 000 t in 1998, mainly due to an increase in landings of herring.

In the North Sea at present 30 to 40% of the biomass of commercially exploited fish species is caught each year. The total annual landings in the North Sea (Region II) increased from around 1 million t in 1900 to 2 million t in 1960. During the 1960s the landings increased sharply to about 3.5 million t, followed by a decline to less than 3 million t in recent years; in 1995 landings in the North Sea totalled 2.9 million t, compared to 0.17 million t in the Channel and 0.4 million t in the Kattegat. Over this period, there has been a decrease in the landings of gadoids and an increase in landings of pelagic species and species for industrial processing for fishmeal and oil. Landings from industrial fisheries (mostly sandeels) account for about 55% of the total catch weight in the North Sea. Due to increased beam trawling in the southern and central parts of the area, fishing effort in the North Sea rose between the late 1970s and 1995 when it totalled 2.25 million hours (2 million hours in 1990) (Jennings *et al*., 1999).

In Region III the average yearly landings of fish between 1990 and 1995 were 840 000 t; 75% of which were pelagic species and the remainder demersal. Irish and Scottish fleets account for approximately half the total fish landings in the region.

In Region IV, the major fisheries in economic terms are for tuna, the most noteworthy being the albacore (*Thunnus alalunga*) fishery which extends into Region V ranging from the Bay of Biscay to the Azores (14 000 t), the bluefin (*Thunnus thynnus*) fishery in the Bay of Biscay (yearly 1000 to 4000 t) and the swordfish (*Xiphias gladius*) fishery (6000 t in the entire North-East Atlantic). The species yielding the highest landings are sardine (*Sardina pilchardus*), horse mackerel (*Trachurus trachurus*) and mackerel (*Scomber scombrus*). The fisheries for sardine and anchovy (*Engraulis encrasicolus*) are important for the survival of coastal communities.

In Region V, fisheries aim at large pelagic tuna and tuna-like fish (mainly in the southern sector), deep-sea species on the continental slopes, and demersal and pelagic stocks (other than tuna and related species) in deep oceanic waters. Artisanal fisheries around the Azores and adjacent seamounts target a great variety of species. An important target species in Region V is Atlantic bluefin tuna with annual catches around 40 000 t. Redfish catches peaked in 1994 and 1995, at 94 000 and 127 000 t, respectively. Catch data are sparse and assessment of the status of the stocks in Region V is severely hampered by insufficient monitoring and reporting. Despite this, assessments have been carried out using total international landings data and the French trawl CPUE (catch per unit effort) data for a range of species. The assessments support the view expressed by ICES in 1998, that most deep-water species are currently harvested outside safe biological limits. Fishing effort in the deeper waters tends to be unpredictable, since it waxes and wanes according to the fluctuations experienced by fishermen as their access to other stocks is limited by regulation or overfishing.

Fleets and gear types

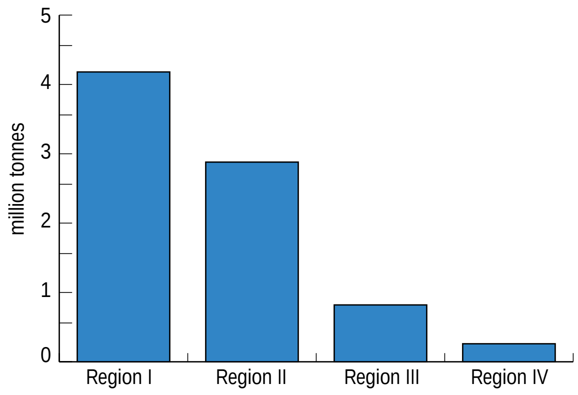
In most Regions the coastal fishing fleets consist mainly of smaller fishing vessels. Additionally, many OSPAR countries have deep sea fishing fleets (e.g. longliners, industrial and factory trawlers). Many nations operate within Region V, including a number of fleets from non-OSPAR countries (e.g. in 1996 282 Japanese longliners operated in the Atlantic Ocean). In the northern part of Region V, the primary fishery is trawling for redfish.

In the North Sea, the capacity of demersal and pelagic fleets was enhanced rapidly after the Second World War. Larger ships with more powerful engines came into operation. Three types of modern fishing vessel are responsible for the majority of the landings: purse seiners for the substantial exploitation of herring (*Clupea harengus*) and mackerel; from the early 1950s otter trawlers started targeting herring, cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), saithe (*Pollachius virens*) and subsequently small demersal and pelagic species, notably sandeel (*Ammodytes* spp.), Norway pout (*Trisopterus esmarki*) and sprat (*Sprattus sprattus*) for the fishmeal and oil industry; the beam trawlers targeting flatfish.

The gear types used are:

- demersal active gear (e.g. otter and beam trawls, demersal seines);

Figure 3.4 **Landings of the commercially important fish species in 1997.**



- pelagic active gear (e.g. purse seines, pelagic trawls); and
- passive gear (e.g. nets, traps, lines).

Some gear types used in North Sea fisheries in relation to target species and by-catch are listed in *Table 3.3*, and the by-catch of some marine mammals owing to fishing activities is shown in *Table 3.4*.

Discards

In Icelandic and Norwegian waters, regulations prohibit the discarding of commercially important fish. Fleets subject to EU regulation are obliged to discard undersized fish. Commercial sized fish may also be discarded when catches are in excess of the quota or to maximise economic returns from the catch (high grading). Many discarded organisms die. Discarding of young fish is considerable on inshore nursery grounds as well as in the mixed roundfish fisheries. The levels of discarding vary largely by species, areas, fleet and season.

In Region II, the estimated average percentage of cod and haddock discarded in North Sea demersal fisheries are 22% and 36% respectively by weight and 51% and 49% by numbers (5NSC, 1997). In the beam trawl fishery, approximately half the numbers of plaice (*Pleuronectes platessa*) caught are discarded, although on inshore grounds this may be as high as 80%.

In 1996, estimates from one of the demersal fleets operating in Region III indicated that about 18%, by weight, of the total catch was discarded. However, this is considered to be a conservative estimate of the extent of discarding. In Nephrops fisheries, just under half a tonne of whiting (*Merlangius merlangus*) is discarded for every tonne of Norway lobster (*Nephrops norvegicus*) landed from the Irish Sea.

Within Regions III and IV, the discarding of pelagic species is generally below 25% of the total weight caught by trawl gears. There is a lack of reliable information on discards by purse seiners. Occasionally whole catches may be discarded because they are under the marketable size.

Demersal and pelagic fisheries in Region V have been expanding rapidly. Only in a few cases have by-catch and discard rates been studied, indicating that weights of discards often equal the weights of the fish that have landed.

3.5.2 Shellfish (crustaceans and molluscs)

Landings of shellfish are listed in *Table 3.5*.

The most common methods employed in directed fisheries for shellfish are dredges (mechanical for scallops, oysters and blue mussel (*Mytilus edulis*), and suction for cockle (*Cerastoderma edule*)), trawls for Norway lobster and shrimp, and pots for Norway lobster, edible crab (*Cancer pagurus*) and lobster (*Homarus gammarus*).

In all Regions the largest landings by weight originate from the fisheries for shrimp, mussel and cockle *(Table 3.5)*.

Outside the Arctic and Wider Atlantic regions the major commercial crustacean is the Norway lobster, which is caught by trawl and pots on muddy ground in a range of locations in coastal waters, near seas, and along the western shelf. Potting for edible crab has also been increasing in the Channel, Western Approaches and off the Irish–Scottish west coast. Potting for lobsters remains locally important in many coastal areas but fishing is gradually spreading further offshore. Landings from the brown shrimp (*Crangon crangon*) fisheries show substantial natural fluctuations year on year, but landings from the other crustacean fisheries are more stable, although most of the stocks are fairly heavily exploited.

In addition to the large-volume mollusc fisheries for mussel and cockle, fishing effort has been increasing steadily in many great scallop (*Pecten maximus*) and queen scallop (*Chlamys opercularis*) fisheries. New fisheries are also being developed for whelk (*Buccinum undatum*), razor clams (*Ensis directus*) and *Spisula* sp. Most mollusc stocks are heavily exploited, and some scallop and cockle fisheries are giving rise to management concerns. Mollusc stocks invariably show substantial natural variations in recruitment, which contribute to the difficulties in assessment and fishery management.

3.5.3 Seaweed

The harvesting of seaweed (algae) for use in alginate and

Table 3.3 Some of the gear types used in North Sea fisheries in 1996 in relation to target species and the by-catch of target and non-target species. Source: 5NSC (1997). Where this type of fishery occurs this table is also representative for the other OSPAR Regions.

	Fisheries	By-catch
Demersal active gear		
otter trawl (human consumption fisheries)	Norway lobster, roundfish and some pelagic species	unwanted sizes of target and non-target species of fish and other vertebrates
otter trawl (industrial fisheries)	small fish species (sandeel, Norway pout, sprat)	human consumption fish species
demersal seines:		
single and pair	human consumption fish species (roundfish and flatfish)	unwanted species and sizes of fish
beam trawl:		
light nets equipped with bobbins	brown shrimp	significant by-catch of flatfish and benthic organisms
heavy gear equipped with chains	flatfish (mostly sole and plaice)	juvenile target species, non-target fish and benthic organisms
dredges	molluscan shellfish	flatfish, damage to target and non-target species
Pelagic active gear		
purse seines, pelagic trawl, single and pair	shoaling pelagic species (herring, mackerel and sprat)	low by-catch of non-target species, unmarketable* fish released dead or damaged
Passive gear		
nets:		
gillnets, demersal set nets	human consumption fish species (cod, turbot, plaice, sole and others)	seabirds, harbour porpoise (for which species gillnets are the main source of by-catch)
drift nets	tuna	dolphins
traps:		
portable baited traps and coastal trap nets	crustacean shellfish and salmonids	undersized and non-target shellfish
lines:		
longlines and handlines†	deep-water demersal fish species	seabirds

* unmarketable non commercial species or undersized commercial species; † little used in the North Sea.

Table 3.4 By-catch numbers of some marine mammals owing to fishing activities on a species and gear type basis for the OSPAR Regions. Source: after ICES (1998).

	Number by-caught per year	Gear type	Comments
Region I			there have been no direct assessments of by-catches of marine mammals in Region I during the 1990s
Region II			
harbour porpoise	average 6785 (range: 8061 in 1994 to 5031 in 1998)	bottom-set nets	Danish observer programme (Vinther, 1999) central North Sea
	113	gillnets	observer programme, Swedish Skagerrak
Region III			
harbour porpoise	2200 (95% confidence limits 900 – 3500)	bottom-set nets	observer programme, estimate does not cover smaller boats
Region IV			
common dolphin	204*	drift nets	
striped dolphin	573*	drift nets	
Region V			
common dolphin	330 – 400	drift nets	observer programme. French fishery
striped dolphin	1135 – 1160	drift nets	observer programme. French fishery

* data from French albacore drift netters during 1992–3 (see also section 5.3.4).

fertiliser production, and occasionally for pharmaceutical use, is a significant industry along parts of the coastlines of Regions I, II and III. The main species harvested are knotted wrack (*Ascophyllum nodosum*) and kelp (*Laminaria hyperboria, L. digitata*). Typical quantities of algae harvested annually in recent years are on average 180 000 t in Norway, 72 000 t in France, 40 000 t in Ireland and 12 500 t in Iceland.

3.5.4 Fisheries management

The overall objective of fisheries management is to ensure sustainable use of fish resources. Management of the fisheries in the OSPAR Convention area is regulated within EU waters under the EU Common Fisheries Policy, and within Faroese, Icelandic and Norwegian waters by national policy and legislation. There is a general overcapacity in most of the fleets fishing in the OSPAR area. The EU and the Icelandic and Norwegian authorities have implemented measures intended to decrease the fishing effort by special programmes. In the EU fleet the reduction has been compensated for by an increase in efficiency, with the result that no reduction in fishing pressure is achieved (5NSC, 1997). The Northeast Atlantic Fisheries Commission (NEAFC) aims at promoting conservation and optimal utilisation of straddling fish stocks in the North-East Atlantic area. For the North Sea, the Intermediate Ministerial Meeting on the Integration of Fisheries and Environmental Issues held in 1997 (IMM 1997) recognised problems to achieve agreed goals and requested the development and application of an ecosystem approach to the management and protection of the North Sea. The International Commission on Conservation of Atlantic Tuna (ICCAT) is responsible for the international management of the fisheries of large pelagic tuna and tuna-like fish.

A wide range of national conservation measures have been introduced to protect vulnerable life stages of different stocks, including permanent inshore nursery areas, temporary closures to protect juvenile fish and spawning area closures at peak spawning times of the year. A 12 nautical mile coastal limit to exclude large trawlers is in place in most regions and technical conservation measures such as mesh sizes and sorting grids are widely used to reduce the capture of juvenile fish. Other measures have been aimed at restricting effort through licensing schemes and days at sea limitations.

The main tools at present agreed upon in fisheries (fish and shellfish) management are:

- setting of the Total Allowable Catch;
- technical measures (such as minimum mesh size, minimum landing size);
- fleet reduction programmes; and
- effort restrictions.

The most widely used tool in fisheries management is the yearly setting of TACs. This is done both on national bases, by international fora (e.g. NEAFC, ICCAT) and by the EU based on advice from ICES. The advice from ICES is intended to provide a precautionary approach to fisheries management. As a means to achieve this, ICES has suggested precautionary reference points for spawning stock biomass and fishing mortality. However,

Table 3.5 Landings or catches of the main crustacean and mollusc species.

	Landings/catches (t)	Location
Region I		
crustaceans		
pandalid shrimp	56 000 (1998)	Icelandic waters
	32 000 (1996)	North-east Atlantic
	9 000 (1996)	East Greenland
molluscs		
Iceland scallop	10 000 per year	Iceland
ocean quahog	4300 to 7700 (since 1996)	Iceland
Region II		
crustaceans	catches:	
Norway lobster	12 000 to 20 000 per year	Skagerrak, Kattegat, Moray Firth, Farn Deep, Firth of Forth, Fladen Ground
pandalid shrimp		Norwegian Deep, Fladen Ground
brown shrimp	25 000	in all coastal regions from Denmark to northern France and in some areas of the UK. The main area is near the Wadden Sea
edible crab		
spider crab		
lobster		
molluscs	catches:	
blue mussel	~ 150 000 (mean for 1990 to 1995)	east coast of England, the French Channel coast and the Wadden Sea
cockle	in the Netherlands 50 000 ww	Moray Firth, Wash, Dutch Wadden Sea, Delta area, to a limited extent in Denmark
scallop	~ 2500 per year	Orkney, Shetland, Moray Firth
Spisula spp.		
whelk		
winkle		
Region III		
crustaceans		
Norway lobster, crabs lobster, shrimp	96 000 (1995)	
molluscs		
blue mussel, clam, queen scallop, scallop, cockle, whelks		
Region IV		
crustaceans		
Norway lobster	3400 (1997)	
total landings of prawns and large crustaceans	< 2500 (1997)	
molluscs		
cephalopods	17 600 (1997)	

these precautionary levels are relevant for single stocks and may not be considered as being precautionary with respect to multi-species interactions nor to wider ecosystem effects. In the management of fisheries resources, social and economic considerations also need to be taken into account.

International TACs, and national allocations within the TACs, are agreed for the main commercial fish stocks and also for Norway lobster, northern prawn (*Pandalus borealis*) and other shellfish.

The accuracy of annual stock assessments and TACs depends upon good quality catch data. Illegal landings and unrecorded discards undermine the accuracy of stock assessments and thus the TACs. Programmes to monitor fisheries for discards have been implemented in only some fisheries and usually only in very recent years.

Few data from these programmes have yet been provided for use in assessing stocks.

Technical measures are designed to control aspects of the fishery such as mesh size, net geometry, minimum landing size, by-catch limits, closed seasons and closed areas. Enforcement is a national responsibility and is assisted by, for example, vessel inventories and licences, logbook regulations and satellite monitoring. At European Community level, a revised package of technical measures came into force EU-wide on 1 January 2000. These are designed to improve selectivity and thereby reduce discards, and include the mandatory introduction of square mesh panels into certain nets, limitations on twine and rules on gear construction. In addition, specific controls were introduced to deal with the problem of cetacean by-catch; and as from 1 January 2002 the use of high seas drift nets to catch tuna and other species will be prohibited.

From 1992 to 1996 the EU Multi-Annual Guidance Programme (MAGP III) aimed at reducing the capacity of fleets by reducing tonnage and engine power used catching roundfish by 20% and fleets targeting flatfish by 15%. In a report in 1997 the European Commission noted that the implementation of the MAGP III was successful as regards restructuring the fleets (EC, 1997). Between 1991 and 1996 the EU fleet tonnage and engine power were reduced by more than 10% *(Figure 3.5)*. Although fleets have been reduced, the North Sea IMM 1997 criticised that 'the reduction has been compensated for by an increase in efficiency, with the result that no reduction in fishing pressure has been achieved'. On account of this, the European Commission adopted MAGP IV for the period 1997 to 2001, aiming to reduce the fishing effort by up to 30% on stocks considered to be outside safe biological limits. In 1998, Norway introduced a decommissioning scheme for coastal vessels, similar to that for purse seiners in 1996. Other regulations were aimed at prohibiting access of new trawlers to the shrimp fisheries. Norway has halved the number of vessels from 26 642 (in 1982) to 13 251 (in 1998) while the engine power (1 136 178 KW in 1982 and 1 236 989 KW in 1998) and the gross tonnage (295 925 t in 1982 and 275 524 t in 1998) have remained nearly constant.

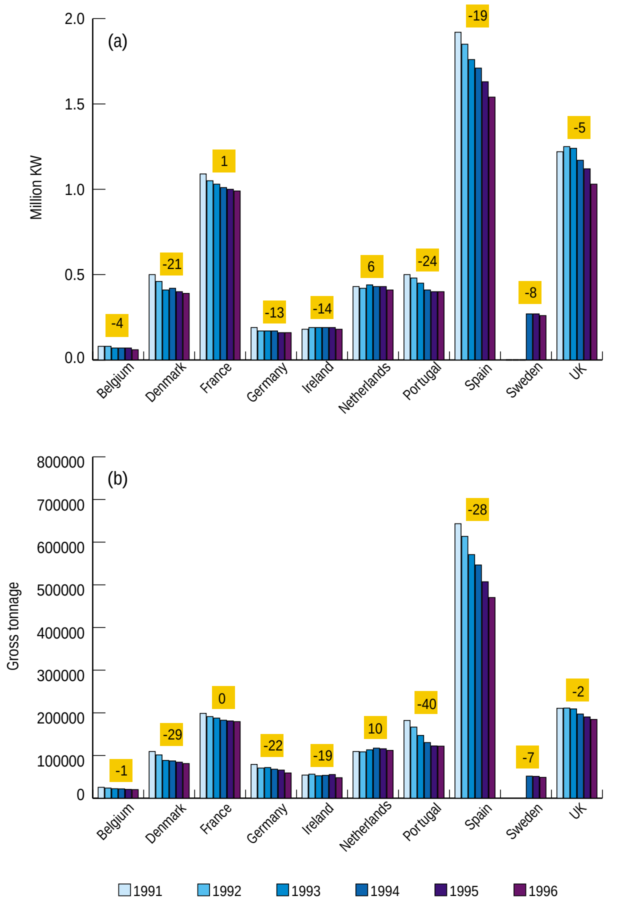
In Iceland, the fisheries management system was introduced with the view to making sure that active fishing capacity does not surpass the carrying capacity of the commercially exploited stocks. This is achieved by the use of Individual Transferable Quotas (ITQs). Every year, based on rigid scientific assessment and prognosis, a TAC is established for nearly all the species that are fished on a commercial basis. To ensure that the TAC is not surpassed, while maximising the economic efficiency of the fishing operations, the Government of Iceland extended in 1990 the ITQs system introduced in 1984, to cover all the commercial species. At the beginning of each fishing year the TAC for individual species is divided between all the fishing vessels which hold a quota share for the species concerned. The quotas are divisible and transferable, which affords the fishing operations the necessary flexibility to maximise their economic return from limited catch. Thanks to the fisheries management system, the active fishing capacity in Iceland has reduced, whether considering the number of fishing vessels, the value of the fishing fleet or the tonnage. For instance there was close to a 38% reduction in demersal fishing efforts in the period from 1984 to 1997.

Shellfish fisheries are under national management in Iceland and Norway; in the EU area these fisheries are not completely EU-regulated because of the localised nature of the stocks. Existing regulations are directed at the restriction of fishing techniques, a reduction in fishing effort (absolute or by temporal or spatial restrictions) as well as minimum landing size or a combination of these practices (OSPAR, 1998a). Norway lobster and northern prawn fisheries are, however, regulated by TACs.

3.5.5 Hunting

Approximately 20% of the population of Greenland is directly or indirectly dependent on hunting activities. The most important resources are ringed seal (*Phoca hispida*) and harp seal (*Pagophilus groenlandicus*), but a wide variety of other mammal species are also taken. In the OSPAR area the whaling activities are managed through two international organisations, the North Atlantic Marine Mammal Commission (NAMMCO) and the International Whaling Commission (IWC), for parties to these organisations. With the exception of minke whales (*Balaenoptera acutorostrata*) and pilot whales, whales are not harvested in the maritime area. The Management Committee of NAMMCO considers that for the Central Stock Area the minke whales are close to their carrying capacity and that catches of 292 animals per year (corresponding to a mean of catches between 1980 and 1984) for the whole central North Atlantic are sustainable. This issue has not yet been considered by the IWC. In the Faroe Islands, the annual traditional whaling for long-fin pilot whale (*Globicephala melaena*) averaged 850 individuals out of a stock of 800 000 individuals. Hunting of small cetaceans like the narwhal (*Monodon monoceros*) and the beluga (*Delphinapterus leucas*) are not under IWC authority, but hunting is regulated bilaterally between Greenland and Canada. Recent assessments by the bilateral commission have concluded that the harvests of narwhal and beluga are sustainable overall, although concerns remain that some sub-components of the greater stock complexes may be over harvested. The areas and species used for hunting and fishing vary by location and season. Polar bear (*Ursus maritimas*) are hunted in

Figure 3.5 **Implementation of EU MAGP III (1992 to the end of 1996): (a) reduction of engine power of fishing fleets, (b) reduction of gross tonnage of fishing fleets.**



-5 Percentage change in situation for 31.12.1997 with respect to objectives for 31.12.1996.

These figures should not be interpreted without reference to the explanations given in the text for each Member State.

northern Greenland. Traditionally, seabirds are also caught; the catch is regulated by law as regards species, periods and methods.

3.6 Mariculture (fish and shellfish farming)

During the last decades there was a strong increase in the use of intensive forms of aquaculture such as the mass production of salmon in net cages, and in some countries mariculture production has become comparable in economic value to that of the demersal and pelagic fishing. Concerns about the environmental impacts of mariculture are discussed in Chapter 5 and relate to the following: localised enrichment of sediments; the use of various pharmaceuticals and chemicals; the potential threat to wild fish populations of the transfer of parasites and diseases and genetic interactions with fish escaped from farms.

According to an assessment of data supplied by the UN Food and Agriculture Organization (FAO), aquaculture production in the OSPAR area in 1997 was about 1.1 million t *(Table 3.6, Figure 3.6)*. The largest aquaculture producer was Norway, with a volume (mostly salmon), corresponding to 35% of the total marine production of the OSPAR Contracting Parties, followed by Spain (18%) and France (18%) (mostly shellfish in the latter two countries). Other major producers were the UK and the Netherlands *(Figure 3.6)*.

3.6.1 Fish

Fish farming is undertaken in all OSPAR Regions, with the exception of Region V. Mariculture is now a major industry in Ireland, Norway and Scotland. The main aquaculture species are salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*) (Regions I, II and III). Other species are halibut (*Hippoglossus hippoglossus*), Arctic char (*Salvelinus alpinus*), cod, turbot (*Psetta maxima*) (Regions I, II and III) and eel (*Anguilla anguilla*), as well as seabass (*Dicentrarchus labrax*) and sea bream (*Diplodus* sp.) (Region IV).

3.6.2 Shellfish

Crustacean production is quite low in all OSPAR Regions. In all Regions other than Region I the main mariculture species are blue mussel and oysters (*Ostrea edulis*, *Crassostrea gigas*). There is increasing interest in scallops and queen scallops in Region III.

In Region II, mollusc species including blue mussel are cultured in the Wadden Sea and in the Oosterschelde, along the coast of Brittany, in Norway, Sweden and the UK. Oysters are cultured mainly in the Orkney, Shetland, and other Scottish regions, in the east and south-east of England, in the south-west of the Netherlands, in Norway, and along the coasts of Normandy and Brittany.

In Region III, cultivation of wild stocks of shellfish has been practised for more than a century but in recent times attention has turned to the culture of shellfish hatchery reared stocks. In the UK part of Region III the value of shellfish cultured doubled between 1991 and 1995. In Ireland the tonnage of shellfish produced exceeds production of finfish, due to the rapid expansion of longline culture of blue mussels.

In Region IV, French oyster and mussel cultivation (3500 farms) produces 80 000 t/yr. Spain produced 200 000 t/yr molluscs (90% mussel culture) between 1987 and 1996. Other species are clams and oysters (4000 t/yr for each group). In Portugal clams, oysters and cockles (total 3000 t/yr) are produced.

Table 3.6 Marine aquaculture production in 1997 (tonnes) within the OSPAR area and the Baltic Sea. Source: national data; FAO (1999).

	Salmon	Rainbow trout	Turbot	Blue mussel	Oyster
Denmark*		667			
Faroe Islands*	21 103	1 435			
France	650	232	980	52 350	135 650
Germany		28		22 330	
Iceland	2 513				
Ireland†	15 442	1 020	30	16 371	3 535
Netherlands			25	93 244	1 200
Norway	331 367	33 491		502	
Portugal			196	455	
Spain	851		1 800	188 793	
Sweden		2 166		1 425	
UK	99 422			13 127	400

* national data and reflecting production in the North Sea; † national data from Ireland.

3.7 Coastal engineering and land reclamation

Factors contributing to shore erosion include tidal action, littoral currents and rising sea levels. Apart from these natural phenomena, coastal defence works and infrastructures may locally contribute to significant erosion. Sea surface levels are rising very slowly by natural processes – 50 m over the last 10 000 years, currently 1.5 to 1.9 mm/yr for major parts of the OSPAR area – but there are signs that the rate may be increasing due to global climate warming, especially the thermal expansion of oceanic water.

On parts of the Celtic Seas and Biscay/Iberian coastlines, erosion rates are in the range 0.5 to 1.5 m/yr and, in a few cases, up to 2 m/yr (north of Liverpool). Winds tracking along the shoreline also contribute to coastal erosion. The movement of sand from coastal beaches toward the interior can be significant, ranging from 20 000 to 40 000 m^3/yr (e.g. the coast of Les Landes in France), to extreme values of 200 000 m^3/yr (e.g. Pyla dunes) per kilometre of coastline. Rocky and volcanic coasts (e.g. the Arctic and Azores) are resistant to erosion.

3.7.1 Coastal defence

Coastal defences are necessary on exposed, soft and low-lying shores of Regions II and III and on parts of the French and Portuguese coasts in Region IV. According to the local situation sea defence works have been undertaken for decades using rock armouring, construction of breakwaters, piers and jetties or beach replenishment. Coastal land reclamation and diking change the physical environment and in some cases may reduce spawning areas, biological diversity and sanctuaries for wildlife.

Around the North Sea coastal defences are common, particularly on the shallow south and east coasts, the Wadden Sea and on islands vulnerable to storm surges and sea level changes. Beach protection is partly accomplished by offshore breakwaters. Dunes are occasionally protected by hard structures – although this may prevent natural beach nourishment by sediment transport and cause enhanced erosion elsewhere. The present tendency is to use artificial nourishment. In 1996 the Netherlands replenished 7.7 million m^3 of sand and may need to double this quantity to keep ahead of the predicted rise in sea level. In other parts of the North Sea there are plans to improve coastal defences through the restoration of natural coastal dynamics.

On coasts of the Celtic Sea there are large areas of land bordering estuaries, or close to centres of population or industry, that have been protected by sea walls. In the upper reaches of the Bristol Channel and the Severn Estuary much of the shoreline is protected from flood damage by embankments. Shoreline management plans are being drawn up for the whole of the English and Welsh coastlines.

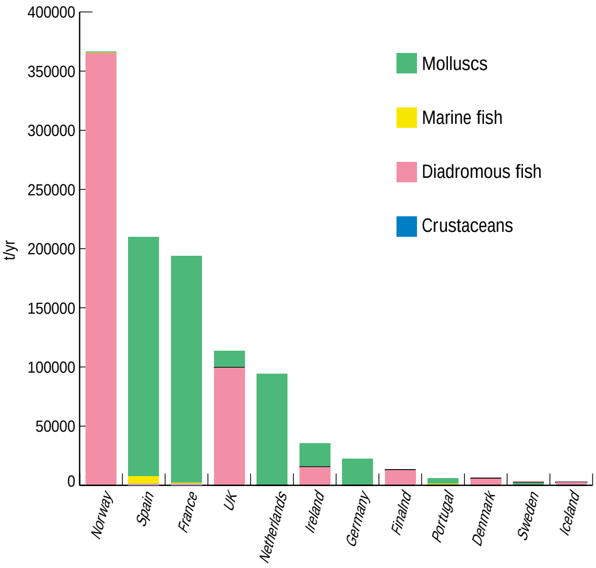
In Region IV, the French coast between Biarritz and Adour is most prone to erosion due to a powerful swell (reaching a wave height of 15 m) and a continuing deficit of replenishing sediments. Nearly 1000 transversal structures such as jetties, and 500 longitudinal structures such as sea walls and breakwaters, have been constructed.

Coastal erosion also affects the Portuguese coast. Large spurs and rock walls have been constructed in several sectors, thereby significantly modifying local sediment transport and, in some cases, resulting in the destruction of once sandy beaches.

3.7.2 Land reclamation

Coastal land reclamation was most common around the North Sea, particularly on the shallow south and east

Figure 3.6 **Aquaculture production in the Atlantic area. Source: FAO.**



For Germany, Denmark and Sweden production in the Baltic Sea area is included

coasts. New plans exist to expand the port of Rotterdam seawards.

3.7.3 Power generation

Power generation at sea is not practised on any significant scale at present but there is growing interest in offshore wind-power installations and experiments are underway with wave-power generators. The only tidal power station (240 MW) in the OSPAR area is located on the Rance estuary (Region II), near St Malo in Brittany; it commenced operation in 1967.

As wind is a source of renewable energy there are intensive efforts to find convenient sites with sufficient wind energy and low population. Wind-power generation is cost-effective when average wind speeds exceed 5 – 6 m/s. The problems with this technology are the space required as well as visual and noise impacts which can be especially detrimental to birds (Kruckenberg and Jaene, 1999). In many countries wind energy is generated from coastal wind power stations (e.g. 23 MW in Region III; between 5.1 and 8.8% of the power demand of the Azores).

In several countries there are plans to construct wind parks offshore. In Denmark four to five offshore wind parks (with up to 400 turbines) are planned to be built within the next five years. The effects of noise and electro-magnetic impact on fish and marine mammals are under consideration. Several other OSPAR countries also have plans for an offshore wind park; the UK has plans for five.

3.8 Sand and gravel extraction

Sand and gravel are essential materials for private and industrial construction work, for coastal protection and beach replenishment. In many OSPAR countries land-based sand and gravel deposits are in short supply and in some countries up to 15% of the national requirement is taken from the sea (ICES, 1992). The amount of sand and gravel extraction is listed in *Table 3.7*.

The main targets for exploitation are siliceous sand and gravel deposits. Calcareous deposits such as banks of mussel shells and of the algae *Lithothamnion* (maërl) are also subject to exploitation in some of the OSPAR countries. These lime deposits are used for the production of cement or as a soil fertiliser and conditioner.

The exploitation of marine aggregates may have negative effects on the marine environment. The removal of shallow banks close to shore increases the potential for coastal erosion by enhancing wave and current activity. Depressions produced by excavation act as traps for fine-grained sediments. In areas where aggregates underlie spawning or fishing grounds, their extraction may compete with fisheries.

Various measures have been introduced at national and international levels to minimise the environmental impact of marine aggregate extraction (e.g. the ICES Code of Practice on Commercial Extraction of Marine Sediments (ICES, 1992)). Nevertheless, extraction continues at high rates and there is limited control on quantities removed. Although some countries are developing more stringent licensing systems, in many cases national approaches to the regulation of this practice appear somewhat ambivalent.

By far the highest demands for marine sand and gravel exist in the North Sea area (Region II). Production increased from 34 million m^3 in 1989 to 40 million m^3 in 1996. Most of the material is needed for coastal protection, construction work and for beach replenishment.

In the Irish/Celtic Sea area marine aggregates are used mainly for beach replenishment and as infill for harbour development and for building and road construction purposes. The extraction of aggregates at offshore sites in Region III is presently confined to the Bristol Channel (seven sites, in 1997 more than 2 million t) and the north-eastern Irish Sea (two sites, in 1997 about 300 000 t).

Sand and gravel are extracted in larger amounts along the Atlantic coast (Region IV) for construction and beach replenishment. In France annual extractions amount to around 2.2 million m^3. Maërl and shell sands are excavated mainly along the Brittany coast.

Around the Azores (Region V), licences have been approved for the annual extraction of 140 000 m^3 of sand.

3.9 Dredging, dumping and sea-based discharges

Dumping of waste or other matter is prohibited by the OSPAR Convention except dredged material, waste from fish processing, inert material of natural origin and vessels or aircraft (until 2004). A wider range of material, including sewage sludge and industrial waste has been disposed of in the past.

3.9.1 Dredged material

Dredged material dumped at sea consists primarily of material removed to keep navigation channels clear (maintenance dredging) or removed during the construction of coastal engineering projects, like harbours (capital dredging). Amounts of dredged material are listed in *Table 3.8*. For Belgium, France, Germany and Spain, the bulk of the dredging came from estuaries and sea channels. In some other countries most of the dredgings came from harbours. Trends in the amounts dumped are difficult to establish, as the dredging requirements are strongly influenced by natural conditions as well as dumping strategy. Regular reporting takes place within the OSPAR framework.

A licence for the disposal of waste at sea is issued only where it can be shown that the material is not seriously contaminated and will not harm the marine environment. Dumping of dredged materials can, nevertheless, introduce contaminants to the marine environment. The size and location of dumpsites are designated by the national licensing authorities and the sites are subject to periodic monitoring to ensure that impacts are within approved limits.

The disposal of dredged material at sea affects the environment both through the contaminants it contains and also physically. According to the OSPAR Guidelines for the Management of Dredged Material (OSPAR ref. no. 1998-20) measures to keep the volume of dredged material to a minimum are regarded Best Environmental Practice (BEP) for minimising the effects on the environment.

3.9.2 Sewage sludge

The disposal of sewage sludge at sea, which ceased at the end of 1998 by agreement of the OSPAR Contracting Parties, was practised only in Regions II and III. Germany ceased the practice in 1981, Ireland early in 1999 and the UK in 1998 (see *Table 3.8*).

3.9.3 Industrial waste

The dumping of industrial wastes was phased out in 1993 when the last few licences for disposal at sea of liquid industrial waste and fly ash from the UK expired.

Table 3.7 Sand and gravel extraction 1992 to 1997. Source: national data; OSPAR (1998b,c).

	Total (m^3)	Average (m^3/yr)
Belgium	11 000 000*	1 833 333*
Denmark	30 500 000	5 083 333
France	13 200 000	2 200 000
Germany	17 000 000	2 833 333
Iceland	ni	ni
Ireland	ne	ne
Netherlands	104 200 000*	17 366 666*
Norway	710 000	118 333
Portugal	ni	ni
Spain	ni	ni
Sweden	ne	ne
UK	81 600 000	13 600 000

* mainly sand; ni no information; ne no extraction.

Incineration of liquid industrial waste on special incinerator vessels in the North Sea was terminated in 1991. The dumping of waste from the titanium dioxide (TiO_2) industry was terminated in the North Sea in 1989 and by Spain in 1993. Discharges from the TiO_2 industry are permitted under OSPAR and EU regulation and are mainly confined to French and UK estuarine waters (Seine, Humber and Tees).

3.9.4 Radioactive waste

Since 1983, there has been a global moratorium on radioactive waste disposal within the framework of the London Convention. The OSPAR Convention 1992 contains a legally binding ban for such dumpings, which is now accepted by all Contracting Parties.

Before 1967, sea-disposal of radioactive wastes was uncoordinated and a number of shallow sites were used for the disposal of relatively small amounts of wastes. After 1967, its disposal was done in deeper waters and co-ordinated by the Nuclear Energy Agency (NEA).

The wastes consisted mostly of low-level materials mostly from nuclear plant operations, fuel fabrication and reprocessing, radionuclide use in medicine, research and industry, and decontamination of redundant plant and equipment. A report on the main dumpsite (OECD, 1985) concluded that it posed negligible human radiological risk. However, in the absence of baseline data on the benthic biology, it is difficult to draw firm conclusions about the environmental impacts. In 1995, the OECD/NEA finalised its Co-ordinated Research and Environmental Surveillance Programme related to Sea Disposal of Radioactive Waste (CRESP), and summarised the results in the CRESP Final Report 1981 – 1995 (OECD, 1996). While this programme collected new biological information for a radiological assessment of dumping, none of these new data radically changed the conclusions of the last main site suitability review (OECD, 1985). Several OSPAR Contracting Parties expressed concern that the surveillance of the former radioactive dumpsite was terminated.

3.9.5 Inert materials of natural origin

Dumping of inert material of natural origin (such as mine stone) has been carried out only in Ireland. Some inert material is deposited onto the foreshore in the UK and Norway, but such deposits from land do not constitute dumping under the OSPAR Convention.

3.9.6 Other waste

The dumping of ships in the OSPAR maritime area will be prohibited from 2005. In 1996 Norway dumped eighteen mostly wooden fishing vessels. Dumping of iron/steel hulled vessels is now forbidden in Norway.

During the First and Second World Wars, numerous vessels were sunk in the Atlantic and in some Regions, in the post-war periods, large quantities of redundant munitions were dumped at sea.

3.9.7 Discharges from offshore installations

Offshore installations are significant sources for the input of oil to the maritime area, especially in Region II. Variations in oil discharges are shown in *Figure 3.7* (not taking into account synthetic muds, which fall into a different category). Overall, inputs of oil have decreased from a maximum of about 28 300 t in 1985 to about 9500 t in 1997 (-66%). This reduction was mainly achieved by decreasing the amount of oil discharged via cuttings from about 25 800 t to about 6000 t in 1996 after which only synthetic fluid muds have been used (discharge via cuttings in 1997: 7200 t). During the period 1985 to 1997, the discharge of oil with production water increased from about 2500 t to about 8500 t. This rise is due to the increased number of installations and increasing amounts of production water associated with progressive exploitation of the oil fields.

Heavy metals, polycyclic aromatic hydrocarbons (PAHs) and production chemicals are, together with oil, discharged via produced water. These inputs increase with increasing age of the field. The amount of discharged produced water can be reduced by for example re-injection into the reservoir or by downhole separation, which is largely experimental at present. Operational discharges of water-based and synthetic drilling muds are strictly regulated.

In 1996, OSPAR adopted Decision 96/3 on a Harmonised Mandatory Control System for the Use and Reduction of the Discharge of Offshore Chemicals. This Decision is a key element in the control of chemicals intended for use on offshore installations. Following a trial period its effectiveness was reviewed in the light of experience and a package of new OSPAR measures was established. These were adopted in June 2000 and supersede the previous OSPAR measures with respect to offshore chemicals.

Table 3.8 Summary of amounts of wastes dumped at sea in 1996 (tonnes dry weight). Source: national data; OSPAR (1999b).

	Dredged material	Sewage sludge*
Belgium	29 264 498	0
Denmark	562 784	0
France	24 273 000†	0
Germany	19 123 000	0
Iceland	220 698	0
Ireland	1 372 734	11 758
Netherlands	8 016 381	0
Norway	399 716	0
Spain	2 055 148	0
Sweden	3 308 608	0
UK	24 105 334	276 609
TOTAL	112 701 901	288 367

* all dumping of sewage sludge ceased early in 1999; † national data from France.

Water-based muds, oil-based muds (OBMs) and, more recently, synthetic fluid muds have been, and in some cases still are being, used when drilling wells. With the exception of geological or safety reasons, the use of oil-based muds is prohibited in the upper part of the well. Cleaned cuttings contaminated with drilling fluid may be discharged to the sea. Since the end of 1996 they must comply with the target standard for oil on cuttings of 10 g/kg dry cuttings (previously 100 g/kg). Ministers at the Fourth International Conference on the Protection of the North Sea invited OSPAR to ban (with certain exceptions) the discharge of oil contaminated cuttings by 1997. Since then only cuttings contaminated with water-based and synthetic fluids have been discharged. As some synthetic fluids were found to possess properties that could result in adverse impacts on benthic communities, the UK industry undertook a voluntary agreement to phase them out by 2000. Following a review within OSPAR of measures relating to cuttings contaminated with organic-phase drilling fluids, a new comprehensive Decision was adopted in June 2000 (OSPAR Decision 2000/3 (contaminated cuttings)), which rules out discharges of such cuttings except, in exceptional circumstances, those contaminated with synthetic fluids.

3.9.8 Litter

Despite pertinent laws and regulations, litter is still a considerable problem for the marine environment and the coastal communities around the whole OSPAR area. Potential sources of litter are mainly related to waste generated by shipping (fishing and commercial) and tourist and recreational activities.

The use of plastics and other synthetic materials has increased exponentially. Non-degradable plastic constitutes 95% of the total amount of litter in many parts of the OSPAR area. Marine sources include shipping, fishing and mariculture operations, and land-based sources include coastal landfill sites, sewage discharges and beach recreation. On many beaches discarded drink containers (bottles and cans) are a growing component of the litter problem. Whereas the recreation and commercial fishing sectors are likely to be most affected economically by litter, it is also a hazard to wildlife. Drifting fishing nets and ropes may foul ship propellers, lead to entanglement and drowning of mammals and seabirds, and carry epiphytic organisms beyond their normal ranges. The feeding of seabirds, particularly fulmars (*Fulmarus* sp.) (NSTF, 1993), can be harmed through ingestion of small plastic particles. Litter also reduces the value of fishing products since catches containing hazardous objects (e.g. glass) may have to be discarded.

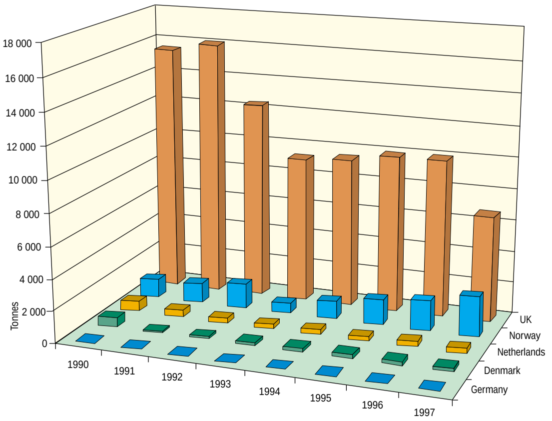
In Region II it was roughly estimated that annually at least 70 000 m^3 of litter were thrown overboard in the North Sea (OSPAR, 1997). Estimates of litter resting on the seabed are at least 600 000 m^3, based on a Dutch investigation. In Region III, one study to quantify the scale of the litter problem was undertaken in the Minch off the Scottish west coast. The results suggest that quantities of litter on beaches have increased over the last ten years and that the main sources were fishing, shipping, aquaculture and tipping. The North Sea (1991) and the Baltic Sea (1988) have been designated as MARPOL Special Areas (Annex V) to prohibit dumping of garbage and litter from ships. However, the situation with regard to litter seems not to have improved (OSPAR, 1997).

In Region IV, significant quantities of floating litter have been observed by air far to the west of the coastal Bay of Biscay, several hundred kilometres from the shore. In the Bay of Biscay, fieldwork carried out since 1992 shows that between the surface and 200 m, there are at least 50 million individual items of litter, for areas of greater depth (1800 m, canyons off Cap Breton and Cap Ferret), debris concentrations are around 15 items/ha.

3.10 Oil and gas industry

Refineries within the Convention area are located mainly in coastal areas or on large rivers. Their effluents are a source of oil and other substances. There have been many rationalisations and environmental improvements in this sector. This is reflected in the large reduction in the quantities of oil discharged.

Figure 3.7 **Total discharges of oil (tonnes) from offshore installations to the OSPAR area. Source: OSPAR (1999a).**



There are substantial offshore oil and gas activities in the OSPAR area *(Table 3.9)*. *Figure 3.8* gives the number of installations in the OSPAR area. There is believed to be considerable scope for expansion in the future. In Region V offshore exploration is at an early stage of development. Environmental problems associated with discharges of oil *(Figure 3.7)*, heavy metals and PAHs are dealt with under Section 3.9.7 and in Chapter 4. Generally, improvements in environmental performance relating to the offshore oil and gas sector will be addressed through the OSPAR Strategy on Environmental Goals and Management Mechanisms for Offshore Activities agreed in 1999.

In Region I oil and gas production takes place at several fields along the Norwegian coast. Oil exploration occurs both in the Russian and the Norwegian sectors of the Barents Sea. Some of the worlds biggest offshore gas reserves have been found at the Shockmanov and Murmansk fields but production is difficult and expensive because of seasonal ice cover. Very big oil reserves have been discovered close to the shore in the Pechora area. In the Norwegian part of the Barents Sea some larger gas reserves are found.

In Region II the major developments of offshore oil industry have been in the northern North Sea, in the UK and Norwegian sectors. Gas fields are exploited mainly in the shallower southern regions in the UK, Dutch and Danish sectors, as well as in Norwegian waters. Between 1990/2 and 1996 the number of offshore platforms and oil production have almost doubled, primarily reflecting increased activity in the Norwegian and UK sectors.

In Region III offshore gas production started in 1985.

The Kinsale Head Gas Field and Ballycotton Field reserves are expected to last no more than about ten years. Exploration drilling continues in the Irish Sea, Celtic Sea and Bristol Channel. Oil was found in 1990 in the UK Douglas Field in Liverpool Bay. Following discoveries of oil west of Shetland and the development of the technology required to exploit such deep water areas there has been renewed interest in exploration off Scotland, west of the Hebrides. Oil exploration and production activities continue to expand into previously unexploited areas (Rockall, west of the Shetland Islands etc.).

In Region IV on the Spanish Atlantic coast, oil rigs and production wells are found off the Basque coast and used for storing gas; gas production wells are situated in the Gulf of Cadiz.

Considering an initiative of the Fourth International Conference on the Protection of the North Sea (1995), the 1998 Ministerial Meeting of the OSPAR Commission adopted Decision 98/3 on the Disposal of Offshore Installations prohibiting the dumping and the leaving wholly or partly in place of disused offshore installation within the marine area. Subject to assessment and consultation under agreed procedures, derogations are possible for the footings of steel installations weighing more than 10 000 t and for concrete installations.

3.11 Shipping

Commercial shipping, its navigational requirements and land-based facilities, have various impacts on the marine environment. These include large-scale coastal development for port facilities, the dredging and disposal of sediments, the transfer of non-indigenous species through ships' ballast water and hull fouling, and the operational, accidental, and occasionally illegal, release of oil. In addition, shipping causes inputs of hazardous substances through the cleaning of tanks, the burning of fuel containing waste products, losses of antifoulants containing biocides, releases of wastewater and garbage, and the loss of cargo and dumping of litter. Along the old Atlantic shipping routes, the seabed is littered with large amounts of clinker from coal-fired vessels. Plastic litter and tar balls commonly occur at the surface, particularly in shipping lanes, and these may affect coastal resources and seabirds. Additional environmental effects of shipping include air pollution through the release of for example sulphuric (SO_x) and nitrous (NO_x) oxides. The increasing use of so-called High Speed Craft increases fuel consumption and thus the release of greenhouse gases such as carbon dioxide (CO_2).

In the whole OSPAR maritime area, discharges of oil from bilges and engine room spaces of ships should, in accordance with the rules, not give rise to visible oil at the sea surface. Under the name North West European Waters, the North Sea, and the seas around Ireland and their approaches have received the status of a Special Area under MARPOL Annex I (oil) as from 1 August 1999; that means that the discharge of oily cargo residues into the sea from any oil tanker is prohibited. Limits for bilge water from machinery space remain 15 ppm, although a Special Area demands modern oily water separation equipment. Slicks do occur when ships fail to observe the rules concerning discharge rates.

Within the IMO, a mechanism for a general ban on the use of organotin compounds in antifouling paints has been decided. The target is to prohibit their application from 2003 and to require the removal of tributyltin (TBT) from ships' hulls by the year 2008. Given the serious effects of TBT on snail and bivalve populations, effective implementation of this measure is required. Within the EC, the control on other TBT applications has been increased with the revision of Council Directive 76/769/EEC. Also within the IMO framework, traffic separation schemes have been introduced to reduce the risk of accidents and activities are ongoing to reduce air pollution by emissions from ships.

3.11.1 Traffic and cargo

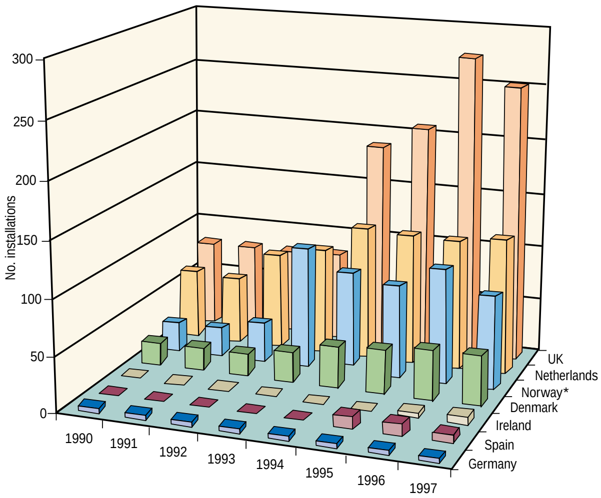
Ocean transportation grows as world trade expands.

Table 3.9 Oil and gas production in the OSPAR area in 1998. Source: regional QSRs; national data; BP and AMOCO (via www.bpamoco.com).

	Natural gas		Oil	
	production (billion m^3/yr)	proved reserves (trillion m^3)	production (million t /yr)	proved reserves (thousand million t)
Denmark	7.6	0.11	11.7	0.1
Germany	0.3*		0.5*	
Ireland	2.46	0.00685		
Netherlands	27.4*		1.8*	
Norway (whole)	47.8	1.17	150	1.4
Norway (> 62° N)†	0.7		26	
UK	90.3	0.77	132.6	0.7

* data from the QSR for Region II and reflecting 1996; † data from the QSR for Region I.

Figure 3.8 **Total number of offshore installations in the OSPAR area.**



* The Norwegian count of the number of installations is done in a more aggregated manner, and therefore results in a lower number of installations compared to the counting method used by other Contracting Parties.

Large bulk carriers convey increasing quantities of raw materials. In the decade to 1995, the worldwide transportation of crude oil increased by 61% in tonnage and 86% in tonne-miles. Of the 1415 million t of crude oil transported by sea worldwide about 26% (374 million t) were either destined for, or came from north-western Europe *(Figure 3.9)*. Sea-borne trade in iron ore, coal, grain, bauxite and alumina, and phosphates also increased by an average of 2.6% per annum during the same decade. Of the 402 million t of iron ore carried by ships, about 31% (125 million t) passed through the OSPAR area *(Figure 3.9)*. There was an increase of 59% in coal shipments.

Container traffic is also increasing. As an example, by 2020 the port of Rotterdam is expected to handle 20 million containers each year. The maximum size of container vessels continues to grow (now up to 7000 containers). Losses of containers in bad weather are quite frequent and recovery of hazardous cargoes from deep water is often impossible.

In the main ports of Regions II, III and IV there is an estimated 500 000 vessel movements annually. Most of Europe's largest ports are on North Sea coasts and rivers, the largest being Rotterdam/Europoort. The North Sea contains some of the busiest shipping routes in the world.

In some areas shipping activity consists to a large extent of regional and local traffic such as ferries, and roll-on/roll-off vessels on fixed routes. There is little cargo traffic in the Arctic.

3.11.2 Accidents

Depending on the location and the types and amounts of substances released, maritime accidents may result in harmful effects to marine life and occasionally to humans. Accident probability depends strongly on shipping density – so in the open ocean accidents are less frequent and tend to have less impact than those nearer shore. Unintentional pollution at sea has a number of causes: explosions, collisions, groundings, ship damage and breakdowns. One source (Quell and Klimsa, 1997) recorded eighteen accidents in 1994, and a further thirteen in 1995, involving pollution of sea water in the OSPAR area, more than half in the North Sea. Some of the more notable accidents in the last decade are listed in *Table 3.10*.

3.12 Coastal industries

Industries tend to be grouped together in places that combine a series of facilities: transport, communication, energy and water supplies etc. Thus, many of the major industrial centres in coastal states of the North-East Atlantic are located along estuaries and close to the main cities and ports. Some of the larger industries to be found at such locations include: metal and metal-processing; smelters; chemical, petrochemical and paper-making plants; oil refineries; gas terminals; vehicle factories; shipbuilding; power stations; and fish processing *(Figure 3.10)*.

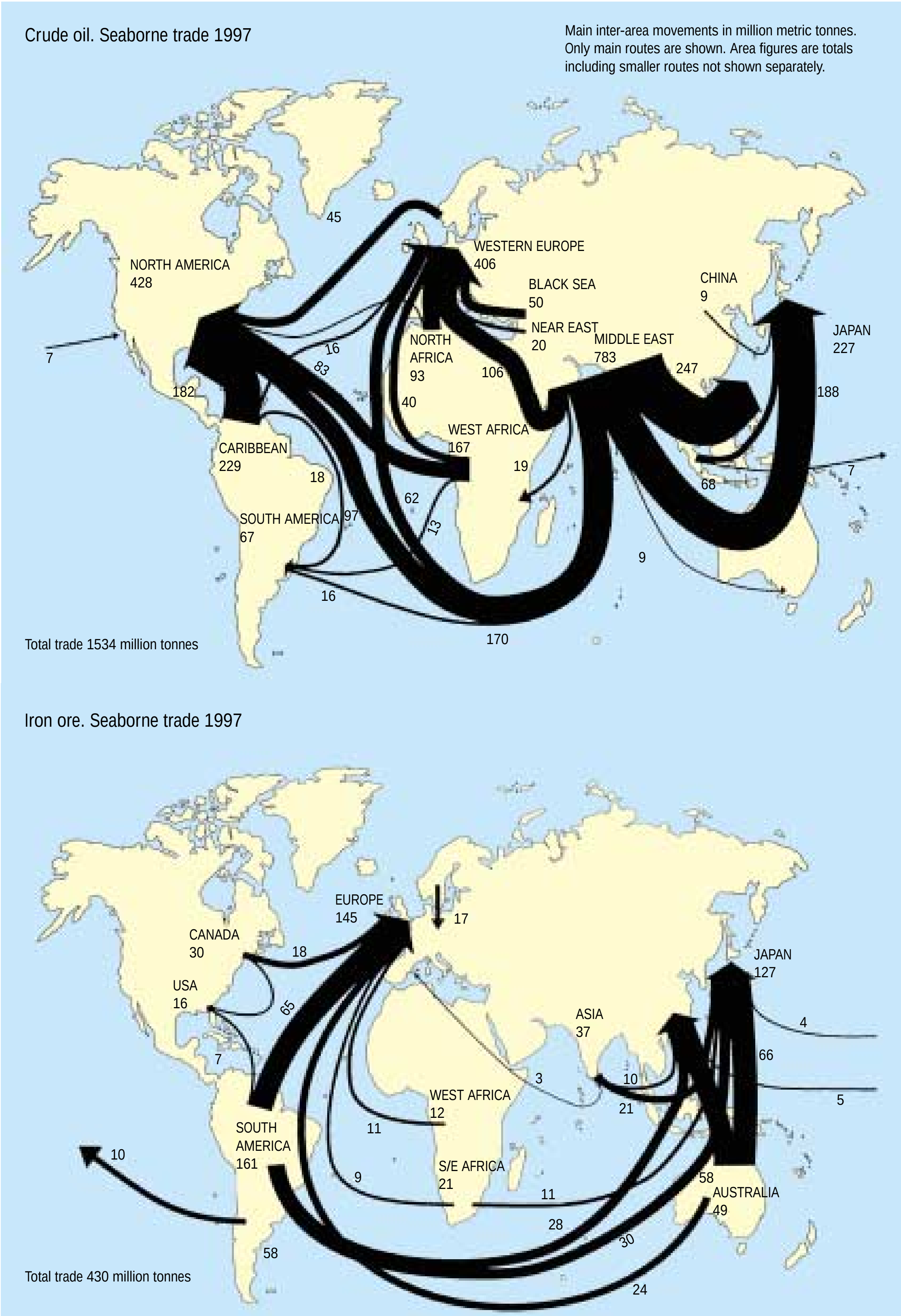
Coastal habitats have been, and continue to be, altered, disturbed or destroyed by industrial development. Other environmental impacts arise as a result of discharges, emissions and losses to land, air and water. Several estuaries are under considerable pressure from industrial pollution as a result of paper-milling, petroleum refining, production of chlorine, titanium dioxide and surface coatings, iron and steel working, metal fabrication and other heavy industries. Many of these industries use water in large quantities for cooling, rinsing and cleaning.

Some nuclear power plants and the French and UK reprocessing plants can be considered as coastal industries discharging heat and radioactive substances into the marine environment. OSPAR reports show that the discharges of most facilities are much lower than those permitted. In their Sintra Statement, OSPAR Ministers agreed to 'ensure that discharges, emissions and losses of radioactive substances are reduced by the year 2020 to levels where the additional concentrations in the marine environment above historic levels, resulting from such discharges, emissions and losses, are close to zero'.

3.13 Military activities

In peacetime, military operations constitute only a small part of sea-borne and coastal activity. They include port

Figure 3.9 **Shipments of crude oil and iron ore through the OSPAR area in 1997. Source: Fearnleys (1998).**



activities, construction and upkeep of the fleet, underwater disposal of weapons and munitions, and manoeuvres and firing exercises. Firing exercises are held within clearly identified zones. Military activities can lead to disturbance of wildlife and interfere with other uses of the areas involved.

At the end of the First and Second World Wars in most of the Regions considerable quantities of arms and munitions were dumped at sea including considerable quantities of chemical warfare materials (mustard gas, tear gas, nerve gas, tabun, chloroacetophenone, different arsenic-containing compounds (and other agents)). Usually the material was disposed at sites with some distance from land. An exception was the use of the deep trough in the North Channel between Northern Ireland and Scotland. From time to time items (mainly phosphorus incendiary devices) are washed up and present a hazard to beach users.

In the wider Atlantic during the Second World War some 20 million t of shipping were sunk. The seabed along the western European continental margin is littered with items ranging from sunken vessels, some nuclear or armed with nuclear devices, to munitions and pyrotechnics used in exercises, to hydrophone arrays (still operational).

3.14 Land-based activities

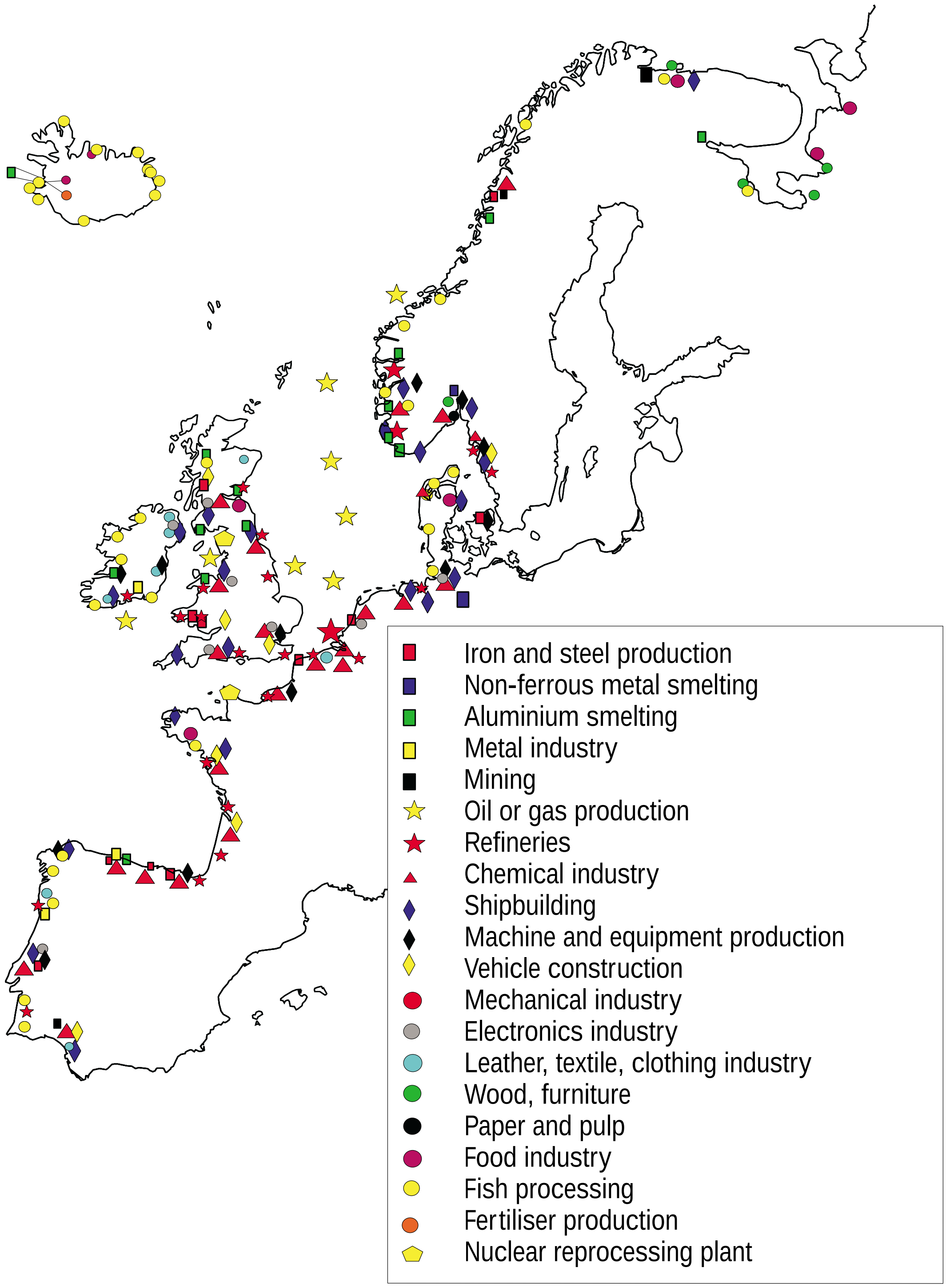
Land-based activities such as agriculture, industry and households have enormous impact on the marine ecosystem via riverine or atmospheric inputs of nutrients and contaminants; their quantification is often incomplete and tentative. Environmental policy has resulted in measures to reduce inputs of nutrients and contaminants. For example, the reductions in nutrient inputs were mainly achieved by improvements at point sources such as sewage plants for phosphorus and farm waste discharges for nitrogen compounds. However, little success is reported in reducing inputs from diffuse sources where the main problems occur from flushing of fertilisers from arable land, volatilisation, and leakage of industrial and municipal waste deposits.

The ban on certain persistent organochlorine compounds in OSPAR countries such as PCBs, hexachlorobenzene (HCB), lindane and DDT has been beneficial to the marine environment. Anthropogenic sources of some contaminants are listed in *Table 4.1*. In the chlor-alkali industry, reduction in mercury discharges has been achieved by applying Best Available Techniques (BAT) and BEP measures. In certain products mercury was replaced by less hazardous substances. The discharges of mercury from dentistry were also reduced. The (non)-ferrous metals and fertiliser industry minimised cadmium discharges and further reductions have been achieved through the substitution of cadmium by less harmful elements. Efficient flue gas treatment has reduced atmospheric emissions of cadmium, mercury and dioxins. The enhanced use of unleaded fuel caused a significant

Table 3.10 Major shipping accidents since 1992.

	Ship	Location	Accident
Oil accidents			
1992	tanker	Spanish coast, Galicia	the Aegean Sea ran aground and burned; 80 000 t crude oil were spilled
1993	tanker	UK, Shetlands	the Braer ran aground; 84 000 t crude oil were spilled
1996	tanker	UK, Milford Haven	the Sea Empress ran aground causing major oil pollution; 74 000 t were spilled
1998	cargo	Germany, Amrum	the Pallas ran aground with a fire on board and spilled 250 m^3 oil in the Wadden Sea; 16 000 dead seabirds
1999	tanker	France, south-western Brittany	the Erika was wrecked and sank to 120 m. 14 000 t of bunker oil were released and stranded on 400 km of French Atlantic coasts. 11 200 t of oil were removed from the wreck during summer 2000
Chemical accidents			
1993/94	unknown	Region V	the Sao Miguel was dumped in Region V, during dumping the ship exploded. Several thousand detonators from the ship were found on the beaches of Region IV
1994	unknown	Netherlands	containers lost five times with various types of cargo; in one instance packages of the pesticide *Apron plus*; in another instance the coast of a Dutch Wadden Sea island was polluted by phosphorus
1997	bulk carrier	France, south-west of Ouessant Island	the Albion II was lost with all hands. Cargo included 110 t of calcium carbide, a substance which reacts with water to form the flammable gas, acetylene
1997	container ship	Atlantic	the Carla released three (sealed) containers with radioactive caesium-137

Figure 3.10 **Simplified overview of industry located near the coast of the OSPAR area.**



decline in lead release to the environment. Less progress has been made with respect to some other substances (e.g. PAHs and dioxins) identified by the OSPAR Commission for priority action (Annex 2 of the Strategy with Regard to Hazardous Substances).

Efforts have been made toward the collection of urban and industrial wastewater and the application of appropriate levels of treatment. Nevertheless, even if households and industries are served by tertiary treatment, exceptional rainfall or tourism during the summer could reduce the efficiency of these systems. Measures were adopted by the Paris Commission in relation to the reduction in nutrient inputs (PARCOM Recommendations 88/2 and 89/4). The EC Directive on Urban WasteWater Treatment (91/271/EEC) provides for the required level of treatment for wastewater. The deadlines for this application are from 31 December 1998 to 31 December 2005, depending on the size of the population, its agglomeration and the sensitivity of the surface waters. The proportion of the population connected to sewage treatment ranges approximately from 80 – 98%.

3.15 Agriculture

There are extensive areas of agricultural land in Regions II, III and IV. Farmland accounts for more than 42% of the total land in Europe, although the proportion varies from less than 10% to over 70% between countries. In Region I – with only 1 % to 3% cultivated land – forest-based industries dominate; by far the largest resources of wood in the European Arctic are in Russia.

Agriculture results in inputs and emissions of nutrients (phosphorus and nitrogen compounds) and pesticides (e.g. atrazine, carbofuran, triphenyltin (TPT), lindane, DDT, aldrin and dieldrin). There are considerable environmental impacts in certain areas; the main types of pollution are from nitrates, phosphates, ammonia, methane, pesticides ***(Figure 3.11)***, and run-off of silage and slurry. Losses of nitrogen and phosphorus contribute to eutrophication of coastal waters. Atmospheric emissions from agriculture are a source of contaminants (e.g. ammonia and pesticides) in the deep ocean and atmosphere (e.g. methane). The EC Directive on the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC) provides for the establishment of codes of good agricultural practice, for the designation of vulnerable zones and for action programmes to reduce pollution by nitrates.

The highly productive agricultural systems in Western Europe fall into two broad categories. Firstly, there are areas of intensive field-crop farming, dominated by large holdings; secondly, there are areas of very intensive agriculture specialising in animal production and/or fruit and vegetable farming. The OSPAR Strategy to Combat Eutrophication includes a commitment to source-oriented approaches, including the promotion of good agricultural practice and ecological agriculture.

3.16 Regulatory measures and future developments

The environmental policy framework for the OSPAR area is developed through the International Conferences on the Protection of the North Sea, under the OSPAR Convention, within the framework of the European Union, by the Trilateral Governmental Wadden Sea Conferences, under the Bonn Agreement and, more generally for the marine environment, under the London Convention and within the framework of the IMO. It takes into account the Rio Declaration and policies developed under the Convention on the Protection of the Marine Environment of the Baltic Sea Area (the Helsinki Convention 1997/1992). Additionally there is co-operation within the framework of international river conventions, such as for the Elbe, Rhine, Scheldt and Meuse. So not all of the measures and regulations apply to all OSPAR Contracting Parties. This is particularly the case with regard to EC regulations.

The OSPAR Convention, which was opened for signature in 1992 and came into force in March 1998, served to merge and modernise its predecessors the Oslo Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft, and the Paris Convention for the Prevention of Marine Pollution from Land-based Sources. It has the general objective of preventing and eliminating pollution of the maritime area of the Convention, to ensure that the ecosystems are in a sound and healthy condition, used in a sustainable way, and that human health is protected. The 1998 Ministerial Meeting of the OSPAR Commission expanded the Convention by a further Annex which allows for the protection and conservation of the ecosystems and biological diversity of the maritime area. In 1998/1999, the OSPAR Commission adopted five strategies that established objectives and requirements for action relating to hazardous substances, radioactive substances, the combating of eutrophication, the protection and conservation of the ecosystems and biological diversity of the maritime area and environmental goals and management mechanisms for offshore activities. Amongst other measures, the OSPAR Convention provides for the adoption of legally binding 'Decisions', the first five of which were adopted in 1998

The OSPAR Strategy to Combat Eutrophication takes up agreements made within the North Sea Conference framework, followed through by the Oslo and Paris Commissions and which have been partly fulfilled to date, regarding the reduction of nutrient inputs by about 50%. An important element of the OSPAR strategy is the Common Procedure for the Identification of the Eutrophication Status of the Maritime Area.

OSPAR has agreed on measures for a number of substances (e.g. mercury, hexachloroethane, short chained chlorinated paraffins, PAHs and PCBs) and industrial sectors (e.g. iron and steel, aluminium, PVC, pulp and paper), and has defined BAT or BEP for a number of industrial sectors (e.g. the pulp and paper industry, the aluminium and the non-ferrous metal industry, combustion plants, use of toxic chemicals and pesticides in agriculture and aquaculture).

The OSPAR Strategy with regard to Hazardous Substances takes up agreements made within the North Sea Conference framework. This strategy contains provisions for the development of a dynamic selection and prioritisation mechanism to identify hazardous substances and assist the Commission in selecting those for which priority action will be taken to continuously reduce discharges, emissions and losses of hazardous substances with the ultimate aim of achieving concentrations in the environment near background values for naturally occurring substances and close to zero for man-made synthetic substances. Every endeavour will be made to move towards the target of cessation of discharges, emissions and losses of hazardous substances by the year 2020. OSPAR 1998 also adopted Decisions relating to the disposal of disused offshore installations (see Section 3.10) and radioactive dumping (see Section 3.12).

Specific OSPAR guidelines for the identification, selection and implementation of measures for Marine Protected Areas (MPAs) are under consideration. However, several other national and international initiatives have led to the establishment of a number of MPAs within the OSPAR maritime area. Most MPAs are located at or near the coast.

The OSPAR Convention prohibits incineration at sea. It also prohibits the dumping of all wastes or other matter except for dredged material, inert materials of natural origin, fish waste and, until the end of 2004, of vessels and aircraft. On a worldwide level, the London Convention regulates dumping of waste and its 1996 Protocol, yet to enter into force, places particular emphasis on the need to identify and control sources of contamination for dredged materials.

Environmental policy objectives of the EU are contained in the Amsterdam Treaty of the EU (1997). While fisheries management is directly governed by EC Regulations, the EC has no legislation specifically addressing the protection of the marine environment with regard to land-based activities. However, implementation of EC legislation on air and water quality, nature protection, chemicals, nutrients and industrial processes would lead to a reduction in pressures on and improvement in quality of the marine environment.

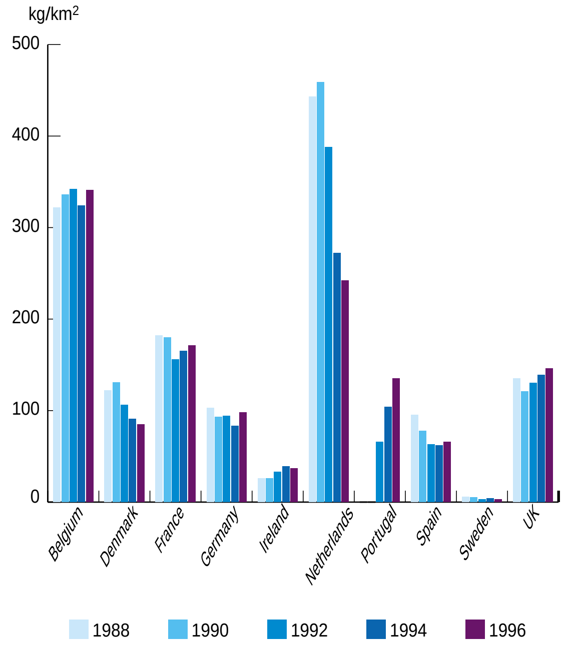
The four ministerial North Sea Conferences held since 1984 have resulted in political commitments to implement certain measures at a national or OSPAR level, or within the EU. Important agreements were to adopt the precautionary principle and to reduce inputs of nutrients and hazardous substances, the latter with the target of their cessation by 2020.

Eight governmental conferences about the protection of the Wadden Sea have been held since 1978 and have resulted, *inter alia*, in the agreement of a trilateral monitoring and assessment programme as well as common targets for nature conservation.

The Bonn Agreement, which first came into force in 1969, was a reaction to major oil spills and aimed to encourage North Sea states to jointly improve their capacity for combating oil pollution. The current Bonn Agreement (1983) is a commitment by North Sea states and the EU to combat pollution by offering mutual assistance and co-operation and to execute surveillance and to prevent violations of anti-pollution regulations.

The UN Conference on Environment and Development (UNCED 1992, Rio de Janeiro) has made 'sustainable development' an underlying principle in the development of environmental policy. The 'precautionary principle', and the 'polluter pays' principle were introduced on a global level. The Agenda 21 was agreed to implement this key idea and to express the general policy direction for the Twenty-First Century. The Rio Declaration emphasised that

Figure 3.11 **Total pesticides used in agriculture. Source: Eurostat (1998).**



States have the sovereign right to exploit their own resources pursuant to their own policies, but also the responsibility of ensuring that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction. At UNCED the Convention on Biological Diversity (CBD) was signed, aiming at the conservation of biodiversity, the sustainable use of its components and the fair and equitable sharing of the utilisation of genetic resources. In adopting the Jakarta Mandate (1997) parties to CBD have provided concrete provisions that are specifically suited to the conservation of marine and coastal biodiversity. Annex V implements this CBD on the regional OSPAR convention level.

In 1994, after several years' efforts, the UN Convention on the Law of the Sea entered into force, setting out the overall legal framework for the Governance of the Oceans, also including environmental issues. An agreement for the implementation of the provisions of UNCLOS relating to the conservation and management of straddling fish stocks and highly migratory fish was adopted in 1995.

The International Maritime Organization deals with the safety of shipping and the protection of the marine environment against risks related to shipping. The IMO Marine Environmental Protection Committee (MEPC) deals with issues relating to the prevention and control of pollution from ships. As well as conventions relating to ship safety, the IMO has agreed on the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) which relates to operational discharges from ships.

chapter 4

Chemistry

4.1 Introduction

This chapter summarises available data on the inputs, concentrations, spatial distribution and temporal trends of trace metals, persistent organic substances, nutrients, radionuclides and oil in the OSPAR Convention area. It is based on the information presented in the five regional Quality Status Reports produced by OSPAR, only references to additional sources of information are included. The first section deals, in general terms, with inputs to the sea through rivers, direct discharges (i.e. industrial and municipal outlets) and deposition from the atmosphere. Subsequent parts discuss concentrations of substances in water, sediments and marine biota. Where appropriate, the concentrations are compared to existing guidelines or standards. The data used in the current assessment were extracted from relevant OSPAR documents, the ICES database, national monitoring programmes and the scientific literature.

Substances are either natural or anthropogenic (i.e. man-made). Many substances (such as nutrients and metals) occur naturally in soils, plants and animals and it is therefore important to distinguish between the natural concentrations and fluxes of these substances and the extent to which these are augmented by human activities. Such distinctions, although often difficult to make, are essential if informed decisions are to be made regarding the management of contaminants.

The substances discussed in this report can be divided into trace metals, organic contaminants (in particular persistent organic pollutants (POPs)), oil, radionuclides and nutrients. Some examples of the main anthropogenic sources are summarised in *Table 4.1.*

Table 4.1 Examples of anthropogenic sources of contaminants.

	Main sources
Heavy metals	
cadmium	metallurgic processes, fossil fuel, fertiliser
mercury	fossil fuel, incineration, metallurgic industry
lead	mining, petrol
copper	mining, antifoulants
Persistent organic pollutants	
PCBs	industrial products, oils
TBT	antifoulants
PAHs	oil production, fossil fuel
DDT, HCH, toxaphene, dieldrin, chlordane	pesticides
HCB	industrial processes
dioxins and furans	incineration
Nutrients	
nitrate, ammonia, phosphate	agriculture, mariculture, sewage
Radionuclides	
caesium, polonium, technetium	reprocessing plants, phosphate production

The effects of substances on biota are dependent on a number of factors. These include bioavailability (see *Box 4.1*), bioaccumulation, biomagnification, toxicity and the capability of the organism to metabolise the substance. The bioavailability of the substance is dependent on the matrix (sediment, water, biota) and the chemical form (speciation) in which it occurs.

Box 4.1

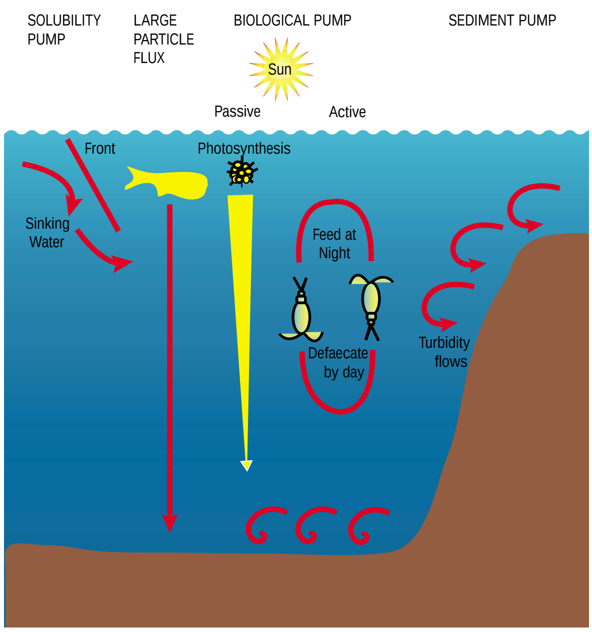
Bioavailability: The extent to which a substance can be absorbed into the tissues of organisms and so influence their physiology. Bioavailability is possibly the most important factor in determining the extent to which a contaminant in water or sediment will enter the food chain and accumulate in biological tissues. It depends on a) the properties of the substance, especially its solubility in water, and b) the habitats and feeding mechanisms of the organisms concerned. The bioavailability of contaminants that are tightly bound to clay sediments is relatively low. On the other hand those substances that are more soluble in lipid (i.e. fats) than in water, and that are loosely bound to fine suspended sediments easily scavenged by filter feeders (e.g. mussels), tend to be readily available and accumulated in fatty tissues.

Contaminants may occur in the water column either in solution or attached to particles. Many of the contaminants of concern in the marine environment have low water solubility and a high affinity for particles. There are several ways that contaminants can reach the seafloor *(Figure 4.1)* and once there they may become incorporated in seabed sediments. Contaminants can be taken up by organisms either directly, by absorption from sea water, or by ingestion of particles and can be relayed to successively higher levels in the food chain via grazing and predation.

In marine animals, individual contaminants tend to concentrate in specific organs. Persistent organic substances (e.g. POPs) which are highly lipophilic, accumulate mainly in fatty tissues; the highest levels are thus often found in liver tissue and in blubber. Amongst the heavy metals, cadmium tends to concentrate in the kidneys, mercury in the liver and lead in bone tissue. The ability to accumulate a particular contaminant varies between species but is also dependent on the form of the contaminant and the route of uptake. For example, methyl mercury is absorbed through the intestine of fish six times more effectively than inorganic mercury. Excretion rates also vary. The tendency for cadmium and mercury to be excreted slowly partly explains the high levels of these metals in long-lived species.

Many of the persistent organic contaminants that have

Figure 4.1 **Schematic diagram of the various 'pumps' whereby material is exported to the ocean.**



traditionally been monitored in the marine environment are no longer produced and the use of others is severely restricted. However, because of the scale of historical usage, large reservoirs of some POPs still exist in soils and sediments as well as in landfills and abandoned equipment. Continuing releases from such sources means that environmental concentrations are slow to decline. However, for most contaminants, the extent to which they are remobilised from marine sediments, particularly those in the deep ocean, is unclear. Some contaminants are also transported into the OSPAR area through the atmosphere and by ocean currents.

It has not always been possible to make confident comparisons between regions.

4.2 Input of contaminants (in general)

Input of contaminants to the maritime area is via three main routes; direct, riverine and atmospheric inputs. The relative importance of individual input routes differs between and within regions, and also for individual contaminants. For large parts of the maritime area, especially the oceanic parts, the atmospheric transport source is dominant. *Table 4.2* shows the contribution of different routes for cadmium and lead.

Direct input of contaminants arises as a consequence of municipal and industrial outfalls in coastal waters and from offshore activities and dumping. The major impacts of direct inputs are therefore likely to occur in coastal waters and especially in semi-enclosed areas and/or where water exchanges are low. The extent to which sewage is treated prior to discharge varies but in most locations improvement schemes are under way and indications are that in impacted areas the concentrations of some associated contaminants are decreasing. As a consequence of national legislation and improvements to industrial manufacturing processes, the direct input of contaminants to the Convention area has in general decreased.

In the offshore oil and gas industry, discharges of oil via cuttings have been strongly reduced and produced water constitutes the main source of oil input. The quantity of produced water is increasing and it is anticipated that the quantity of chemicals associated with this source will follow the same trend.

Dredging activity is often regarded as relocation of material. Old dumpsites are potential ongoing sources of contaminants.

Riverine input is made up of the run-off from land and discharges into the rivers and their tributaries. Estimates of the flux of substances from riverine inputs are heavily dependent on river flow. Estuarine processes can also significantly modify the level of inputs to the marine environment. This makes it difficult to interpret trends and to make regional comparisons.

When considering riverine inputs it is important to be aware that the catchment area of individual rivers can include areas in more than one country, some of which may be outside the OSPAR Convention area. It is not appropriate therefore to ascribe the total load to the most downstream country.

Table 4.2 Aquatic and atmospheric contributions to the total inputs (t/yr) of cadmium and lead to the maritime area.

	Aquatic input (direct + riverine)		Atmospheric deposition*	Total (aquatic + atmospheric)		Proportion of atmospheric deposition to total (%)	
	min	max		min	max	min	max
Cadmium							
Region I	2	10.7	2.6	4.6	13.3	20	57
Region II	36	64	14.6	50.6	78.6	19	29
Region III	36	51	1.8	37.8	52.8	3	5
Region IV	9	9	4.5	13.5	13.5	33	33
Region V	0	0	3.5	3.5	3.5	100	100
TOTAL	83	134.7	27	110	161.7	17	25
Lead							
Region I	19.8	65.9	235	254.8	300.9	78	92
Region II	999	1095	1531	2530	2626	58	61
Region III	389	492	199	588	691	29	34
Region IV	680	680	501	1181	1181	42	42
Region V	0	0	345	345	345	100	100
TOTAL	2087.8	2332.9	2811	4898.8	5143.9	55	57

* the atmospheric deposition values are derived from modelling based on estimations of European emissions in 1990. Region I and Region V are not fully covered by the receptor grid used in the modelling exercise, particularly to the west, therefore the deposition estimates for these regions are likely to be underestimates.

Atmospheric input is the dominant source to the marine environment for several substances including mercury, lead, POPs and some nitrogen compounds. Its quantification, especially for POPs, is affected by large uncertainties. The sources of atmospheric inputs may be located within or outside the OSPAR area. Some substances have a relatively short residence time in the atmosphere and are consequently deposited close to their sources, while others (mercury, POPs) can be transported on a global scale through the atmosphere. Atmospheric contributions from non-OSPAR countries are likely to be proportionately smaller in coastal waters near industrialised areas, such as in the southern North Sea, but more significant elsewhere in the OSPAR maritime area.

Ocean currents are important in the transport and distribution of contaminants. The transport is both to and within the Convention area. Although contaminant concentrations in sea water are low the high volumes transported mean that fluxes are large and that ocean currents represent a major contributor of soluble contaminants and nutrients to the Convention area.

Many contaminants are adsorbed onto particulate matter and may become trapped in the sediment. The sediment however is subject to resuspension and bioturbation, leading to the potential re-mobilisation of contaminants or their burial in deeper layers.

4.3. Assessment criteria

OSPAR has developed and adopted ‘Background/Reference Concentrations’ (BRCs) and ‘Ecotoxicological Assessment Criteria’ (EAC) values as assessment criteria.

In general man-made substances would be expected to have a background concentration of zero. However, due to their persistence and long-range transport many substances are now detected all over the world. Therefore typical concentrations in remote and selected parts of the OSPAR area are used as background/reference concentrations. For naturally occurring substances the BRC is the range of concentrations that would be anticipated to be present in the environment in the absence of any human activity. *Tables 4.3*, *4.4*, *4.5* and *4.6* summarise available BRCs for trace metals in sea water, sediments and biota (mussel tissue) and for some persistent organic contaminants in sediments and sea water.

EACs are defined as concentration levels of a substance above which concern is indicated. Criteria for the specific contaminants were derived using all the available ecotoxicological data that passed predefined selection and quality criteria. In a number of cases EACs are provisional due to insufficient information and in these cases higher safety factors are included. These assessment criteria can be used to identify possible areas of concern and to indicate which substances might be a

Table 4.3 Ranges in background/reference concentrations of cadmium, mercury, lead and copper for fine-grained marine sediments, sea water and blue mussel within the OSPAR area.

	Sediment (metal/Al (x 10^{-4}) ratio)	Sea water (ng/l)	Blue mussel (mg/kg ww)
Cadmium	0.007 – 0.04	5 – 25	0.07 – 0.11
Mercury	0.0034 – 0.0066	0.1 – 0.5	0.005 – 0.01
Lead	1.8 – 4	5 – 20	0.01 – 0.19
Copper	2.2 – 5.7	50 – 360	0.76 – 1.1

Table 4.4 Ranges in background/reference concentrations of PAHs in surface sediments (µg/kg dw) for application in selected regions of the OSPAR area.

	northern North Sea/Skagerrak	southern North Sea	Arctic Ocean/ Iceland Sea
Benzo[*a*]pyrene	8.8 – 112	< 0.2 – 51	1.0 – 3.8
Fluoranthene	14 – 160	0.72 – 97	1.5 – 7.5
Benzo[*b*+*k*] fluoranthene	46 – 434	1.1 – 142	7.4 – 30
Pyrene	11 – 128	0.6 – 78	1.7 – 6.4

Table 4.5 Ranges in background/reference concentrations of PAHs in surface water (ng/l) for application in selected regions of the OSPAR area.

	northern North Sea	central and southern North Sea	North-east Alantic
Benzo[*a*]pyrene	0.002 – 0.005	0.002 – 0.004	0.001
Fluoranthene	0.073 – 0.285	0.104 – 0.264	0.036 – 0.054
Benzo[*b*] fluoranthene	0.004 – 0.017	0.003 – 0.009	0.001 – 0.004
Pyrene	0.014 – 0.053	0.011 – 0.024	0.02 – 0.033

Table 4.6 Ranges in background/reference concentrations of HCB, DDE and selected PCBs in surface sediments (ng/kg dw) for application in selected regions of the OSPAR area.

	southern Norway/ Skagerrak	Iceland Sea/ Norwegian Sea
HCB	70	40
CB28	31	< 10
CB52	32	< 10
CB101	62	16
CB138	116	26
CB153	90	20
CB180	60	< 10
DDE	66	40

goal for priority action. *Table 4.7* provides EACs for some important contaminants.

Caution should be exercised in using the assessment tools in specific situations. (See Chapter 5 for the use and limitations of EACs.) Use of the tools should not preclude the use of common sense and expert judgement with regard to the natural concentrations.

4.4 Trace metals

4.4.1 Introduction

The presence of detectable concentrations of metals in the environment does not necessarily indicate the existence of pollution. With the exception of man-made radionuclides, the ubiquitous presence of metals in water, sediments and biota is an inevitable consequence of their natural occurrence in the Earth's crust. Human activities have effectively increased the rate of natural weathering and consequently the rate at which metals are introduced into the environment. At their natural concentrations many metals play an essential role in biochemical processes; organisms are also able to adapt themselves, at least partly, to changing metal levels.

4.4.2 Inputs

The relative importance of input sources for individual metals varies between regions. For offshore areas remote from riverine and direct discharges, atmospheric inputs are likely to dominate. Conversely, in near shore and coastal areas the situation is likely to be reversed. Riverine and direct discharge data for the OSPAR Regions are shown in *Figure 4.2*. The atmospheric input of metals has been less well studied, consequently information is scarcer. Estimates based on models have been made however and these are summarised in *Table 4.2*. For some regions, such as the North Sea, time-series estimates of atmospheric inputs based on observations are available *(Figure 4.3)*.

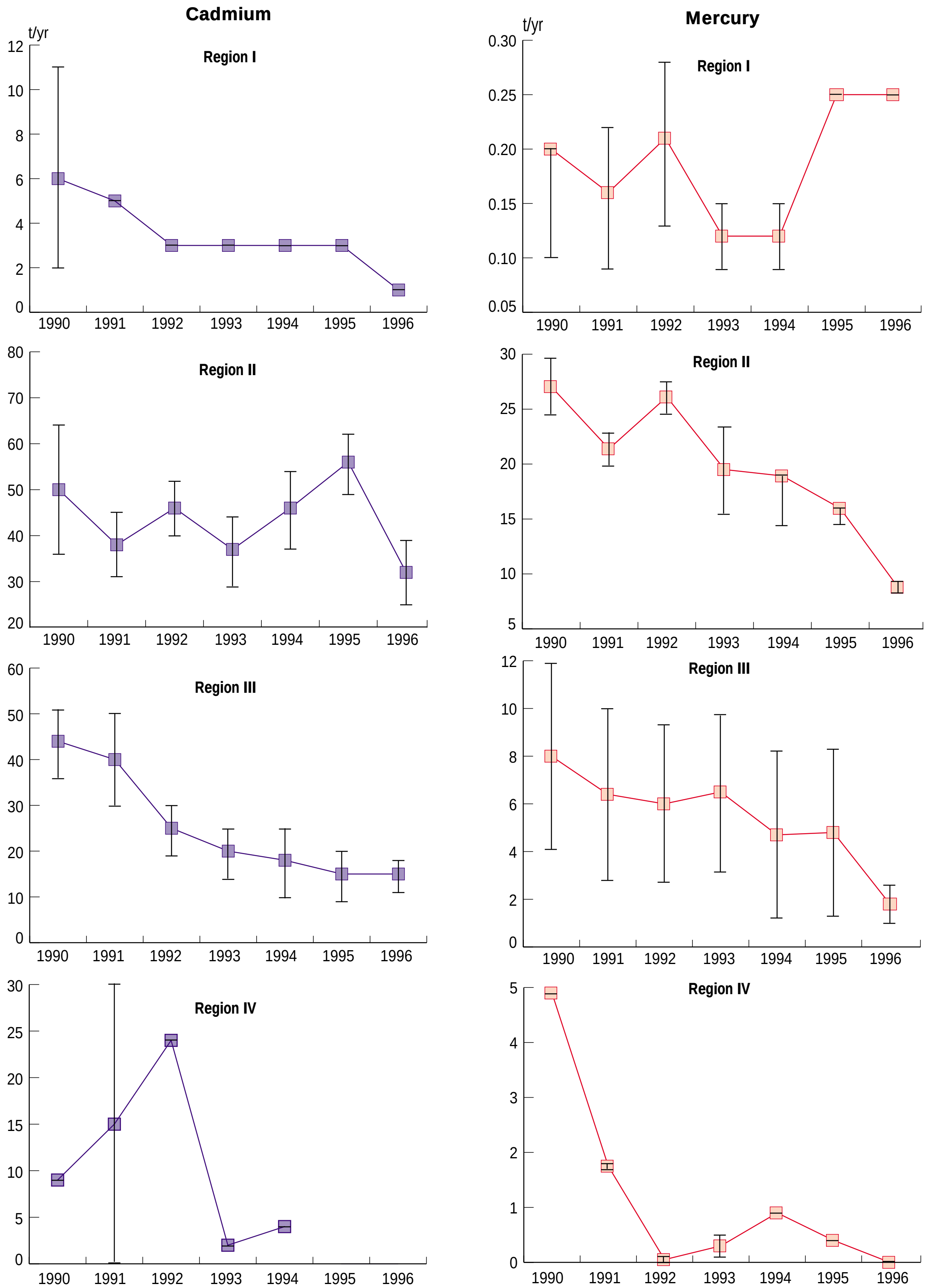
There was a general reduction in direct and riverine inputs between 1990 and 1996 as can be seen in *Figure 4.2*. The reduction in point source discharges, which are the most amenable to control, were mainly responsible for this trend. Specific examples include mercury inputs

Table 4.7 Overview of ecotoxicological assessment criteria for trace metals, PCBs, PAHs, TBT and some organochlorine pesticides.

	Water (µg/l)	Sediment (mg/kg dw)	Fish (mg/kg fw)	Mussel (mg/kg dw)
Cd	0.01 – 0.1*	0.1 – 1†	fc	fc
Cu	0.005 – 0.05*‡	5 – 50†	fc	fc
Hg	0.005 – 0.05*	0.05 – 0.5†	fc	fc
Pb	0.5 – 5*	5 – 50†	fc	fc
Zn	0.5 – 5*	50 – 500†	nr	nr
DDE	nr	0.0005 – 0.005†	0.005 – 0.05*	0.005 – 0.05*
Dieldrin	nr	0.0005 – 0.005†	0.005 – 0.05*	0.005 – 0.05*
Lindane	0.0005 – 0.005	nr	0.0005 – 0.005*	nr
Naphthalene	5 – 50*	0.05 – 0.5*	nr	0.5 – 5†
Phenanthrene	0.5 – 5†	0.1 – 1*	nr	5 – 50†
Anthracene	0.001 – 0.01†	0.05 – 0.5*	nr	0.005 – 0.05†
Fluoranthene	0.01 – 0.1†	0.5 – 5†	nr	1 – 10†
Pyrene	0.05 – 0.5†	0.05 – 0.5†	nr	1 – 10†
Benz[*a*]anthracene	nd	0.1 – 1†	nr	nd
Chrysene	nd	0.1 – 1†	nr	nd
Benzo[*a*]pyrene	0.01 – 0.1†	0.1 – 1†	nr	5 – 50†
ΣPCB_7	nr	0.001 – 0.01†	0.001 – 0.01*	0.005 – 0.058
TBT	0.00001 – 0.0001*	0.000005 – 0.00005†	nr	0.001 – 0.01*

Sediment data are for a reference content of 1% organic carbon. * firm; † provisional; ‡ this range is within the range of background values for natural waters. This value should be compared with the bioavailable fraction of copper in sea water; fc for future consideration; nr not relevant to the current monitoring programme; nd no data available or insufficient data available; ΣPCB_7 represents the sum of CB28, CB52, CB101, CB118, CB138, CB153 and CB180.

Figure 4.2 **Trends in direct and riverine inputs of cadmium, mercury, lead and copper. Data for Region I cover the Norwegian and Barents Sea sub-regions only.**



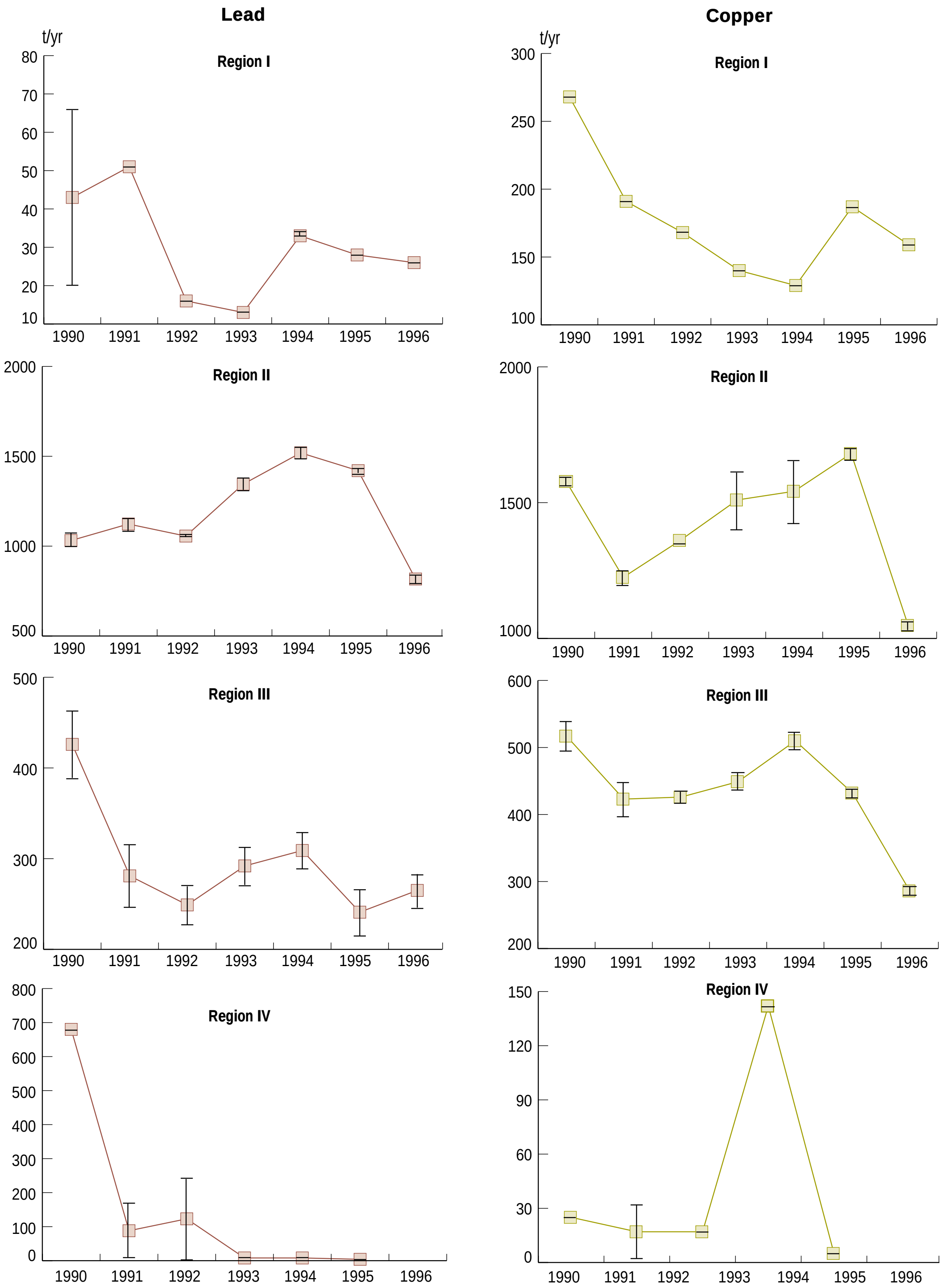
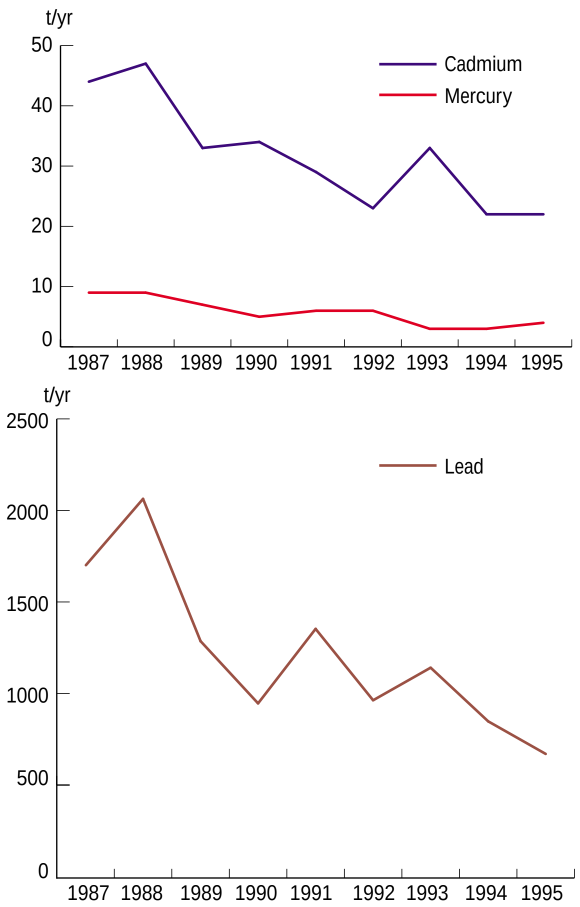

Lead
Copper
t/yr
Region I
Region II
Region III
Region IV
1990
1991
1992
1993
1994
1995
1996

Figure 4.3 **Atmospheric inputs of cadmium, mercury and lead to the North Sea (~ 525 000 km²) based on measurements.**



from two chlor-alkali plants in Portugal where, between 1991 and 1996, inputs decreased from 284 to 45 kg/yr. The pattern of input reduction varies however, for example between 1990 and 1996 there was a strong decrease in lead in the river Elbe while an increase was reported for the Weser. Even where particular activities have ceased (e.g. within the mining and chlor-alkali sectors), their historical activity is likely to provide a legacy of contamination to specific areas (e.g. lead inputs from historic mining activities in Region III).

The reductions in inputs associated with the control of point sources, lead to an increase in the relative importance of diffuse sources. The inherent variability associated with river flows and rainfall means that considerable uncertainty remains regarding the magnitude of inputs relating to diffuse sources.

Atmospheric inputs of metals to the North Sea have generally decreased *(Figure 4.3)*. In the North Sea, atmospheric inputs of lead decreased by 50 – 65% between 1987 and 1995 such that the dominant source is now taken to be rivers. Decreasing atmospheric lead inputs are reported from several Regions and these have been attributed to the reduction in use of alkyl lead derivatives in petroleum.

Changes in the pattern of use of chemicals are also evident in other industries. An example arises as a consequence of the banning of TBT-based antifoulants in mariculture and on small boats. The consequent shift to copper-based formulations has resulted in increased inputs of copper and this is of particular relevance to semi-enclosed areas and bays, for example those on the French Atlantic coast.

Since the introduction of PARCOM Decision 90/3, emissions of mercury to air from chlor-alkali plants in the Convention area have fallen significantly and now meet the key emission limit value of 2 g Hg/t chlorine capacity, due to better emission controls and conversion to less polluting technology. Total mercury losses through ‘product, water and air’ from the 48 ‘mercury cell’ chlor-alkali plants operating in Western Europe (34 within the Convention area) decreased from 56.7 t in 1982 to 8.5 t in 1997.

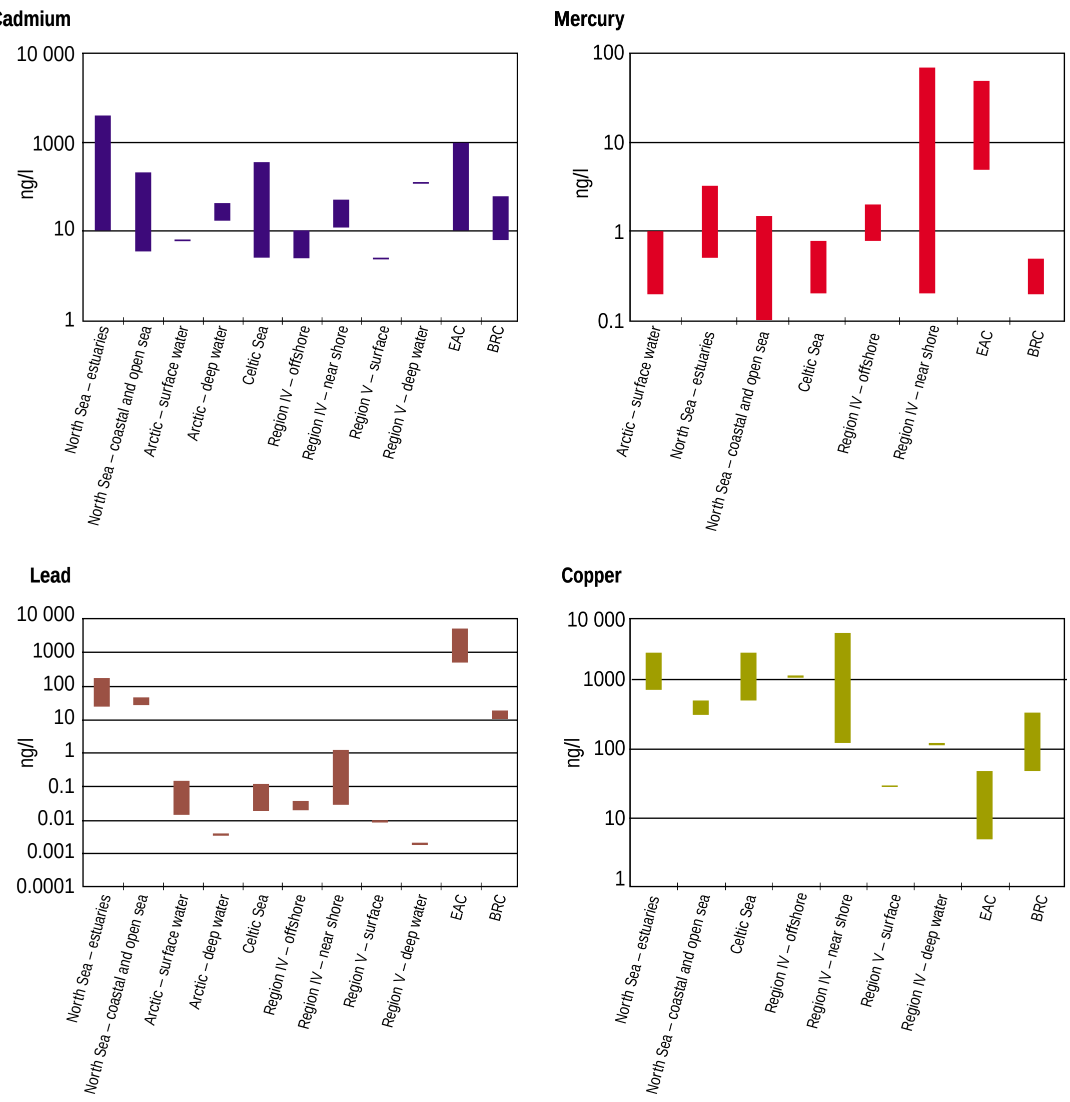
4.4.3 Concentrations in sea water

Figure 4.4 provides a selection of representative data on metal concentrations in sea water from the different Regions of the maritime area. In oceanic areas, cadmium, and to a lesser extent copper, behave similarly to nutrients. Biological activity in surface waters incorporates the elements into particulate material, depleting concentrations in the dissolved phase. The decomposition of the particulate material as it sinks leads to a regeneration of the incorporated elements, and a consequent increase in dissolved phase concentrations with depth. By contrast the depth profile for lead (with a dominant atmospheric source) exhibits a surface maximum in concentration, followed by a decrease with depth associated with dilution and scavenging by particles.

In coastal and estuarine waters the observed pattern of dissolved trace metal distributions reflects the increased importance of riverine inputs, and also the extent to which the elements interact with suspended particulate material. Cadmium and copper tend to exhibit inverse relationships with salinity, this relationship is less apparent for lead and mercury that are termed ‘particle reactive’ and rapidly become associated with particulate material.

For oceanic and offshore areas the reported concentrations are comparable to the BRCs, indicating that widespread contamination is not a general problem. Close to known point sources however the BRCs are sometimes exceeded, indicating localised contamination *(Figure 4.4)*. The practical difficulties in applying BRCs have been recognised. For example, given that riverine concentrations of metals generally exceed those in sea water, it is almost inevitable that BRCs based on offshore concentrations will be exceeded in estuaries. Additionally,

Figure 4.4 **Concentrations of cadmium, mercury, lead and copper in sea water.**



the estuarine geochemistry of metals must also be taken into account. For example the solubilisation of particulate cadmium during estuarine mixing leads to a general mid-estuarine maximum in concentration for this element.

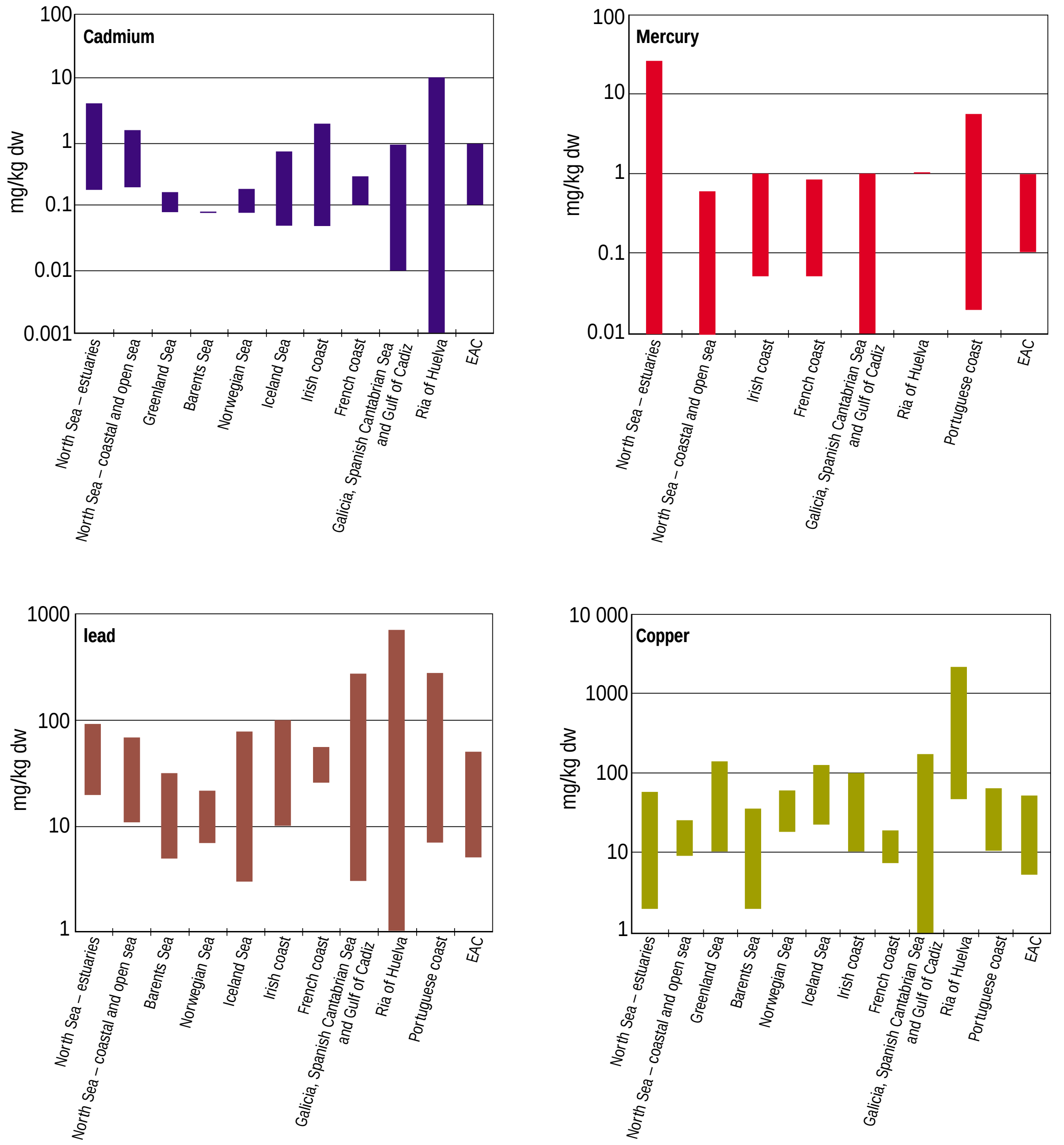
Examples of situations where metal (except copper) concentrations exceed the upper EAC limits are unusual. Such instances are limited to cadmium (upper EAC 0.1 µg/l) in estuaries of the North Sea and mercury (upper EAC 0.05 µg/l) in near shore areas of Region IV. In those areas where monitoring has taken place for copper, the upper EAC limit of 0.05 µg/l is routinely exceeded almost everywhere. The EAC for copper is less useful as a criterion because the toxicological value is only slightly higher than the value needed to avoid biological deficiency.

In some areas decreases in concentration over time have been reported for some metals, for example a 50% decrease in dissolved cadmium for the southern Bight of the North Sea. Decreases in particulate mercury concentrations have been observed in the river Elbe, comparable to those in the Seine and the Scheldt estuaries. Because there have been major improvements in analytical methods for metals in recent years, it is not always possible to compare recent and historical (pre-1980s) data.

4.4.4 Concentrations in sediments

Figure 4.5 provides a selection of representative data on metal concentrations in sediments from the different

Figure 4.5 **Concentrations of cadmium, mercury, lead and copper in sediment.**



Regions of the maritime area.

When interpreting trace metal in sediment data the difficulty is to establish the extent to which the concentrations observed are determined by geological sources and/or anthropogenic inputs. The geological sources can be non-negligible; for example, in Region I differences in copper concentration between areas dominated by tertiary volcanic rock (9 – 140 mg/kg dw) and those with non-volcanic rock (10 – 40 mg/kg dw) are explained by variations in local geological influences. Trace metals associate preferentially with fine-grained material in the sediment. Natural variability is taken into account by normalising the measurements in order to compare sediments from different regions. OSPAR has adopted metal/aluminium ratios as the basis for its background/reference concentrations for fine-grained sediments. In Region I, mercury in Arctic sediments showed a general pattern of increase in the upper layers of sediment cores.

Results reveal a general tendency for metal concentrations to be higher close to coastal inputs of anthropogenic or riverine origin. The upper EACs for cadmium, lead, mercury and copper (respectively 1, 50, 0.5 and 50 mg/kg dw) are exceeded at some locations *(Figure 4.5)*. The elevated metal concentrations at these locations are associated with their proximity to particular activities or industries, both contemporary and historical. Examples include dredged spoil disposal areas (e.g. for lead in the Rotterdam Harbour area), mercury from the chlor-alkali industry (Spain: Pontevedra ria; Portugal: Aveiro and Lisbon; UK: Mersey Estuary) and cadmium from earlier phosphoric acid manufacture (north-eastern Irish Sea).

In general, metal concentrations in sediments from estuaries tend to be higher than in those from coastal areas. Mercury concentrations have been reported to decrease over time in the vicinity of disused disposal sites, for example in the German Bight and off the Belgian coast. In Region II, cadmium levels in sediments from the Dutch coastal zone have significantly decreased in those areas where concentrations had previously been the highest. In the Scheldt estuary the maximum concentrations decreased by a factor of three between 1990 and 1995. Copper concentrations decreased between 1981 and 1996 in the areas north and south of the Rhine/Meuse mouth, and in the area offshore. Decreases were also observed along the Belgian coast and in the Wadden Sea.

4.4.5 Concentrations in biota

Table 4.8 (for mercury) and *Figure 4.6* (for cadmium, lead and copper) provide a selection of representative data on trace metal concentrations in a range of biota from the different Regions of the maritime area.

Mussels

The highest concentrations tend to occur in the vicinity of specific industrial sources or are associated with diverse inputs from densely populated areas. Ratios of observed cadmium and lead concentrations to BRCs are high in Norwegian fjords with smelting activity (Sørfjord). Despite introduction of cleaner technologies, the chlor-alkali industry continues to represent a source of mercury contamination in several places.

Some of the reported decreases in contaminant concentrations in biota can be linked to reductions in specific discharges. Examples include a 50% reduction in cadmium concentrations in mussels from the Seine Estuary following the prohibiting of phospho-gypsum discharges in 1992, and a decline in copper concentrations in mussels from the Elbe, associated with the decline of the former GDR chemical industries.

For the period up to 1996, trend analysis of metal concentrations in mussel has revealed:

- significant decreases in cadmium concentrations in mussels from the Netherlands (Westerschelde and Ems-Dollard), Norway (Sørfjord and Hardangerfjord) and along the French coast;
- significant decreases in lead concentrations in mussels from Germany (Borkum), the Dogger Bank, Norway (Sørfjord) and Spain (Pontevedra, A Coruña and Bilbao);
- significant decreases in copper concentrations in mussels from Denmark (Hvide Sande), Germany (Jadebusen, Borkum), the Netherlands (Terschelling), Norway (Oslofjord, Sande and Sørfjord) and Spain (Bilbao);
- significant decreasing trends in lead concentrations in mussels from the vicinity of the Loire, Germany, along the Belgian coast, the Dogger Bank and Norway;
- significant decreasing trends in mercury concentrations in mussels from Spain (A Coruña and Bilbao); and
- no significant temporal trends in cadmium concentrations in mussels from the Spanish coast.

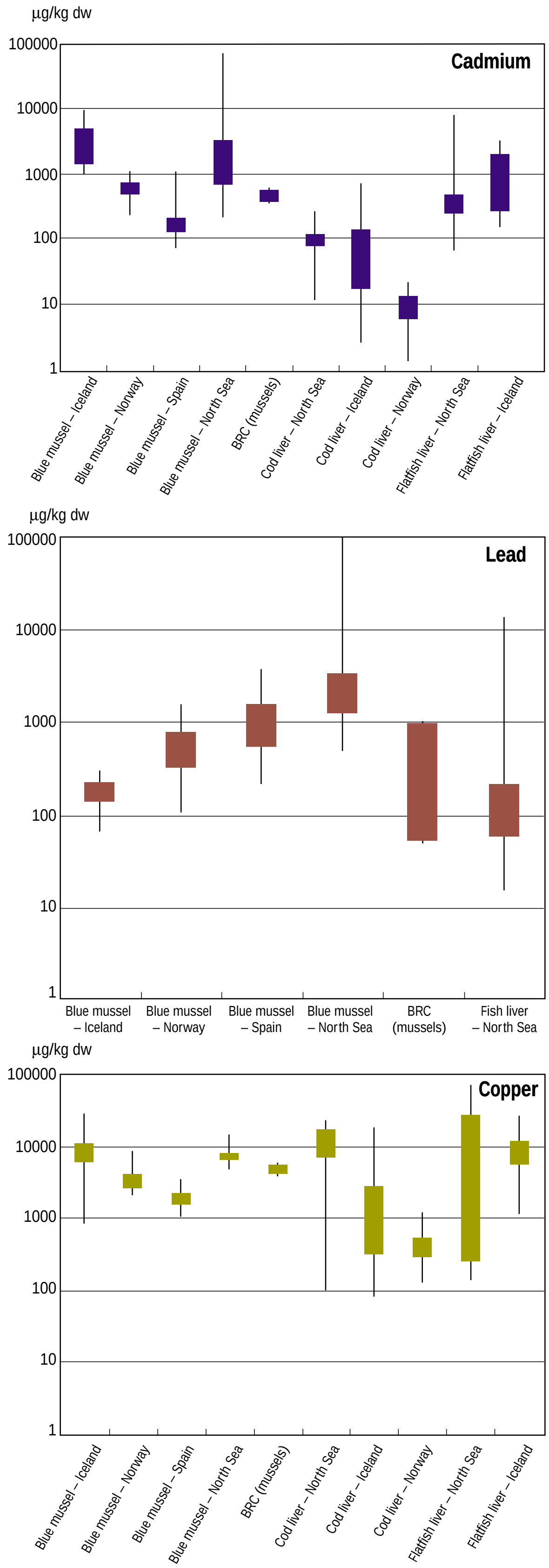
Time trend analysis of copper in mussel and/or fish tissue revealed linear downward trends in Denmark, Germany, the Netherlands, Norway and Spain. By contrast, increasing concentrations of copper have been reported in oysters from the Bay of Arcachon. Concentrations have approximately doubled over the past

Table 4.8 Mercury in biota (mg/kg ww).

	Mussel	Roundfish liver	Roundfish muscle	Flatfish	Deepwater species – liver	Deepwater species – muscle
Region I						
Arctic	0.01 – 0.02		0.01 – 0.1			up to 0.21
Region II						
whole Region	0.01 – 0.03		0.05 – 0.1			
Region III						
Ireland	0.02 ± 0.01		0.11 ± 0.07			
Region IV						
Bay of Biscay	0.11 – 0.26*					
Spanish coast	0.05 – 0.66*			0.15 – 0.4*		
Region V						
Atlantic					0.015 – 0.288	0.02 – 0.88

* mg/kg dry weight (all the other data are expressed as wet weight).

Figure 4.6 **Concentrations of cadmium, lead and copper in biota.**



ten years, and this has been attributed to copper-based antifoulants which, since 1982, have been used as a replacement for the TBT-based paints that were banned in that year.

Fish

As for mussels the geographical patterns of metal concentrations in fish continue to reflect historical and current sources of contamination. For example, past discharges of mercury from chlor-alkali plants close to the Mersey and Wyre estuaries in north-west England are well documented and result in higher concentrations of mercury in fish muscle from that area. Data for mercury in fish flesh from this area, obtained for the application of an environmental quality standard (EQS), suggest declining concentrations. In Region III, mercury is the only metal for which the observed concentrations in biota gave rise to concern. Provided that measures to control the input of mercury continue to be applied, it is unlikely that concentrations will present a threat to marine organisms or human consumers of seafood.

The time trend analysis of metals in fish data indicates significant downward trends in cadmium concentrations for flounder (*Platichthys flesus*) livers in Westerschelde and the inner Sørfjord and for cod livers at the Swedish site Fladen. Significant downward trends for mercury in flounder are observed along the Belgian coast, in the Ems-Dollard, Wadden Sea and Elbe, and also in plaice from the Southern Bight of the North Sea.

Mammals

Information on metal concentrations in marine mammals is largely limited to Regions I and III. Cadmium concentrations tend to be higher in kidney than liver and muscle and blubber levels are low. By contrast mercury concentrations tend to be highest in the liver. The differences in lead concentration between tissues are not as distinct as for cadmium and mercury, the highest concentrations tending to be in liver and kidney. An increase in cadmium and mercury concentrations with age has been noted for seals, whales and polar bear.

Copper concentrations are believed to be homeostatically controlled within marine mammals and are therefore generally not of concern. In Region III, samples of various tissues taken from stranded and by-caught marine mammals over a number of years have been analysed. Most of the animals were taken around the Irish Sea and off the Scottish coast. With the exception of cadmium, where the highest concentrations are found in the kidney, the highest concentrations of metals are generally found in the liver. High concentrations of lead and mercury were found in animals from the Liverpool Bay area, probably due to past industrial discharges: highest concentrations, 7 and 430 mg/kg respectively, were encountered in grey seals (*Halichoerus grypus*). Marine mammals appear to have a mechanism for detoxifying the mercury as mercury selenide. The highest concentrations of cadmium (up to 11 mg/kg) were found in the livers of striped dolphins (*Stenella coeruleoalba*). This is attributed to the dominance of squid, which accumulate cadmium naturally, in their diet rather than to direct anthropogenic sources. There are few data for samples from the Irish coast, but mercury concentrations in samples from Strangford Lough in Northern Ireland were among the higher values encountered in the Region. Off the Scottish coast, samples taken from a variety of stranded marine mammal species (over a period stretching back almost twenty-five years) have been analysed. In all cases, the concentrations found were at the lower end of the ranges for the species concerned.

4.5 **Organic pollutants**

4.5.1 Introduction

Many organic substances are released to the marine environment. Many of them are degraded rather effectively, while more persistent compounds may be distributed over large areas and accumulate in organisms. Within OSPAR, attention is given not only to POPs but also to a range of hazardous substances based on a range of criteria such as bioaccumulation and toxicity (see Glossary).

Most of the contaminants dealt with in this section are not single substances, in some cases they are made up of several hundreds or even thousands of individual compounds. This complicates the presentation of analytical results since these can represent the whole mixture or one or several individual compounds. Furthermore these results can be related to different matrices, for example wet weight, dry weight or lipid weight. Additionally variations in the composition of the matrix can influence the result, for example the number of particles in the air or water, the organic carbon content of the sediment and the lipid content of the tissue. The absence of information on these factors limits the extent to which data from different sources can be compared.

4.5.2 Organotin compounds

Inputs

Organotin compounds have had a widespread use as antifouling agents in paint formulations for ships. Despite the ban (introduced in 1990) on the use of TBT on vessels under 25 m in length, many areas still show the legacy of historical inputs. However, its continued use on larger vessels is now the major source for the marine environment. In addition to direct leaching from hulls, dry docks (where the hulls of ships are cleaned by sandblasting) and wastewater treatment plants (where a proportion of the organotin compounds may be discharged in the effluent) also represent potentially important sources. In the past, finfish aquaculture sites were a significant local source of TBT. This industry now uses modern antifoulants that contain copper and booster biocides as the active ingredients. Recent studies in Denmark indicate that both copper and booster biocides, which are now replacing TBT-based antifoulants, are likely to be present in certain areas of the marine environment at concentrations which might impact on the biota. Sewage treatment plants can be a significant source of dibutyltin in coastal areas and estuaries.

Sea water

The toxicological effects of TBT on molluscs occur at very low concentrations in sea water, below the levels that can be routinely measured by most laboratories. Consequently, the existence of TBT contamination is frequently inferred from biological indicators (i.e. imposex measurements).

The general picture of TBT levels in sea water indicates that concentrations offshore are generally less than the detection limit, whereas much higher values are found in frequently used waterways This creates great difficulties for sea water monitoring. TBT released to the water will degrade to dibutyltin and monobutyltin. Usually only TBT and total organotin values are reported, which makes it difficult to construct budgets for the fate and distribution of organotin compounds.

Toxicological effects due to TBT have been observed at very low concentrations and therefore the EACs are very low, even below detection limits.

Sediments

Sediments are sinks for TBT. However, resuspension can sustain higher concentrations in overlying waters. TBT is highly persistent in anaerobic sediments. The concentrations in sediment vary over a wide range. The highest concentrations of organotins are observed in harbours, marinas and along major shipping routes (e.g. as high as 10 mg/kg). In offshore areas it can be difficult to detect these compounds.

The EAC is 5 – 50 ng/kg dw; in all places that were monitored the concentrations were above the EAC and in some places the concentrations exceeded the EAC by six orders of magnitude.

Biota

In blue mussels and some other species, a geographical distribution similar to that in sediments is observed. A wide range of concentrations has been reported. TBT has now also been identified in higher organisms including whales, although the levels in mammals are at the lower end of the range.

4.5.3 Polychlorinated biphenyls

Inputs

Polychlorinated biphenyls are synthetic compounds that were used extensively in a variety of industrial products, including transformer and capacitor oils, hydraulic and heat exchange fluids, and as plasticisers in paints, plastics and sealants. There are 209 different forms of PCB (congeners) of which about 150 are used in technical products. However, the same properties that led to their extensive use in industry (resistance to degradation, low volatility etc.) also make them persistent environmental contaminants.

Total accumulated world production of PCBs has been estimated at 2 million t and much is still contained in sealed systems. Releases occur for example as leaks from sealed systems, accidental losses and spills, and emissions from PCB-containing materials and soils. OSPAR countries have banned the major PCB uses for some years. OSPAR and EU regulations aim at a complete phase out of PCBs in the period between 1995 and 2010. However, not all PCBs in smaller applications, in particular in electrical equipment, may be removed within that period.

PCBs emitted and deposited during the years of intensive production and use are still a diffuse source to the global environment. Evaporation of PCBs from polluted soils and waters has been shown to be a significant source to the atmosphere. Once in the atmosphere, PCBs enter the global circulation and can be transported to remote places. The atmospheric input through precipitation in the OSPAR Convention area is estimated to be 3 – 7 t/yr for the period 1992 to 1994. Riverine and direct inputs of PCBs are low in absolute terms. Although it is not possible to derive reliable estimates of inputs because most concentrations are below the limit of detection, estimates derived for the Greater North Sea were in the range 0.13 – 2.4 t/yr for the period 1990 to 1995.

Individual PCB congeners have a range of toxicity and physical properties, such as their solubility and vapour pressure. Thirteen of them, which have a flat (planar) structure, cause effects similar to those of the chlorinated dioxins, but they are not as potent as the most toxic dioxins. PCB concentrations are often reported as the sum of seven congeners (ΣPCB_7) or as 'total PCB'.

Sea water

PCBs are hydrophobic compounds; i.e. they have extremely low water solubilities. Concentrations in ocean water are generally very low and this makes reliable quantification difficult. PCB concentrations in filtered ocean water are usually reported to be in the low pg/l range.

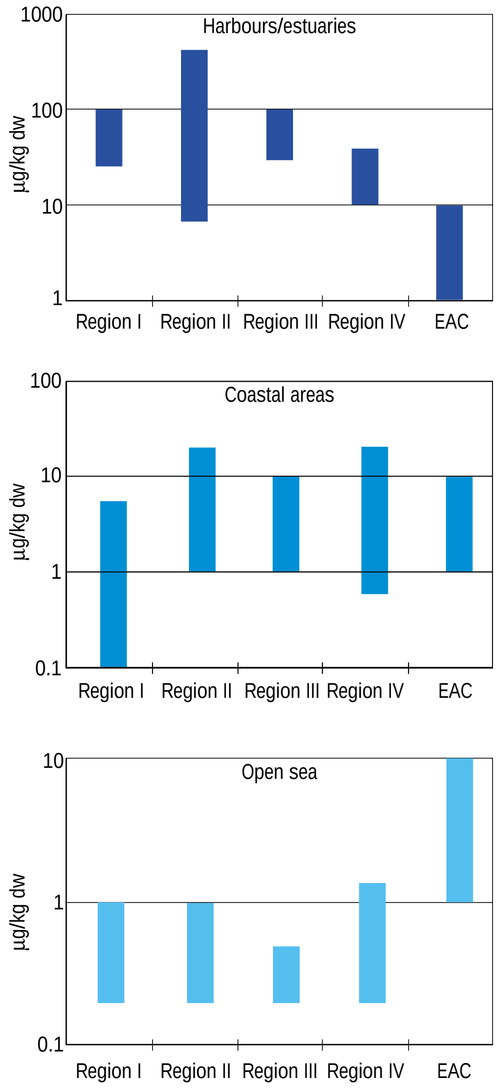
Sediments

The ΣPCB_7 concentrations found in sediments depend not only on the distance from point sources, but also on the organic carbon content of the sediment. Therefore, in more contaminated estuarine areas, concentrations of several hundred µg/kg dw have been measured, and in areas distant to the coasts levels are relatively low *(Figure 4.7)*. These sediment-bound PCBs may re-enter overlying waters as a result of resuspension of the sediment. The provisional EAC for ΣPCB_7 in sediment is 1 – 10 µg/kg dw, indicating that there may be cause for concern in the more contaminated areas.

Biota

As a consequence of their hydrophobic and persistent character PCBs are bioaccumulated and high concentrations are found in biota. Mussels are used to monitor the

Figure 4.7 **ΣPCB_7 in sediment.**



levels in several places and in all Regions except Region V levels higher than the EAC have been reported.

Elevated PCB concentrations have been measured in many of the Regions. PCBs are accumulated by marine organisms, especially within the fatty tissues of piscivorous birds and marine mammals. Anomalously high concentrations of PCBs were found during the early 1990s in cetaceans from Cardigan Bay in the southern Irish Sea and in otters from south-west Ireland.

Most of the reported concentrations of $\sum PCB_7$ in fish exceed the EAC (1 – 10 µg/kg fw), sometimes by several orders of magnitude. In the livers of whiting from Liverpool Bay and Morecambe Bay the levels of $\sum PCB_7$ recorded in 1996 were 1900 µg/kg and 1700 µg/kg ww respectively. The range in cod liver from Region I is 28 to 615 µg/kg ww *(Figure 4.8)*. Seabirds (in Region I) and marine mammals, at the top of the food chain, contain still higher $\sum PCB_7$ concentrations *(Figure 4.9)*.

The declining use and progressive elimination of PCBs have been reflected in the decreasing concentrations observed in ten of the long-term monitoring programmes evaluated. An example is gannet eggs from Ailsa Craig and Scar Rocks (Region III) where PCB concentrations decreased by more than 90% between the 1970s and the mid-1980s. In recent years, a decline in PCBs has been observed in cod liver from Iceland and in seabirds from northern Norway and Svalbard. The same trend has been observed elsewhere, but the rate of reduction decreased in the 1990s and concentrations appear to have levelled out.

There is weak evidence that PCB concentrations in biota have generally decreased. A small number of significant downward trends were observed along the south-west coast of Norway and in the southern North Sea (the Oyster Ground and along the west coast of Belgium).

Figure 4.8 **$\sum PCB_7$ in cod liver in Region I.**

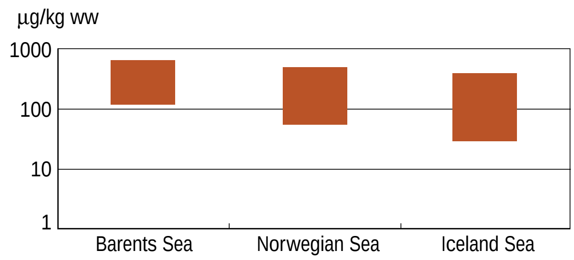
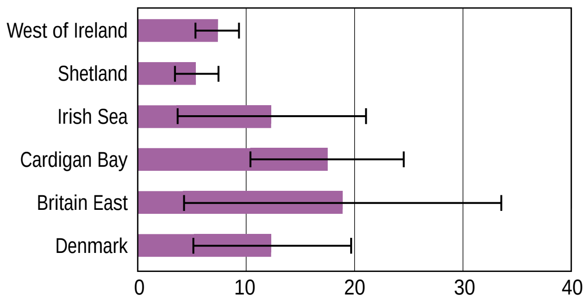


Figure 4.9 **Mean concentrations (±1 standard deviation) of $\sum PCB_7$ in the blubber of male harbour porpoises (mg/kg lipid) from areas of Region II and Region III.**



4.5.4 Dioxins and furans

Inputs

The term dioxin is used to describe two groups of substances: polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs). There are 210 congeners of dioxins and furans, but only seventeen are regarded as very toxic. The World Health Organisation (WHO) has adopted a human Tolerable Daily Intake (TDI) for dioxins (including the PCBs) of 1 – 4 pg/kg body weight per day. In several European countries the human intake of dioxins is within or above this range and this provides an extra reason to reduce emissions of these hazardous substances to the environment.

Dioxins are not produced intentionally, but arise as by-products in some chemical processes. They are formed during a number of thermal processes, such as waste incineration and metallurgical processes, through the use of active chlorine, for example in the bleaching of pulp, and during the production of certain chlorinated chemicals.

Sediments and biota

Information on dioxin levels in the Convention area is scarce, but a few point source emissions have been well studied, such as in Frierfjorden in Region II. Comparison of measurements for surface sediments shows that dioxin concentrations seem ten to twenty times lower in samples from the Barents Sea than in samples from the northern North Sea. The proportion of more volatile congeners is relatively high in the Barents Sea indicating a fractionation process. In general, concentrations of PCDD/Fs in Arctic seals are lower than in animals from the Baltic Sea and the North Sea, but higher than those found in Antarctic seals.

High levels of dioxins in sediments and biota were found near a magnesium production plant on the south coast of Norway. Concentrations in sediments were five to a hundred times higher than the background levels, even 20 km from the source. The presence of high dioxin levels in the tissue of several seafood species from locations close to the factory reflects the high values in sediments at those sites. Despite the 1990 reduction target, concentrations of these compounds in edible species have not decreased enough to lift the restrictions on consumption.

In the Dutch coastal zone, the highest concentrations of dioxins have been measured in the estuaries of the rivers Scheldt and Rhine. In these areas there was no significant change in the concentrations of dioxins between 1985 and 1994.

4.5.5 Hexachlorobenzene

Inputs

Hexachlorobenzene was previously used as a fungicide, but today the major sources are associated with incomplete combustion, limited use as a pesticide and disposal at dumpsites.

Sea water

As HCB is hydrophobic concentrations in the relatively few sea water samples analysed are in the ng/l range or below the detection limit. High HCB concentrations are reported in sediments from the Forth Estuary (two orders of magnitude higher than elsewhere in Scotland) reflecting known historic inputs. Concentrations in the Scheldt Estuary were comparable. In Irish Sea sediments HCB is present at low, almost background levels.

Biota

Concentrations of HCB in the livers of flatfish sampled at sites in the Irish Sea were low, while slightly higher levels occurred in the livers of dab (*Limanda limanda*) from Liverpool Bay. The levels of HCB in the blubber of harbour porpoises stranded on the coasts of the Irish Sea and to the west of Ireland are in the range 300 – 600 µg/kg lw. No EAC or BRC has been adopted for HCB. The International Programme on Chemical Safety (IPCS) has identified a TDI of 160 ng/kg body weight per day, indicating that the levels observed in fish do not pose a problem for human consumption.

There is evidence that HCB concentrations in biota have generally decreased. A number of significant downward trends were observed in some southern Norwegian fjords, in the Kattegat, in the southern North Sea (including the German Bight) and along the north coast of Wales.

4.5.6 Pesticides

Lindane is the name for the early technical formulations of hexachlorocyclohexane (HCH) products (α-,β-,γ-HCH). Today, however, pure γ-HCH is used. Lindane is relatively volatile and consequently effectively transported over long distances via the atmosphere. Lindane is also more water-soluble than most of the other chlorinated hydrocarbons discussed in this report, and a major input is via rivers from the application areas. There are indications of a slight decrease in the riverine input of lindane to the Irish Sea.

In water, lindane concentrations are higher in the southern North Sea and the German Bight than in the north-western North Sea. The highest concentrations exceed the EAC (0.5 – 5 ng/l).

Concentrations of lindane in fish liver and mussel tissue generally decreased during the period 1990 to 1995, especially in relatively polluted regions of estuaries, fjords and near coastal zones. In contrast, a significant upward trend was observed in dab muscle from Lista (southern Norway) for the same period. Concentrations of lindane in mussels around the Irish Sea, Bristol Channel, Celtic Sea and Atlantic coasts are in the µg/kg ww range and, in the livers of flatfish from the Irish Sea, are approximately ten times higher. In a UK study, the highest levels of lindane in fish liver occurred in Liverpool Bay. Concentrations of α- and γ-HCH in the blubber of stranded male harbour porpoises from the Irish Sea and west of Scotland during the past ten years have been approximately 2000 – 4000 µg/kg lipid.

There is evidence that lindane concentrations (α-, γ-HCH) in biota have generally decreased. A number of significant downward trends were observed in southern and south-western Norwegian fjords, in the Kattegat, and in the southern North Sea (along the west coast of Belgium, the Oyster Ground, the German Bight).

DDT is metabolised in the environment to produce DDE and DDD; the major compound found in biota is often DDE. The analytical results are, however, often expressed as total DDT, which is the sum of the parent compound and its metabolites. DDT has been used in large amounts, but is today banned in many countries, including those in Western Europe and North America. It is still used in other parts of the world, especially in tropical climates, areas from which it is subject to long-range transport.

In sediments DDD is the major component of the DDT derivatives; but data are usually reported as total DDT. Comparison with EACs is difficult because only an EAC for DDE is available. The available data, however, have not revealed any locations with significantly elevated concentrations.

All concentrations of DDT in commercial species from the Irish Sea, for the ten years prior to 1996, were below EACs for DDE. Some DDE data for mussel and fish exceed the EACs (i.e. mussel: 5 – 50 µg/kg dw, fish: 5 – 50 µg/kg ww) which indicates that some concern is still necessary.

Up to the mid-1980s, the eggs of seabirds from colonies in the Malin Sea and Celtic Sea, as well as on the Atlantic coast of Ireland, had concentrations of DDE in excess of 1000 µg/kg ww. However, records from the 1990s indicate that there has been a marked decrease in concentrations of DDE at most of these sites and in the eggs of seabirds levels are now generally below 400 µg/kg ww. Levels of DDE in the blubber of male harbour porpoises stranded in the Irish Sea and to the west of

Scotland and Ireland during the past ten years have been in the range 2000 – 6000 µg/kg lipid *(Figure 4.10)*.

For DDT there is evidence that concentrations in biota have generally decreased, whereas for related compounds (e.g. DDE, TDE) no such conclusions can be drawn. Four of seven DDT time series revealed significant downward trends, for example in the Kattegat and in the southern North Sea. A number of DDE time series from several sites, for example on the north coast of Wales, the west coast of Belgium, the western Dogger Bank, the Kattegat, and in some southern Norwegian fjords, showed significant decreasing trends.

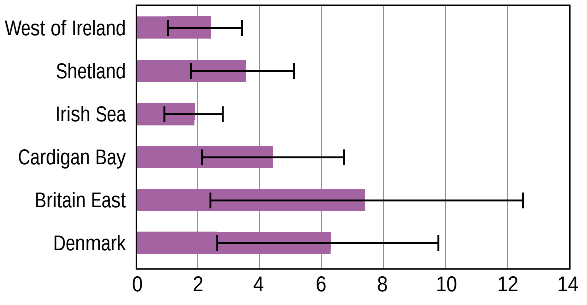
Toxaphene is a trade name for a pesticide of very complex composition. Until recently the analytical results were reported as total toxaphene, but today reference compounds have been synthesised and major emphasis is given to three individual congeners that seem more stable than the others. Toxaphene has not been used in the OSPAR region. However, the pesticide has been used extensively in cotton-producing countries, and is another example of a pollutant that is subject to long-range transport. This pesticide, because of its high toxicity to fish, was also used as a piscicide in some non-OSPAR countries.

The large volumes that were produced (no known production today) and the use pattern have resulted in high toxaphene concentrations in the environment and these concentrations are often the highest of all the organochlorine contaminants. Analyses of white fish and mackerel sampled around Ireland and the UK indicate higher levels to the west of Ireland than in the Channel. Some years ago Germany introduced a tolerance level (10 µg/kg ww) for toxaphene in fish to be marketed. This level was exceeded in many fish samples, including species from the marine environment. This tolerance level was reconsidered and adjusted to 100 µg/kg ww for the sum of three congeners. Areas remain where toxaphene concentrations can be expected to cause effects on the ecosystem.

Dieldrin has no known use today but previous usage may still affect the environment. The concentrations reported in fish (except for some liver oil samples) are below the EAC of 5 – 50 µg/kg fw. Data from Regions I and II indicate low and decreasing concentrations in the marine environment.

Triazines, such as atrazine and simazine, are still being used in some applications and are still detected in sea water, the highest levels are observed along the coast. Concentrations of atrazine and simazine measured in a survey of the eastern Irish Sea ranged from 42 and 37 ng/l respectively in samples from the Mersey Estuary down to less than 2 ng/l in the open sea. Atrazine and simazine were detected in the waters of the Wear (27 ng atrazine/l), Humber, Tees and Tyne (up to 6 ng simazine/l) and in the German Bight.

Figure 4.10 **Mean concentrations (±1 standard deviation) of DDE in the blubber of male harbour porpoises (mg/kg lipid) from areas of Region II and Region III.**



Dichlorvos was used at salmon farms to control external parasites. This use has been virtually phased out in response to concerns and the North Sea Conference reduction targets.

4.5.7 Polycyclic aromatic hydrocarbons

Some polycyclic aromatic hydrocarbons are persistent and toxic to aquatic organisms and also bioaccumulate. They can influence the development of liver tumours in several fish species and may adversely affect the reproductive process in fish and other aquatic organisms. PAHs include aromatic molecules containing fused aromatic rings. In general the two main contributors to PAHs in the environment are fossil fuels, mainly crude oil, and the incomplete combustion of organic materials such as wood, coal and oil. Both the atmospheric and aquatic pathways to the maritime area are important. Information on riverine inputs is very limited. Emissions of PAHs from North Sea riparian states have been estimated at 7000 t in 1990. In addition to the many domestic and industrial combustion processes, coal tar containing coating systems are important sources of PAHs. Offshore activities, oil spills, offshore installations and shipping exhausts are important sources. Under anaerobic conditions some naturally synthesised compounds can be reduced to PAHs. Among the PAHs formed by natural processes are perylene, retene, and phenanthrene homologues. PAHs are also formed naturally in forest fires and volcanic eruptions. As a consequence of their hydrophobic nature, PAHs in aquatic environments rapidly tend to become associated with particulates. Sediments therefore represent the most important reservoir of PAHs in the marine environment. The background levels of PAHs in the marine environment are also present as a result of biosynthesis and natural oil seeps. Anthropogenic activities are generally accepted as the most important source of PAH release to the environment.

High variability is typical for total and individual PAH concentrations in sea water. PAH concentrations in

Atlantic sea water range from 0.3 ng/l for individual, more water-soluble, lower molecular weight PAHs (two and three ring compounds) to less than 0.001 ng/l for the high molecular weight PAHs (five or more ring compounds). Higher concentrations were generally found in coastal and estuarine samples with total PAH concentrations ranging from not detectable to 8500 ng/l.

On a worldwide basis, background values for PAHs in sediments appear to be within the range 0.01 to approximately 1 mg/kg dw. Several areas of the Arctic have elevated levels of PAHs relative to global background concentrations, and sediments from near Svalbard contained up to 8.1 mg/kg dw. The highest levels of oil in bottom sediments typically occur in river mouths, estuaries, and bays, as well as in areas of regular shipping, oil production and transportation.

From a sediment survey, which described the presence of PAHs in twenty-two estuaries in Western Europe, it appeared that fluoranthene was the most prominent PAH. Total PAH concentrations in the twenty-two estuaries were between 200 µg/kg dw (Wadden Sea) and over 6000 µg/kg dw (Scheldt Estuary).

PAHs are less prone to bioaccumulation or biomagnification than the organochlorine compounds. Fish and organisms higher in the food chain tend to metabolise and excrete PAHs relatively rapidly. Little is known about the degradation products of PAHs in the sea, such as their sulphone, hydroxy and nitro analogues, which are often appreciably more toxic than their parent compounds. Some of these can be expected to have a greater persistence than their precursors. In marine invertebrates, like blue mussel, the processes of PAH metabolism are usually slower. Consequently these organisms are considered more suitable for monitoring purposes.

The EACs for the majority of individual PAHs in sea water are not usually exceeded at most locations. PAH concentrations in sediments often exceed the EAC, especially in the estuaries of the Seine, Humber and Scheldt.

4.5.8 Other substances of concern

Use of several of the classic persistent organic compounds has been banned or severely restricted. There are, however, still other chemicals in use that are sufficiently persistent to show up as global environmental contaminants. These are not yet included in the ongoing monitoring programmes and knowledge of their occurrence is consequently more sporadic. For many of these substances, there are no agreed assessment criteria. However, much information on the sources and pathways of these substances is being gathered in connection with risk assessments being carried out under the EC Existing Substances Regulation (Commission Regulation (EC) No 1488/94).

Brominated flame retardants are a diverse group of various brominated substances, some of which are used as additives to polymers and textiles. The polybrominated diphenyl ethers (PBDEs), especially those with four to six bromine atoms, are found in biota and sediments in the marine environment far from known sources.

The input of PBDEs via rivers to the Convention area has been investigated, sediments from river mouths were analysed and large differences in concentration were observed. Sediment and fish samples from Region II also reveal a wide variation in the PBDE levels, indicating the dominance of localised point sources. The concentration of DeBDE in sediment in the North Sea varies from $<$ 0.001 to 1.7 mg/kg dw. The occurrence of these compounds in sperm whales (*Physeter macrocephalus*), normally staying in offshore waters, indicate that PBDEs are widespread contaminants.

Chlorinated paraffins are an extremely complex group of compounds that are used as plasticisers, flame retardants and additives in metalworking fluids and the leather industry. These mixtures are difficult to analyse and it is not possible to determine individual compounds. To some extent however it is possible to distinguish between six groups: short- medium- and long-chain lengths, all with a low or high degree of chlorination. The highly chlorinated short-chained chlorinated paraffins have been the most extensively studied.

There are only a few data available on chlorinated paraffin concentrations in the Convention area. Sediment from river mouths was found to contain up to 10 µg/kg dw, fish samples from the North Sea have been shown to contain up to 100 µg/kg ww. A recent EU risk assessment for short-chained chlorinated paraffins with a high degree of chlorination identified a need to limit the exposure of aquatic organisms to local emissions associated with metalworking applications. PARCOM Decision 95/1 provides for the phase-out of the use in a range of applications of short-chained chlorinated paraffins.

Synthetic musks are used as fragrances in products such as cosmetics, soaps and detergents. There are two main groups in use today: nitro musks and polycyclic musks. Both groups contain compounds that are relatively persistent and can be found at high concentrations in water, sediment and biota, especially in freshwater systems.

The database for musks in marine environments is very limited. For individual nitro musks levels in marine waters are between $<$ 0.02 and 0.17 ng/l and in mussels are between $<$ 1 and 8 µg/kg ww. Among the polycyclic musks, HHCB (trade name: Galaxolide®) and AHTN (trade name: Tonalid®) have been detected in mussels from the North Sea at levels of around 1 µg/kg ww.

Octyl- and nonylphenol ethoxylates (OPE and NPE) have a wide range of applications in industry and public uses. The main environmental burden results from their use in industrial cleaning and public institutional cleaning as well as from textile and leather processing. Only very few data are available with regard to the marine environment. However, high levels of OPE and NPE were found in sediments in the river Scheldt (20 µg/kg and 300 µg/kg respectively) and in the Elbe (5.6 µg/kg and 107 µg/kg respectively). In the UK, the OPE levels varied between < 0.1 µg/kg and 15 µg/kg and the NPE levels between 23 and 44 µg/kg. In line with PARCOM Recommendation 92/8, the use of NPEs as cleaning agents for domestic uses was phased out by 1995.

4.6 Inputs from mariculture

Both finfish and mollusc culture operations generate significant amounts of organic wastes that, in sheltered locations, accumulate on the adjacent seabed. Fish farms release dissolved nutrients to the surrounding water, which may have the potential to contribute to eutrophication effects. In general, the flux of nutrients from fish farms to coastal waters is small compared to natural fluxes, such as from rivers and through the advection of coastal waters. Over recent years, there have been considerable improvements in the formulation and utilisation of feeds, and current rates of nitrogen excretion from salmon farms per tonne of fish produced are probably about 30 to 40% of those in the 1980s.

A number and variety of chemicals are used in the sea-cage culture of salmon, the dominant form of intensive mariculture in the OSPAR region. In terms of quantity, the main contaminating materials from these operations are antibiotics, parasiticides and antifoulants. Most antibiotics used to control disease are administered as feed additives and enter the sea via waste feed and faeces. Due to the use of vaccines, there has been a marked reduction in recent years in the use of antimicrobial agents in Norway, Ireland and Scotland, even though the production of fish has increased considerably.

A major problem in salmon farming is parasitic sea lice. Traditionally, control has been achieved through the use of a range of compounds (such as dichlorvos, organophosphate compounds, pyrethroids, benzoylphenylureas, avermectins and hydrogen peroxide) to kill the lice although in some areas cleaner fish (wrasse) have been used effectively to graze the lice off the salmon. The compounds used are mostly released to the environment after use, where they can present some hazard to non-target marine organisms.

TBT was commonly used as an antifoulant on mariculture cages prior to 1987. Copper has replaced TBT as the active ingredient in some antifouling agents so that – assuming a 20% leaching rate – cage aquaculture today represents a significant copper source. However, the loss rate from various formulations is likely to vary significantly, therefore it is very difficult to estimate the quantity of copper released.

4.7 Offshore chemicals

Sources of contaminants arising from the offshore oil and gas industry are drilling muds and cuttings, produced water and spills. Produced water contains considerable amounts of dissolved substances, including monocyclic aromatic hydrocarbons (i.e. BTEX), PAHs and phenols. There may also be (as yet) unidentified organic compounds. *Table 4.9* gives a partial overview of the amounts of some of the priority contaminants in produced water discharged to the North Sea. As the amount of produced water has increased it might be expected that the amount of chemicals associated with this source has followed the same trend. Due to lack of harmonised reporting formats, it is not yet possible to present an overview of the total amount of offshore chemicals discharged on either a Convention-wide basis or even on a Region-wide basis. As oilfields mature, it is anticipated that the discharges of produced water and associated oil will increase. In the case of the relatively small discharges of produced water from gas platforms, the discharge of aromatic compounds may exceed the discharge of dispersed oil (ICES, 1999).

Table 4.9 Estimated amounts of PAHs, organohalogens and substances other than oil in aqueous discharges to the North Sea from offshore installations in 1996.

	Quantity discharged (t)	Average Concentration* (mg/l)
Cadmium	0.6	0.01
Mercury	0.3	0.0003
Lead	6.9	0.09
Nickel	18.6	0.3
Total aromatics	2130	28
phenol/benzoic acids*	1345	14
benzene	454	
PAHs (95% naphthalene)	28	0.36
Organohalogens	< 0.003	

Data show estimated discharges for Denmark, the Netherlands and Norway, except * (Norway only). Information for the UK is not available.

4.8 Oil

Crude oil is a complex mixture of tens of thousands of compounds. Most of the compounds (> 75%) are types of hydrocarbons in the classes n-alkanes, branched alkanes, cycloalkanes, triterpanes, aromatics, naphthenoaromatics and PAHs with up to ten condensed aromatic rings. In addition, organosulphur compounds, acids, phenols, pyridine and pyrroles are present, as are highly complex asphaltenes.

Petrogenic hydrocarbons arise from natural oil seeps, emissions, spillages or effluents during the production and transportation of crude oil, from the refining and petrochemical industries, from general shipping activities and from the dumping of oil-contaminated dredged materials. Riverine inputs of oil constitute a significant part of the overall load of oil entering the maritime area. 'Oil' occurs naturally in the marine environment but not necessarily everywhere and, consequently, when it is present it is more likely to be there due to human activity than to natural causes.

The quantity of oil discharged by refineries decreased by more than 90% between 1981 and 1997; from $>$ 9000 t/yr to $<$ 800 t/yr. Concentrations of oil in water discharged have to comply with the 5 mg/l standard of PARCOM Recommendation 89/5.

Oil exploration and production activities continue to expand into previously unexploited areas (Rockall, west of the Shetland Islands etc). This has raised concerns about localised impacts, however experience in the North Sea suggests that with careful and sensitive environmental management the impacts can be minimised.

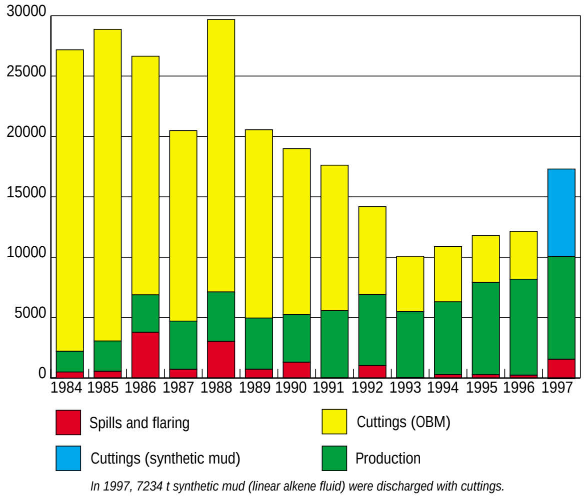
Produced water is the main source of oil from the offshore oil and gas sector; quantities discharged have progressively increased even though the concentration of oil has fallen in line with the OSPAR target standard of 40 mg/l. Oil discharged via cuttings has, however, been drastically reduced as a result of alternative technologies and increased use of synthetic-mud based drilling fluids and water-based drilling fluids. Discharges of oil-based mud ceased at the end of 1996. Leaching from old drill cuttings is a possible source of oil, but quantities released will be small if the cuttings are not disturbed. The contributions from the different sources for oil discharged to the North Sea from offshore installations are shown in *Figure 4.11*.

The majority of accidental spills involve $<$ 1 t of oil, but larger spills resulting from tanker accidents have occurred, often in shallow waters. In the spill from the oil tanker Aegean Sea in 1992, 80 000 t of oil were released in shallow waters at the rias of northern Spain and following the grounding of the MV Braer on the southern tip of the Shetland Islands in January 1993 some 85 000 t of crude oil were lost from the ship.

The Sea Empress spill resulted in a release of 72 000 t of oil at the entrance to Milford Haven in February 1996. For the purpose of judging return to normality following the Sea Empress oil spill, background concentrations of total petroleum hydrocarbons for the region were judged to be 200 to 900 ng/l in water, up to 10 000 µg/kg in dry sediments and 2000 to 10 000 µg/kg in biota.

The oil spill from the timber carrier Pallas off the northern German Wadden Sea in 1998 released only a

Figure 4.11 **Contributions from the different sources of oil input (tonnes) to the North Sea from offshore installations.**



small amount of oil (250 m^3). However, due to unfavourable conditions the impact on the environment was considerable (see Section 5.3.11).

On 12 December 1999, the wrecking of the tanker Erika off the French Atlantic coast resulted in a spill of 12 000 t of bunker C oil. By the following weeks, 400 km of coast were polluted. At the end of March 2000, 130 000 t of waste were collected and beaches cleaned. Forty per cent of marine cultures on the Atlantic French coast stopped their exploitation during this period because the total concentration of the sixteen PAHs easily identified in shellfish exceeded 500 µg/kg dw, a health safety limit decided by the national health authorities.

Illegal discharges from ships continue to be a matter of concern. Oil slicks are still detected along the main shipping corridor of the North Sea, although their frequency and volume seems to have generally decreased.

4.9 Radioactivity

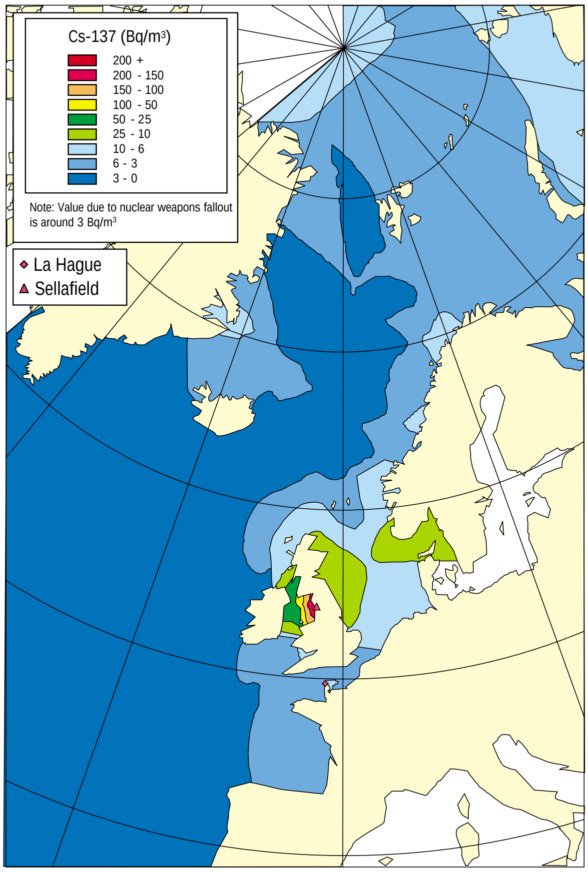
4.9.1 Sources and input

Radioactivity has both natural and anthropogenic sources. Natural radiation stems from decay of radionuclides in the Earth's crust and cosmic radiation. The anthropogenic input can be divided into three main categories: historic (weapons testing), accidents (Chernobyl) and industrial processes (e.g. nuclear reprocessing facilities and phosphate fertiliser production). There is also some concern about leakage from old dumpsites and sunken submarines within and outside the Convention area.

All authorised releases of radioactivity, including those unrelated to reprocessing, are subject to regular monitoring. Environmental levels due to authorised releases unrelated to reprocessing are relatively low and difficult to distinguish from radiation discharged from European reprocessing plants and fallout from nuclear weapons testing. In all cases, individual radiation exposures are generally also very low and well within international dose limits.

Anthropogenic inputs contain both naturally occurring and artificial radionuclides. Phosphate fertiliser production is the main anthropogenic source of naturally occurring uranium which results in substances such as radium-226, polonium-210 and uranium-238, but mining and ore processing, and the burning of coal, oil or natural gas in thermal power plants also contributes. Amongst others, the artificial radionuclides caesium-137, technetium-99 and iodine-129 originate from reprocessing facilities (e.g. Sellafield and Cap de La Hague). Soluble radionuclides like caesium-137 are transported from the Sellafield reprocessing facilities by the Norwegian Coastal Current to the Arctic via the North Sea *(Figure 4.12)*. The input from La Hague follows the currents through the Channel to the North Sea and subsequently the Arctic (Region I). The contaminants reach the Barents Sea after four to five years and the Iceland and Greenland Seas after seven to nine years.

Figure 4.12 **Activity concentrations of caesium-137 in sea water in the North-east Atlantic (based on measurements made 1992 to 1996). Source of data: Bailly du Bois and Guéguéniat (1999); Dahlgaard *et al*. (1995); Josefsson *et al*. (1998a,b); Kershaw *et al*. (1997); Nies *et al*. (1998); MAFF/SEPA (1997).**



This map was produced using a computer contouring package and is based on available published data for 1992 to 1996. Consequently, it provides a general picture of the spread of activity from Sellafield and La Hague but may not reflect actual current activity levels. Because of the sparsity of sampling data in some areas, some localised slight elevations in activity may be an effect of the contouring package used.

4.9.2 Sea water

Traces of man-made radionuclides are found with a decreasing gradient with increasing distance from the reprocessing facility. The level of caesium-137 ranges from approximately 500 Bq/m^3 in the vicinity of the outlets of reprocessing plants down to 2 Bq/m^3 in the open ocean. The trend has been steadily downward in the Irish Sea since 1988, however the signal is still present in the Irish Sea and as far afield as the Norwegian west coast and in the Arctic. At Sellafield, releases of the actinides and ruthenium have decreased, but there were consequential increases of the less radiologically significant technetium-99 in 1994 and 1995 and the level of technetium-99 in the Irish Sea close to Sellafield outfalls were approximately 350 Bq/m^3. This has resulted in the rapid spread and detection of technetium-99 in the North Sea and along the Norwegian west coast at very low concentrations. Discharges of technetium-99 from Sellafield have decreased since 1997.

4.9.3 Sediment

Concentrations of artificial and natural radionuclides in sediments are in general low except near outlets from the reprocessing industry and from phosphate fertiliser production. The specific activity of caesium-134 and caesium-137, a major fraction of the Chernobyl fallout in 1986, decreased between 1990 and 1996 confirming a decline in the Chernobyl contribution. The accumulation of sediments in both sub-tidal and inter-tidal areas of the Irish Sea act as a long-term sink for plutonium and other long-lived particle reactive elements. These sediments contain substantial amounts of artificial radionuclides, particularly caesium, plutonium and americium, the redistribution of which is now being observed in the Irish Sea. Sub-tidal sediments contain the highest proportion of the estimated inventory of plutonium in the Irish Sea (*c*. 200 kg in the total sediment of the area). It is however the inter-tidal sediment that is more critical in terms of human contact.

4.9.4 Biota

Seaweeds are good indicators of soluble radionuclides such as caesium and technetium in the surrounding environment. Concentrations of caesium-137 in seaweed diminish with increasing distance from Sellafield and have fallen in response to reductions in the discharge. For example the concentration decreased by approximately 20% per annum during the period 1983 to 1986 on the east coast of Ireland, and although the downward trend continues it is now less pronounced. Parallel decreases have been measured in fish and shellfish from the same area during the same period.

Concentrations of technetium-99 in seaweeds and the edible tissues of lobsters rose rapidly in the Irish Sea in response to increased discharges after 1994. As with caesium, the concentrations decrease with increasing distance from Sellafield. Monitoring on the UK coast close to the discharge shows levels declining in response to decreased inputs.

In general, the concentrations of plutonium and americium are higher in shellfish than in fish. The most recent monitoring indicates that their concentrations in fish and shellfish from routinely monitored sites in the Irish Sea are relatively stable. In the North Sea and Arctic Waters concentrations of caesium-137 of 0.4 – 1.4 and 0.2 – 0.5 Bq/kg ww respectively, were reported.

4.9.5 Exposure

Radiation exposures from unenhanced sources of natural radioactivity are in most cases higher than those from anthropogenically derived sources. An estimate of the maximum likely individual dose to man from natural radionuclides amounts to about 2 mSv/yr. Most of the dose that humans obtain by consuming marine food is due to polonium-210, which was found to be more strongly incorporated into several marine organisms than the other radionuclides.

With regard to individual exposure from artificial radionuclides, generally caesium-137 has by far the greatest significance. However, the dose to man is at least two orders of magnitude less than the dose from natural radionuclides indicated above. For areas in the proximity of discharges, other radionuclides such as technetium-99, plutonium-239, plutonium-240 and americium-241 may be a more significant contribution to the doses to the local critical group.

4.10 **Nutrients and oxygen**

4.10.1 Introduction

Nutrients are necessary for the growth of marine algae, including phytoplankton. For most of the maritime area natural processes (light, temperature, hydrography etc.) regulate nutrient availability and plankton growth. There are a number of natural and anthropogenic sources contributing to the nutrient inputs to the marine environment. These sources include wastewater inputs, agriculture, and emissions from fuel combustion and traffic. Information on inputs, concentrations, and trends and effects of nutrients is currently being used within OSPAR to classify the maritime area with regard to its eutrophication status (see ***Figure 5.4***).

4.10.2 Inputs of nutrients

Information regarding the input of nutrients from direct, riverine and atmospheric sources is far from complete. In the North Sea area, more comprehensive data are available on waterborne nutrients. These show that since the mid-1980s there has been a reduction of the order of 50% in the riverine inputs of phosphorus but, due to variability of flow, no consistent reduction in the riverine inputs of nitrogen. Direct inputs of nitrogen and phosphorus have reduced by 30% and 20% respectively since 1990. However, inputs may vary on a local scale. Consideration of losses and discharges of nitrogen at source indicates that some improvement (up to 25% reduction) has been achieved in the North Sea catchment area. The atmospheric deposition of nitrogen to the North Sea has remained static at about 350 000 t/yr. The relative proportions of nitrogen input for riverine, atmospheric and direct inputs are 10:3:1.

In general, rivers are the dominant source of nutrients in near shore areas. Although the pattern of nutrient input to estuaries closely follows that of river water flow, which varies widely within and between years, the net seaward flux of nutrients through estuaries to coastal waters may be strongly influenced by estuarine processes. Although nutrient fluxes associated with the import of oceanic water masses are substantially higher than anthropogenic inputs, only a proportion of these fluxes is available for primary production. Nevertheless, on parts of the Atlantic seaboard upwelling of nutrient-rich oceanic water plays a significant role in seasonal phytoplankton production.

4.10.3 Concentrations and trends of nutrients

Only a few time trend data sets exist for areas other than the North Sea area. Although there is no clear trend in the area as a whole, this is not the case in local areas that are directly influenced by anthropogenic inputs. For example, a significant decreasing trend in phosphorus concentration was detected in Danish waters (between 1989 and 1997) and the German Bight. The decrease in the phosphorus concentrations in nearly all Danish areas is due to a significant decrease in the load from sewage, industry and detergents (80% reduction in the phosphorus load). The same trend was also seen for phosphorus concentrations in the Wadden Sea. Data sets from a site in the central Irish Sea, near the Isle of Man, suggest that there has been an increase in winter nitrate and phosphate concentrations since sampling started at the site in 1954. This trend may be partially climate-related.

Monitoring programmes and modelling studies have shown that water rich in nutrients and organic content, and originating in the southern North Sea, reaches the Norwegian Skagerrak periodically. This flux leads to reduced environmental quality especially in threshold fjords and coastal basins.

4.10.4 Oxygen

The production and subsequent degradation of excess plant biomass and large input of organic matter may lead to oxygen depletion in the marine environment. This is a major problem in areas with restricted water exchange and stratified water bodies.

Oxygen depletion in marine waters, not permanently stratified, generally occurs in summer–autumn periods when a thermocline develops that reduces the vertical water exchange. Nitrogen is generally regarded as the limiting nutrient for algal growth in marine waters. Danish data have shown that in stratified water in the Kattegat, where oxygen depletion problems are pronounced, nitrogen loading has the most significant influence in relation to oxygen depletion. Model calculations by the Danish Environmental Protection Agency showed that a 50% reduction in the actual nitrogen load would result in an almost equal reduction in the duration of anoxia in these environments.

Low oxygen concentrations in the water are periodically observed in many estuaries, bays, fjords, and in the Wadden Sea, Kattegat and the eastern Skagerrak. In the outer Clyde Estuary and Liverpool Bay oxygen depletion is occasionally detected at times of stratification. In both cases this was attributable to sewage sludge dumping, and the situation is anticipated to improve following the cessation of sludge dumping.

chapter 5

Biology

5.1 Introduction

The organisms living in the OSPAR maritime area belong to a wide range of taxonomic and ecological groups, including viruses, bacteria, plankton, benthos, fish, squid, birds, mammals and turtles. A general description of these groups of organisms is given in Section 5.2, while the impact of various human activities on the organisms is presented in Section 5.3. This chapter forms a basis for the overall assessment of the impacts of human activities in Chapter 6.

The various groups of organisms are interlinked in more or less tightly coupled food webs which together with the abiotic environment, make up the marine ecosystems. In terms of principles, the organisation of marine ecosystems is similar in all OSPAR Regions. Microscopic phytoplankton constitute the ‘grass’ of the sea and the basis for production at higher tropic levels. Phytoplankton is grazed by zooplankton, which again forms the food for plankton-feeding fish (e.g. anchovies, herring, mackerel) and whales. Benthic animals living in or on the seabed feed on plankton and dead organic material sinking out from the upper layer. Fish, squid, sea mammals and seabirds feed on smaller fish or benthic animals. Kelp and other macroalgae grow as plants in the lighted zone in shallow waters. Microorganisms contribute to decomposition of organic material and recycling of nutrients.

Many species of plants and animals have restricted distributions, and the biogeographical regions give distinct characteristics in terms of biodiversity to various parts of the OSPAR area.

Annex V to the OSPAR Convention, adopted in 1998, aims at protecting species and habitats in the OSPAR area. The Annex V strategy is to identify species and habitats for which protection measures will be considered. This work is ongoing and criteria for identifying species and habitats have been developed, including criteria for species and habitats under threat or subject to rapid decline.

5.2 General description of the biology of the OSPAR area

5.2.1 Microorganisms

Microorganisms, principally bacteria (but also yeasts, fungi and viruses), are constituents of the plankton as well as of the benthos. Planktonic bacterial production in the open sea is related to primary production and the abundance of bacteria increases following phytoplankton blooms. One of the main functions of bacteria in marine ecosystems is to remineralise organic matter (including oil) to inorganic components. In doing so, benthic bacteria show great metabolic diversity, utilising oxygen, nitrate or sulphate as their reduction substrate. Their respiratory activity creates a chemical gradient within the sediment with oxygen-utilising forms closest to the sediment/water interface and sulphate-utilising forms at greater depths.

5.2.2 Phytoplankton

Phytoplankton biomass shows considerable spatial variability in the OSPAR area *(Figure 5.1)*. The seasonal cycle is typical of temperate latitudes with a spring increase, summer decline and a second, generally less high, autumn increase. The spring bloom is generated mainly by diatoms which decline as concentrations of the winter accumulated nutrients (e.g. silica and nitrate) are utilised and as grazing pressure from zooplankton increases. In ice covered waters in the Arctic the seasonal cycle has a pronounced peak as the developing bloom moves north with the retreating ice edge. South of 40° N, in the wider Atlantic, the upper water column stays stratified throughout the year so the biomass is lower and less variable throughout the seasons.

The timing of the spring bloom is closely linked with the developing water stratification, which allows phytoplankton cells to remain in the higher light levels of the upper water column. During summer months recycling of nutrients occurs and other algal groups such as the dinoflagellates dominate the phytoplankton. Diatoms may return again in the late autumn as stratification breaks down and nutrients are again mixed into surface waters.

There is marked interannual variability in the timing and intensity of phytoplankton growth, and long-term trends (both up and down) have been described for different parts of the OSPAR area. These trends appear to be linked to changes in coupled ocean-atmosphere circulation.

A wide diversity of different phytoplankton species is found in the North Atlantic. Named species range from ~ 300 in the Arctic to ~ 1000 in Region IV, although many species have not yet been described. Traditionally diatoms were seen to be the most important group, it is now recognised that many very small flagellates and other algal classes may dominate at times. When temperatures increase in the summer flagellates dominate; most toxic species belong to this group (see Section 5.3.2 and *Table 5.5*).

Total annual production of phytoplankton varies from region to region. The lowest rates (*c*. 45 g C/m^2/yr) are found in the Wider Atlantic south of 40º N, the highest (> 400 g C/m^2/yr) on the Galician shelf and in the Cantabrian sea. In the North Sea the rate in the coastal areas (*c*. 400 g C/m^2/yr at a station 6 km off the Dutch south-west coast) is nearly an order of magnitude higher than in its central part. The rates also vary considerably within each region.

5.2.3 Zooplankton

The zooplankton of the epipelagic zone (0 – 200 m) is dominated by species with a size spectrum ranging from protozoans to crustacean euphausiids. In shelf seas, larval stages of benthic organisms (e.g. echinoderms) may be important in spring and summer. In the deep ocean waters of the Wider Atlantic, the maximum number of species occurs at around 1000 m depth. However, the biomass at this depth is an order of magnitude lower than that found in the epipelagic zone.

Zooplankton are the main source of food for pelagic fish and the early life stages of all fish. Variations in zooplankton composition and in the timing and location of occurrence can thus have important effects on fish recruitment and growth.

The growth of zooplankton is governed by temperature and food availability so that their seasonal cycle is linked to that of the phytoplankton. For example, some species such as *Calanus finmarchicus* hibernate during winter in deep water timing their arrival in near surface waters to exploit the phytoplankton spring bloom. The herbivorous copepods of the genus *Calanus* play a key role in ecosystems of the OSPAR area. They are the most abundant form of zooplankton and may account for over 90% dry weight of the total zooplankton biomass in the northern and eastern part of the area.

There are strong year to year variations in zooplankton abundance. For example, *C. finmarchicus* and *C. helgolandicus* abundance in the Irish Sea can vary by an order of magnitude between years. The zooplankton biomass and composition in the central and northern Barents Sea have also shown several fold variations between years, which in part appears to be caused by fish predation. Elsewhere, as for phytoplankton, longer-term changes for many species appear to be related to variability in ocean-atmosphere circulation.

5.2.4 Benthos

The biota living near, on or in the seabed are collectively called the benthos. A distinction is made between plants (phytobenthos) and animals (zoobenthos). The phytobenthos may be composed of microalgae or macroalgae, the latter being colonised by epiphytic plant and animal species. The zoobenthos either lives as infauna within the sediments or as epifauna on the seabed.

Diversity and biomass of the benthos are dependent on a number of factors including substrate (e.g. sediment, rock), water depth, salinity and hydrodynamics. Depending on the characterisation of habitats by such factors, certain communities can be expected.

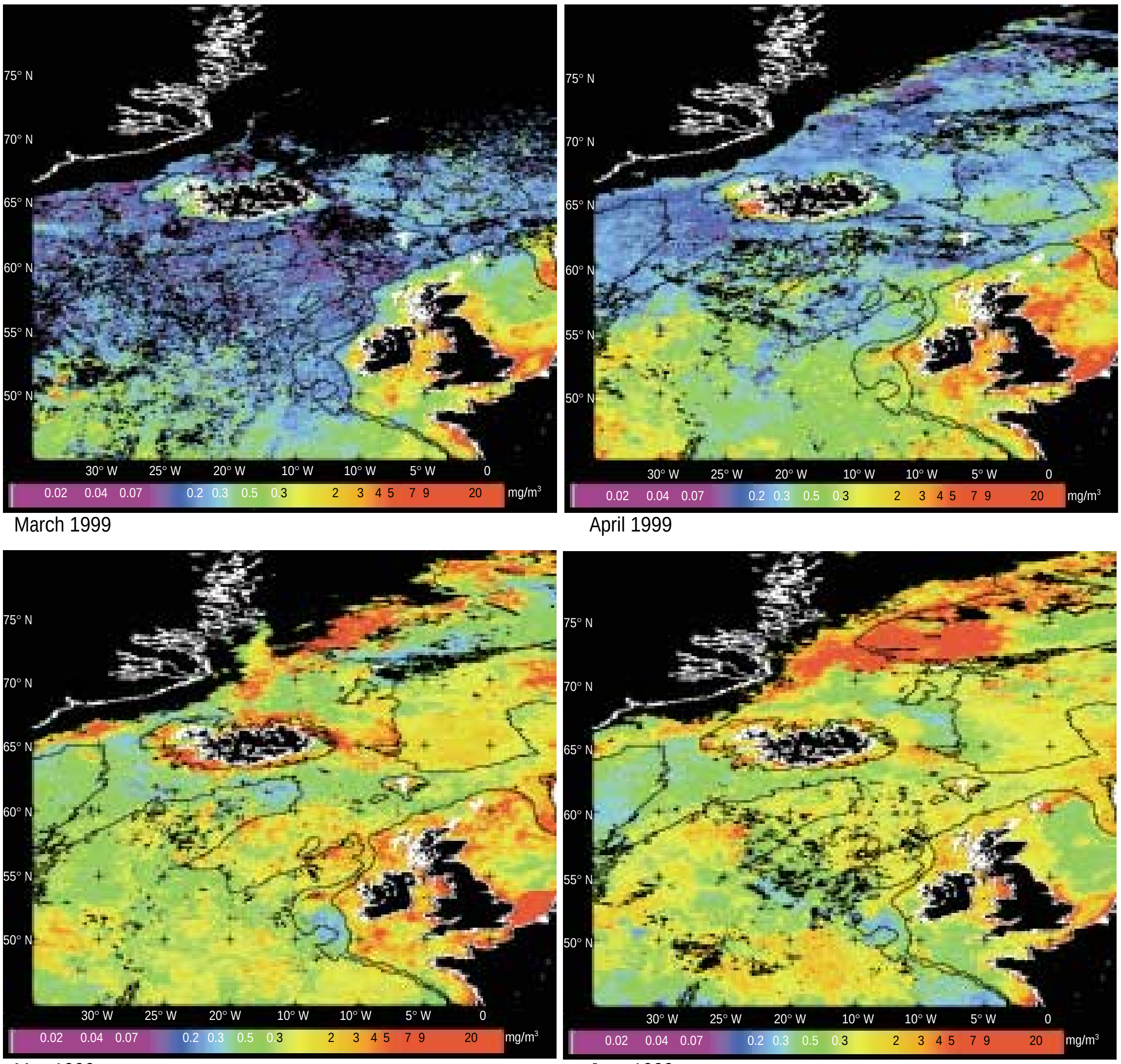
Phytobenthos

Since it is light dependent, the micro- and macrophytobenthos is restricted to shallow waters. Whilst the microphytobenthos may thrive on any substrate, thus for example contributing to the stabilisation of loose sediments, perennial red and brown macroalgae (e.g. *Lithothamnion, Fucus*) require a hard substrate (e.g. rock, stones) whilst green algae (e.g. *Ulva*) may thrive on mussel beds or even (solid) sediments. Higher plants such as eelgrass (e.g. *Zostera*) may be found on sandy sediments.

The total number of macroalgal species decreases from south to north within the Arctic and northern temperate areas. The dominating macrophytes of these areas are large, brown algae (Laminarians or 'kelp'). The main depth to which macroalgae grow is in general lower at high latitudes than in temperate regions.

In the southern part of the OSPAR area the coastal

Figure 5.1 **SeaWiFS satellite images of chlorophyll concentrations in the North-east Atlantic. Source: CCMS.**



March 1999 April 1999 May 1999 June 1999

Table 5.1 Landings and spawning stock biomass of the commercially important fish species in the OSPAR area, and status of the stock according to whether it is within 'safe biological limits'. Source: ICES (1999).

ICES division or stock description	Landings (t) 1997	Spawning stock biomass (t) 1998	Status*
Region I			
Cod			
North-east Arctic	755 000	419 000	outside SBL
Norwegian coastal	36 000	uncertain	uncertain
Iceland	204 000	529 000	within SBL
Faroe plateau	34 000	68 000†	close to or within SBL
Herring			
Norwegian (spring spawning)	1 427 000	9 800 000	within SBL
Icelandic (summer spawning)	64 000	486 000	within SBL
Capelin			
Barents Sea	closed in 1997	254 000	within SBL from 1998
Greenland / Iceland	1 245 000	490 000	within SBL
Saithe			
North-east Arctic	143 000	211 000	outside SBL
Iceland	37 000	90 000	outside SBL
Faeroes	22 000	50 000	outside SBL
Haddock			
North-east Arctic	146 000	219 000	outside SBL
Iceland†	44 000	67 000	harvested outside SBL
Faeroes	18 000	50 000	close to SBL
Region II			
Cod			
North Sea	124 000	136 000	outside SBL
Whiting			
North Sea	59 000	172 000	outside SBL
Haddock			
North Sea	142 000	213 000	close to SBL
Saithe			
North Sea	103 000	132 000	outside SBL
Plaice			
North Sea	83 000	274 000	outside SBL
Sole			
North Sea	15 000	26 000	outside SBL
Herring			
North Sea	248 000	1 145 000	outside SBL
Mackerel			
North Sea	228 000	see combined stock below	see combined stock below
Horse mackerel			
North Sea (excluding IVa)	20 000	see combined stock below	see combined stock below
Region III			
Herring			
VIa	60 000	na	uncertain
Irish Sea (VIIa)	6 600	10 300	harvested outside SBL
Celtic Sea and VIIj	18 800	70 000	harvested outside SBL
VIa, VIIb-c	27 000	57 000	harvested outside SBL
Mackerel			
VIa, VIIa, VIIb, VIIf, VIIg-k	196 000	see combined stock below	see combined stock below
Horse mackerel			
VIa, VIIa, VIIb, VIIf, VIIg-k	~ 358 000	see combined stock below	see combined stock below
Cod			
VIa	7 000	15 100	outside SBL
Irish Sea (VIIa)	5 700	8 750	outside SBL
VIIe-k	11 800	12 800	outside SBL
Haddock			
VIa	19 500	44 300	outside SBL
VIb (Rockall)	5 200	8 400	outside SBL
Irish Sea (VIIa)	3 500	na	unknown
Whiting			
VIa	10 900	17 200	outside SBL
Irish Sea (VIIa)	4 200	8 100	outside SBL
VIIe-k	18 100	31 800	within SBL
Saithe			
VI	9 400	11 900	outside SBL

Plaice			
Irish Sea (VIIa)	1 900	5 600	within SBL
Celtic Sea (VIIf and g)	1 200	1 540	outside SBL
Sole			
Irish Sea (VIIa)	1 000	3 000	outside SBL
Celtic Sea (VIIf and g)	900	2 000	outside SBL
Megrim			
VI	3 600	na	within SBL
Anglerfish			
VI	12 800	na	outside SBL
Elasmobranchs (sharks, skates, rays)‡			
VIa, VIIa, VIIb, VIIf, VIIg-k	32 300	na	na
Region III – IV			
Megrim			
VII and VIIIa,b,d,e	17 300	65 000	within SBL
Anglerfish			
VIIb-k and VIIIa,b	28 900	73 700	within SBL
Region IV			
Sardine			
VIIIc & IXa	115 000	253 000	outside SBL
Anchovy			
VIII & IXa	27 500	na	within SBL
Mackerel			
VIIIc & IXa	41 000	see combined stock below	see combined stock below
Horse mackerel			
VIIIc & IXa	57 000	256 000	close to SBL
Hake			
VIIIc & IXa	7 600	13 200	outside SBL
Sole			
Bay of Biscay (VIIIa,b)	6 900	13 600	outside SBL
Megrim (*L. boscii*)			
VIIIc & IXa	900	5 300	outside SBL
Megrim (*L. whiffiagonis*)			
VIIIc & IXa	360	1400	outside SBL
Anglerfish (*L. budegassa*)			
VIIIc & IXa	1 800	na	outside SBL
Anglerfish (*L. piscatorius*)			
VIIIc & IXa	3 700	na	outside SBL
Region V			
Greenland Halibut			
Tuna			
Marlin			
Region I, II, III, IV, V			
Mackerel (highly migratory)			
North Sea component	~ 10 000, closed in southern and central North Sea		outside SBL
combined stock	570 000	2 650 000	outside SBL
Blue whiting (highly migratory)			
Norwegian Sea	63 000		
Region I			
Region II, III and V	541 000		
Region IV	30 000		
combined stock	634 000	2 718 000	within SBL
Western horse mackerel (highly migratory)	3 000		
Region I			
Region II			
IVa only	64 000		
Region III	~ 358 000		
Region IV			
VIIIc and IXa only	~ 12 000		
combined stock	443 000	1 000 000	outside SBL
Northern hake (highly migratory)			
IIIa, IV, VI, VII and VIIIa,b	44 200	127 000	outside SBL

* A stock is considered to be outside or harvested outside 'safe biological limits' (SBL) when the spawning stock biomass is below B_{pa}, which is the lowest biomass where there is a high probability that the production of offsprings/recruits is not impaired, or when the fishing mortality is higher than F_{pa}, which is a fishing mortality that with high probability is sustainable; † taken from ICES (1999b); ‡ Statlant data.

environment is highly heterogeneous in terms of habitats. For this reason, the algal diversity is high. For example, approximately 700 macroalgal species are found in the Channel area. The sediments of intertidal flats are colonised by hundreds of species of microscopic benthic algae. Most of them are diatoms, whose populations are also accompanied by blue-green algae and interstitial flagellates. In addition to the microalgae populations shallow areas are to some extent covered by beds of higher plants such as *Zostera* and *Ruppia* species.

Besides providing habitat for epiphytic species, macroalgae and eelgrass provide food for numerous grazers and deposit feeders. As with excessive algal blooms, mass development of macroalgae due to excess nutrients may entail oxygen depletion in the bottom water following microbial breakdown of the excess biomass.

Zoobenthos

The bathymetry of the OSPAR area ranges from shallow continental shelf to abyssal plains (around 5000 m depth). Deep-ocean benthos tends to be much smaller than its shallow-water counterparts and it is generally accepted that species diversity increases with depth in the continental shelf regions to a maximum just seaward of the continental rise, and then decreases with increasing distance towards the abyssal plain (Levinton, 1995).

The Greenland–Scotland Ridge is a major biogeographical boundary for benthos within the OSPAR area. This ridge forms a barrier between warm- and cold-water species.

Large areas of coral banks of *Lophelia* occur in the Atlantic Ocean near the continental shelf break off Ireland, Scotland, the Faroe Islands, Norway, and off the south coast of Iceland. High diversity of biota is associated with these coral banks.

In shallow shelf areas such as the North Sea, benthic and pelagic processes are often strongly coupled and work in concert to make the region highly productive. Highly productive benthic communities can be found in tidal areas, for example in the Wadden Sea along the south-eastern border of the North Sea, and in several estuaries along the western European coast.

On the shores of northern and north-western Spain and on the Portuguese shore hard substrata are dominated by sessile and slow moving macrofauna in the upper levels. Intertidal and subtidal soft bottoms on the shores of northern and north-western Spain have a rich infauna related mainly to grain size and organic matter content. Along the Portuguese coast, intertidal sands have a low faunal density, whereas fauna in the subtidal soft substrata is more abundant due to the increase in sediment organic matter.

Frontal regions, where different ocean currents meet, normally have a high primary production resulting in highly productive benthic communities. Such frontal regions occur throughout the OSPAR area: in the Denmark Strait, between Iceland and the Faroe Islands, in the western part of the Barents Sea, in the Norwegian Sea, in the North Sea, in the Kattegat/Skagerrak area and the Irish shelf front, to the west of Ireland.

5.2.5 Fish and squid

Over a thousand species of fish have been recorded in the OSPAR area. Of these, about 5% can be commercially exploited and about 2% of species make up 95% of the total fish biomass. The major commercially exploited fish stocks in each part of the OSPAR area are given in *Table 5.1*. The larvae of many commercially important fish species disperse into the open ocean from their spawning grounds at the continental shelf and in estuarine areas. Some fish species perform long annual migrations between the feeding, spawning, and overwintering areas. Variability in stock recruitment is related to both the size of the parental stock and to a number of factors, including environmental variability and predation, which affect egg and larval survival.

Approximately 160 species of fish have been recorded in the Barents Sea, with the total number of species in Region I unlikely to exceed 200. Much of the total fish biomass is concentrated in a few species, which are exploited commercially. The number of fish species is comparatively low in the shallow southern North Sea and eastern Channel and increases towards the Celtic Sea and Bay of Biscay. Overall, around 250 species have been found in Region II, with more species occurring commonly than in Region I. In the Bay of Biscay and Region III the number of species reaches 700, since many northern species reach their southern limit of distribution and many southern species reach their northern limit of distribution along the boundary for cold temperate species in the vicinity of 47° N. Along the Iberian coast in Region IV, the number of species remains high, as more demersal species of southern or Mediterranean distribution occur. The biodiversity of Region V is less well quantified, particularly in deeper waters, but fewer species are likely to occur than on the continental shelf.

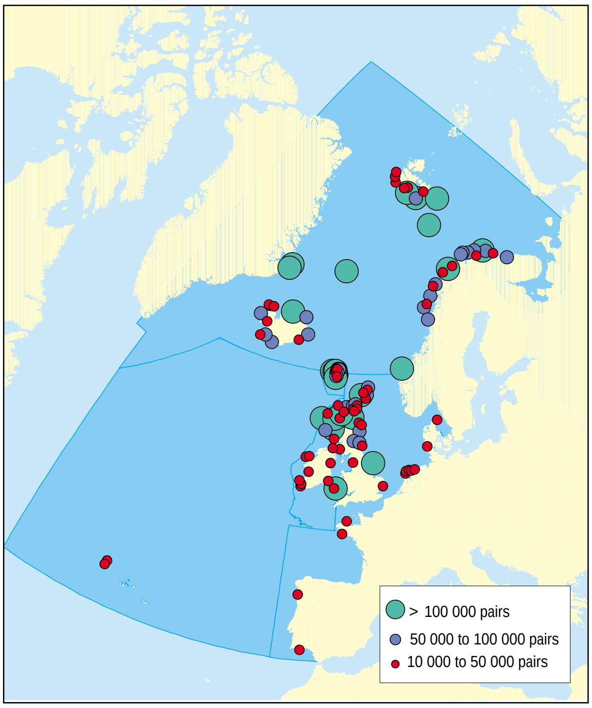
Many deep-water species have an extensive geographical distribution owing to the small environmental variations of their habitat. In the Wider Atlantic, top predators such as sharks probably play an important role in maintaining the structure and diversity of fish assemblages. Large pelagic predators (tuna and marlin) are highly migratory, ranging far beyond the boundaries of the OSPAR region.

The biology of squid is poorly known despite being very abundant especially in the Wider Atlantic. Only a few species are exploited commercially but squid are of considerable ecological importance as predators and as the food of some whales, fish and seabirds.

5.2.6 Birds

Almost all parts of the OSPAR area support breeding and migratory birds dependent on the sea. Proportionately, the greatest numbers of breeding seabirds nest on the coasts of Arctic waters and the North Sea. Total numbers of individuals in these northern areas are several orders of magnitude greater than those in the southern regions of the OSPAR area *(Figure 5.2)*. The total numbers of species, and two most common species in each Region are shown in *Table 5.2*. Only the great skua (*Catharacta skua*) is endemic to the OSPAR area, although some species are near-endemic (e.g. Manx shearwater (*Puffinus puffinus*)) or have endemic sub-species (e.g. shag

Figure 5.2 **Location of large seabird breeding colonies in the OSPAR area. Source of data: Grimmett and Jones (1989).**



(*Phalacrocorax aristotelis*)). Surveys of distribution at sea have not been carried out in all parts of the OSPAR area, but in those that have been studied surveys show shelf seas to hold substantially higher densities than oceanic waters. Large intertidal flats, such as in estuaries and in the Wadden Sea are particularly important for wading birds. Some 6 – 12 million birds of more than 50 different species may be present in the Wadden Sea at some times of the year.

5.2.7 Marine mammals and turtles

Cetaceans

Whales are divided into two groups: baleen whales (primarily feeding on small fish and plankton) and toothed whales (preying on fish, squid and marine mammals). Over 30 species of cetaceans occur throughout the OSPAR area, ranging in size from the small harbour porpoise at < 2 m (*Phocoena phocoena*) to the giant blue whale (*Balaenoptera musculus*) at about 33 m *(Table 5.3)*. Following the moratorium on commercial whaling for most species, numbers of most species of large whale are showing signs of recovery. There has been an increase in recorded strandings of cetaceans in the North Sea and the Celtic Sea over the past few decades, but the reasons for this are not known.

Seals and bears

Some seal species live in coastal areas; others are adapted to the sea ice and never come ashore. All seals are carnivorous, feeding on fish, krill, pelagic amphipods or benthic animals. The vast majority of the seal population is found in Region I *(Table 5.3)*. Individual seals of all species have occurred well away from their normal range in the OSPAR area. Approximately 40% of the world's population of grey seals breed in the waters around Europe. The number of pups has increased steadily (by a factor of three or more) over the past 30 years.

Apart from the effects of commercial sealing, the only major change in the population of seals resulted from the

Table 5.2 Number of species of seabirds breeding on coasts of the OSPAR Regions, with approximate population sizes for the two most common species in each Region. Note that even for the most common species, population sizes are not all well known.

	No. species	Most common two species	Population size (pairs)
Region I	33	little auk	4 600 000
		puffin	3 900 000
Region II	31	common guillemot	480 000
		kittiwake	420 000
Region III	26	common guillemot	110 000
		storm petrel	50 000 – 100 000
Region IV	21	gannet	150 000
		yellow-legged gull	74 000
Region V	13	Cory's shearwater	50 000 – 100 000
		Madeiran petrel	1 200

1988 phocine distemper virus outbreak. This fatal disease, which took on epidemic proportions, had the greatest impact on the eastern side of the North Sea where the population of harbour seals in the Wadden Sea was reduced from 10 000 to 4000 between 1988 and 1989. Since then the population has recovered and in 1998 consisted of more than 14 000 individuals.

Polar bears have a circumpolar distribution and are confined to ice covered areas of the Arctic *(Table 5.3)*. The distribution of bears between Eastern Greenland and Franz Josef Land is largely determined by the extension of the pack ice.

Turtles

The range of most sea turtles is in tropical or subtropical waters but some species undertake long migrations using the warm current of the Gulf Stream. For this reason, a few species visit the Bay of Biscay, the Iberian coast and the wider Atlantic every year. The one species that is frequently recorded in the OSPAR area is the loggerhead turtle (*Caretta caretta*).

5.3 Impact of human activities

Owing to large natural variability and limited knowledge of cause-effect relationships, human influences on the biology of the OSPAR area are difficult to establish in the majority of cases. A direct link to human activities is clear for some contaminants (e.g. TBT), the exploitation of marine mammals, and for fishery effects on benthic invertebrates and seabirds. The need for an improved knowledge of anthropogenic effects on biota is recognised and is being developed within OSPAR and other bodies.

5.3.1 Impact of non-indigenous species

Non-indigenous species may arrive as a result of both natural (e.g. water currents) and human-mediated processes (e.g. ships' ballast water, hull fouling and commercial transport of fish and shellfish). To date, over one hundred non-indigenous species representing a large spectrum of taxonomic and ecological groups of organisms (plankton, macroalgae and benthos) have been recorded in the OSPAR area, mainly in the North Sea, the Celtic Sea, the Bay of Biscay and along the Iberian coast. A few non-indigenous species were deliberately introduced to the area mainly for mariculture purposes. The most significant ecological effects of these introductions are competition (for food, space or light) or predatory interactions with indigenous species, and pathogenic or other harmful effects. A list of some of the non-indigenous species that have had impacts in the OSPAR area is shown in *Table 5.4*.

Table 5.3 Marine mammals of the OSPAR area.

	I	II	III	IV	V
bowhead whale*	X				
northern right whale*			X	X	X
minke whale	X	X	X	X	X
sei whale†	X	(X)	(X)	X	X
Bryde's whale				(X)	(X)
blue whale‡	X	(X)	(X)	X	X
fin whale	X‡	X	X	X	X‡
humpback whale	X‡	X	X	X	X‡
pygmy sperm whale†				X	X
dwarf sperm whale†				(X)	(X)
sperm whale	X	(X)	(X)	X	X
white whale / beluga	X				
narwal†	X				
northern bottlenose whale	X	(X)	(X)	X	X
Sowerby's beaked whale†	X	(X)	(X)	X	X
Blainville's beaked whale†				(X)	(X)
Gervais' beaked whale†					(X)
True's beaked whale†			(X)	(X)	(X)
Cuvier's beaked whale†	(X)	(X)		X	
pygmy killer whale†					X
short-finned pilot whale				X	X
long-finned pilot whale	X	X	X	X	X
killer whale	X	X	X	X	X
melon-headed whale					X
false killer whale				(X)	X
common dolphin	X	X	X	X	X
striped dolphin			X	X	X
Atlantic spotted dolphin				(X)	X
rough-toothed dolphin				X	X
bottle-nosed dolphin		X	X	X	X
Risso's dolphin		X	X	X	X
Atlantic white-sided dolphin	X	X	X	X	X
white-beaked dolphin	X	X	X	X	(X)
harbour porpoise	X	X	X	X	X
walrus	X				
harbour seal	X	X	X	(X)	
ringed seal	X				
harp seal	X				
bearded seal	X				
hooded seal	X	X	X	X	X
grey seal	X	X	X	(X)	
polar bear	X				

X indicates that a species is present. Bracketed records indicate vagrant animals, these are mostly species that normally occur in deep water, or are tropical species; * numbers substantially below 'natural' levels due to past hunting; † the status of most of the beaked whales and some other whales is poorly known; ‡ numbers below or substantially below 'natural' levels.

5.3.2 Harmful algae

The vast majority of algal phytoplankton are harmless and form the basis for marine food webs. At times, however, they may occur in large concentrations and colour the water red or brown. At these concentrations the algae may be harmful to other marine life by reducing levels of oxygen or clogging gills of fish. Some algal species are toxic to marine life and to humans and some species may through their breakdown cause large masses of foam to develop on beaches that are aesthetically undesirable and can affect tourism (see *Table 5.5*). Fish farmers can suffer serious financial losses if harmful algal blooms pass through fish cages. In the period up to the early 1990s, the occurrence of harmful algal blooms increased both in space and time (Hallegraeff, 1995). Several mechanisms related to human activities may have driven this trend:

- introduced species via e.g. ballast water, mariculture;
- coastal installations intensifying stratification e.g. Bay of Vilaine;
- anthropogenic inputs and fluxes of nitrogen into areas susceptible to eutrophication;
- unbalanced nutrient ratios, e.g. N : P and N : Si;
- hydroelectric power plants – exceptional discharges; and
- increasing inputs of humic substances from rivers due to acid rain.

Algal toxins can accumulate in the edible tissue of bivalve molluscs (e.g. mussels) to levels that can be dangerous to the human consumer. Many countries in the OSPAR area have established biotoxin-monitoring programmes that provide early warning of the composition and numbers of toxic plankton species and levels of toxins in bivalve tissue. Warning and closure notices can be issued if permissible standards of toxins in shellfish are exceeded. The principal toxins monitored in the OSPAR area are those that cause Paralytic Shellfish Poisoning (PSP), Diarrhetic Shellfish Poisoning (DSP) and Amnesic Shellfish Poisoning (ASP). ICES provides decadal maps which give information on the regional occurrence of shellfish poisoning (ICES, 1999c and 2000).

5.3.3 Impact of microbiological pollution

Microbiological pollution may affect all marine biota, including invertebrates, fish, and seals. In the OSPAR area, the most important concerns are molluscs and bathing water quality. Discharges of sewage (treated and untreated) to the sea takes place throughout the coastal regions of the OSPAR area. The bacteria and viruses associated with sewage and other sources such as agricultural run-off, mainly attached to fine particulate matter, can affect bathing water quality and can accumulate in filter feeding shellfish such as mussels. The EC Directives for shellfish water quality (79/923/EEC) and shellfish hygiene (91/492/EEC) lay down permissible limits for levels of bacteria in water and shellfish respectively (the latter also applies to Iceland, and both apply to Norway). The country to which the relevant directive applies is obliged to establish appropriate monitoring programmes and to classify shellfish growing waters. Existing standards for the microbiological quality of bathing water (EC Directive on the quality of bathing water 76/160/EEC) and shellfish, although important in the protection of public health, may not protect all individuals against the entire range of human pathogens to which they might be exposed either through bathing or seafood consumption.

Bathing water quality

Since monitoring work began there has been a marked improvement in quality of bathing water, owing to the use

Table 5.4 Some of the non-indigenous species in the OSPAR area including their mode of introduction and potential impact in each Region.

	Mode of introduction*	First observation†	Potential impact	Region‡
bay barnacle	fouling (A)	1844 (Sweden)	habitat altered competition	I, II
soft-shelled clam	aquaculture (A)	1200s (Denmark)	competition	I, II, III
Japanese seaweed	aquaculture (A)	1971 (UK)	interference with water exchange competition	II, III, IV
Pacific oyster	aquaculture (D)	1926 (UK)	competition	II, III, IV
Atlantic razor clam	ballast water / sediment (A)	1968 (Germany)	competition	II
Marenzelleria viridis (polychaete worm)	ballast water (A)	1982 (Germany/UK)	competition	II
slipper limpet	aquaculture (A)	1926 (Netherlands)	habitat altered competition	II, III, IV
common cord grass	aquaculture (A)		decreased habitat availability competition	II, III, IV
Bonamia ostrea (protozoan)	aquaculture (A)		oyster mortality	III, IV
Elminius modestus (barnacle)	fouling (A)	1940 (UK)	competition	II, III, IV

* D: deliberate introduction; A: accidental introduction; † first recorded observation by a Contracting Party in the OSPAR Convention area;
‡ OSPAR Region where the species is established or probably established.

Table 5.5 Harmful algal bloom species in the OSPAR area.

Effect	Probable organisms	Mode of action	Region
Toxic to humans (via the food chain)			
PSP	*Alexandrium* spp. (e.g. *Alexandrium tamarense*)	chemical	I, III, IV
	Gymnodinium catenatum	chemical	IV
DSP	*Dinophysis* spp.	chemical	III, IV
ASP	*Pseudo-nitzchia australis*	chemical	III, IV
Non-toxic to humans, harmful to fish and/or invertebrates			
fish mortality (Ichthyotoxin)	*Chrysochromulina* spp.	chemical	I, II
	Heterosigma akashiwo	chemical	I, II
	Gyrodinium aureolum	chemical	II, III
	Prymnesium parvum	chemical	II
	Chattonella antiqua	chemical	II
	Chattonella marina	chemical	II
fish mortality (neurotoxin)	*Chattonella verruculosa*	chemical	II
	Fibrocapsa japonica	chemical	II
Non-toxic			
clogs / damages fish gills	*Phaeocystis* spp.	physical	II
	Coscinodiscus spp.	physical	II
fish mortality	*Dictyocha speculum*	physical	I, II
foam production on beaches	*Phaeocystis pouchetti*	physical	III
water discolouration	*Noctiluca* spp.	physical	III

of wastewater treatment plants. For example in the UK, the percentage of bathing areas meeting the standards has increased from 66% in 1988 to 90% in 1996. The vast majority of bathing waters in the OSPAR area now conform to the standard under the EC Directive. Where standards are not met, action is taken by the responsible authority within each country to improve bacterial quality of the bathing water.

Shellfish hygiene directive

All molluscan shellfish harvesting areas are required by EC Directive 91/492/EEC to be classified according to the extent to which shellfish samples from each area are contaminated with *Escherichia coli*. The classification of areas ranges from clean areas where molluscs can be sold for direct human consumption, to those from which molluscs need to be treated before consumption and those where molluscs are prohibited for human consumption. In some OSPAR Regions, the contamination of shellfish with *E. coli* has led to restrictions on marketing shellfish and has increased processing costs, which have caused concern within the shellfish industry. These concerns have focused attention on water quality within shellfish harvesting areas and in some cases have prompted water quality improvements through improved sewage treatment systems.

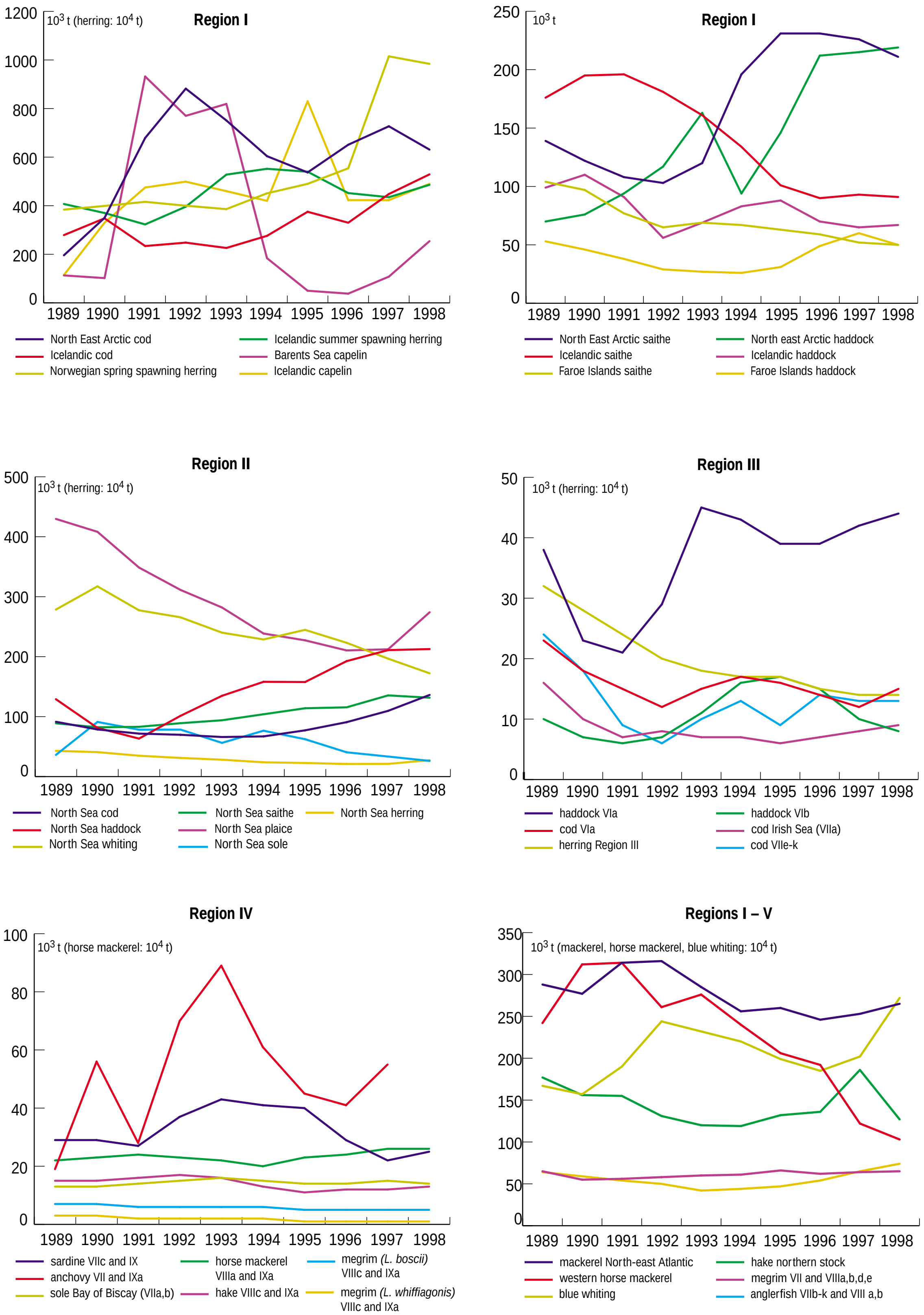
5.3.4 Impact of fisheries on ecosystems

Commercial fishing has direct and indirect effects on the marine ecosystem. These can be summarised as follows:

- removal of target species;
- mortality of non-target species (fish and invertebrates), birds and marine mammals, through their incidental catch in fishing gear;
- physical disturbance of the sea bottom through some demersal fishing gear and therefore an adverse impact on benthic habitats and communities;
- shifts in community structure; and
- indirect effects on the food web.

The fish stock biomass of the exploited species in the main fishing areas has fluctuated considerably over the past 50 years. Ten-year trends in the biomass of a number of the spawning stocks in the OSPAR area are shown in *Figure 5.3*. Two main factors are responsible for these fluctuations, namely commercial fishing pressure and the recruitment of young fish to the spawning stock. In some cases, intensive fishing combined with poor recruitment depleted stocks to the point where they could no longer support a commercially viable fishery. Examples of this are a number of herring stocks such as the Norwegian spring spawning and North Sea stocks that collapsed in the 1960s and 1970s. As a result, bans on fishing were imposed to allow the stock to recover. In 1999, ICES reported that 40 of the 60 major stocks for which OSPAR requested information were outside ‘safe biological limits’ (see definition in footnote to *Table 5.1*). The results of this assessment are summarised in *Table 5.1*.

Figure 5.3 **Ten-year trends in spawning stock biomass for stocks in each of the four main OSPAR Regions together with migratory stocks that extend into more than one Region.**



In regions where commercial stocks have been overexploited, fishing pressure is often switched to stocks in other areas, including deep-sea populations. The slow growth rates and low fecundity of many deep-sea fish makes them especially vulnerable to overexploitation. Evidence is beginning to emerge that deep-sea trawling inflicts damage upon some of the deeper ecosystems. These impacts may already be quite extensive and recovery can be relatively slow.

Non-target catch can include juveniles of target species and juveniles and adults of non-target species as well as large benthos, mammals and seabirds. Juvenile fish are sometimes unable to escape from trawl nets. This occurs mainly where small mesh nets are used such as in fisheries for shrimp and *Nephrops*, and in mixed roundfish and flatfish fisheries. High rates of capture of juvenile whiting in the Irish Sea led in 1992 to the mandatory use of square mesh panels in UK trawl nets. Ireland followed in 1994. Other technical measures introduced to reduce discarding include sorting panels or grids in fisheries for shrimp and deep water *Pandalus*. During the 1990s, about half of the total catch in numbers of whiting and haddock taken by trawlers off the west coast of Scotland were discarded. In *Nephrops* fisheries in the Irish Sea, just under half a tonne of whiting is discarded for every tonne of *Nephrops* landed. In certain flatfish fisheries in the North Sea more than half of the weight of the fish caught may be discarded. The discarded fish represent an additional mortality to the stocks since they do not normally survive to become adults. The discards also alter the competitive relationships within the communities by favouring the scavenging species.

Harbour porpoises, dolphins and seals are the most common mammals entangled in fishing gear. Harbour porpoises are particularly vulnerable to bottom-set gillnets. Some dolphins are vulnerable to drift nets. A Danish action plan for reducing incidental by-catches of harbour porpoises includes measures such as the use of acoustic alarms, modifications to fishing equipment and regulation of certain types of fisheries. In order to assess the significance of any by-catch, it is important to know both the rate of annual by-catch, and the size of the population from which that by-catch was taken. Biological considerations indicate that by-catch rates above 1% of abundance may not be sustainable, and rates above 2% have an unacceptably high risk of unsustainability (ASCOBANS 1997). There have been few studies in the OSPAR area that have acquired the necessary data. Estimates for the central North Sea (extrapolated from Danish set-net fisheries) suggest that there was an average annual by-catch of approximately 7000 harbour porpoises over the period 1994 to 1998 (Vinther, 1999). This estimate exceeds 2% of the relevant porpoise population, which is considered non-sustainable. The proportion of the harbour porpoise population by-caught on the Celtic shelf may have exceeded 6% in the mid-1990s (Tregenza *et al*., 1997), but there has been some reduction in fishing effort since the studies were carried out. In the Bay of Biscay and along the Iberian coast, during 1992 and 1993, observers on French Albacore drift netters recorded a by-catch of 204 common dolphins (*Delphinus delphis*) and 573 striped dolphins during 1420 hauls. As a result of this and other observations, EU Fisheries Ministers voted in June 1998 to introduce a ban on drift net fishing for tuna. This will come into effect after 31 December 2001.

Increases in seabird populations over the past decades have been attributed to a number of factors, for example better protection, increases in small prey fish and an increase in fish discards and offal from commercial fishing boats. Periodically, some species have experienced a sharp fall in numbers. Some changes are directly related to a decrease in fish prey for example the decline in the common guillemot (*Uria aalge*) and puffin (*Fratercula arctica*) populations in some parts of the Arctic area following the decrease in stocks of capelin (*Mallotus villosus*) and herring respectively. In the North Sea, it is estimated that seabirds annually consume approximately 50% of all discards (109 000 t) and offal (71 000 t).

Bottom fishing gear can cause death or severe damage to benthos and physical disturbance to sediments. The degree of the impact is related to towing speed, gear size and weight, substrate type and local hydrodynamic factors. It should be stressed, however, that trawling is very patchy and that the impact of trawling is less severe in areas naturally impacted by storms and wave disturbance. The effects of gear type, in terms of seabed disturbance and species affected, in the North and Celtic Seas are given in ***Table 5.6***. Otter trawl boards may penetrate into soft sediment seabeds by 6 – 20 cm. The tickler chains from beam trawls plough sediments to a depth of 4 – 8 cm. Deep-water benthic habitats tend to be very susceptible to the impact of trawling, due to their slow regeneration rate. A 1994 survey indicated that up to 25% of the Irish Sea seabed is disturbed by otter trawling. The Irish otter trawl fleet alone trawls the Irish Sea *Nephrops* grounds up to five times per year. Data from the Dutch beam trawl fleet, which represents approximately 80% of the total beam trawl effort in the North Sea, indicate that about 171 000 km^2 of the North Sea between the Shetland Islands and the Hardangerfjord, and the Strait of Dover (i.e. approximately 429 000 km^2) is fished by trawlers (Rijnsdorp *et al*., 1997). Within the fished area, 70% is trawled less than once a year and, in total, about 10% of the North Sea region specified above is fished more than once per year. In the Dutch Wadden Sea, fishing for cockles in years of low abundance of this species has caused a food shortage for wader birds, for example oystercatchers (*Haematopus ostralegus*). However, since 1993, strict regulations have prevented

Table 5.6 Effects of different types of fishing gear in terms of seabed disturbance, some of the species affected and estimated area trawled in the OSPAR region. Source: Region II (5NSC, 1997); Region III (Kaiser *et al*., 1996).

Gear type	Penetration depth	Species affected	Estimated area trawled
Otter trawl (pair and twin)	ground rope, bobbins chains: < 5 cm (soft bottom) < 2 cm (hard bottom) trawl door: 6 – 20 cm (soft bottom)	epifauna Region II: Crustacea (*Corystes, Eupagurus*), Mollusca (*Abra alba, Arctica islandica, Donax vittatus, Spisula subtruncata, Placopecten*), Echinodermata (*Echinocardium, Psammechinus miliaris*), Cnidaria (*Alcyonium digitatum*)	Region II: 99 000 km^2 (entire North Sea)
		Region III: Mollusca (*Arctica islandica*), Polychaeta (*Lanice conchilega, Spiophanes bombyx*), Echinodermata (*Echinocardium cordatum, Asterias rubens*)	Region III: 25% of Irish Sea
Beam trawl	chains: 4 – 8 cm (soft bottom) 3 – 6 cm (hard bottom) trawl heads: 7 – 10 cm combined effect of beam trawling in other areas: < 10 – 20 cm deep tracks noted	epifauna Region II: same as otter trawl, plus *Pectinaria* spp. *Aphrodite aculeata*, sipunculida & tunicates, molluscs (*Tellimya ferruginosa, Turritella communis, Chamelea gallina, Dosinia lupinus, Mactra corallina*) Region III: same as otter trawl, plus *Nephthys hombergii, Corbula gibba* and Tanaid copepods	Region II: 171 000 km^2* (area between Shetland Islands and Hardangerfjord, and the Strait of Dover) Region III: 22% of Irish Sea
Demersal pair trawl	ground rope: 1 – 2 cm	same as for otter trawl	Region II: 108 000 km^2 (entire North Sea)
Twin trawl	same as for otter trawl but without door	same as for otter trawl	
Seines and ring nets	zero	minimal effect on benthos	Region II: 245 km^2 (entire North Sea)
Pair seine	zero	minimal effect on benthos	
Dredges	mussel dredge: 5 – 25 cm cockle dredge: 5 cm scallop dredge: 3 – 10 cm	same as for beam trawl	Region II: estuarine and coastal areas of North Sea Region III: 8% of Irish Sea
Shrimp beam trawl	bobbins: 2 cm	benthos and juvenile fish	Region II: estuarine and coastal areas of North Sea
Prawn trawl	bobbins: 2 cm	benthos and juvenile fish	Region II: northern North Sea
Industrial trawls	same as for otter trawl	same as for otter trawl	Region II: 11 000 km^2 pair trawl (central North Sea), 127 000 km^2 single trawl (entire North Sea)

* Source: Rijnsdorp *et al*. (1997).

this from occurring.

Disturbance of the seabed by fishing gear can also change the species and size composition of benthos. For example, in areas of the North Sea, where fishing disturbance has occurred over a long period of time, there has been a shift in benthic diversity and composition from larger more long-lived benthic species to smaller more opportunistic species. In the Dutch Wadden Sea, there is discussion about the effects of cockle fisheries on possible changes in macrozoobenthos and sediment composition. Research has been commissioned to identify the precise nature of these effects. Recent investigations along the Norwegian coast show the damage caused to the coral reefs by trawling to be quite extensive. Legislation for the protection of reef areas in Norway has been implemented.

5.3.5 Impact of mariculture

In the OSPAR region, mariculture activity consists of salmon farming in large cages moored in sheltered waters and intensive and extensive cultivation of bivalve molluscs.

All types of mariculture are faced with the problem of producing an excess of nutrients and deposition of organic material in the vicinity of the mariculture facilities, especially in areas with poor flushing characteristics. This can result in increased organic content of sediments, decreased faunal diversity and the prominence of opportunistic polychaetes.

Shellfish cultivation involves less intensive manipulation of the environment than finfish cultivation. Mussel cultivation in the Wadden Sea involves the removal of young specimens from natural mussel beds; this has contributed to a decline in the area covered by wild mussel beds over the last two decades. Where imported bivalve molluscs are to be cultivated, there is always the possibility of introducing pests and diseases to the area that may affect indigenous species. In recognition of this possibility, ICES issued a Code of Practice on the Introductions and Transfer of Marine Organisms (ICES, 1994), to help minimise problems resulting from shellfish and other introductions. To avoid the introduction of non-indigenous species to Dutch coastal waters, a new policy for the import of shellfish and crustaceans was developed in 1996. Until 2003, specific restrictive regulations exist regarding the introduction of indigenous species into the Wadden Sea and eastern Scheldt area.

The effects of salmon farming are usually confined to inshore waters. What is still not clear, owing to a lack of data, is what effect escaped reared salmon will have on the genetic structure of the wild salmon populations in the OSPAR area.

Sea lice are copepod ectoparasites of fish that are common to both wild and farmed fish. Infestation in most marine salmon farms is initially from local wild salmon. Heavy infection on farmed salmon may result in tissue damage and heavy financial losses. Once caged fish become heavily infected this can lead to them infecting the nearby wild populations. There is also the potential for other parasites and diseases to be transferred from farmed to wild fish and vice versa. Improved husbandry and farm management, combined with the use of chemical treatments and vaccination, are being used to reduce infections and the outbreak of diseases among farmed stocks. In the UK, a recent joint Government–Industry Working Group has identified a range of husbandry and management measures to contribute to the control of Infectious Salmon Anaemia (ISA).

Chemicals are used for different purposes in mariculture, for instance to prevent diseases (antibiotics), to get rid of parasites (pesticides) and to prevent ‘growth’ on cages/nets (antifoulants). There are general concerns over the use of such chemicals but their impact is probably limited to the immediate vicinity of the fish farm area.

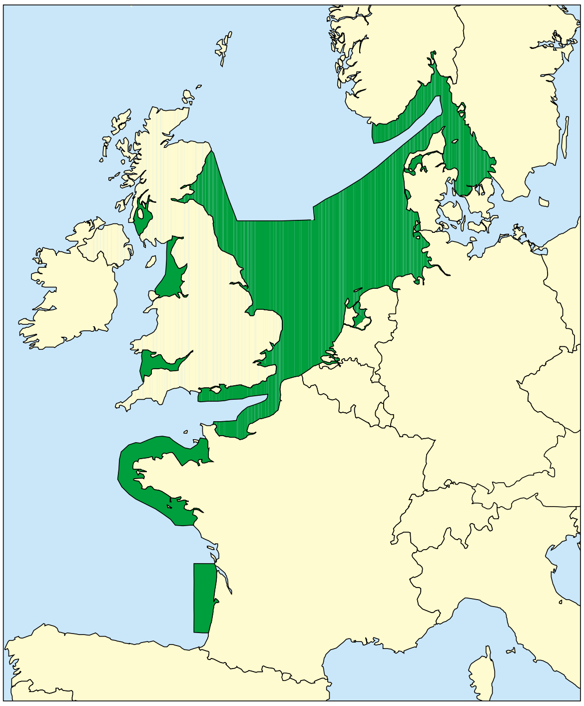
5.3.6 Impact of eutrophication

Eutrophication, as defined by OSPAR, refers to the undesirable effects resulting from anthropogenic enrichment by nutrients as described in its Common Procedure for the Identification of the Eutrophication Status of the Maritime Area adopted in 1997. The impacts of eutrophication include: increased phytoplankton and macroalgae production and biomass; changes in species composition (including the occurrence of harmful algae and short-lived benthic algae in shallow waters as well as changes in the animal communities); and increased oxygen consumption in water and sediments, in some cases leading to detrimental effects on benthic fauna. Eutrophication is non-existent in the open shelf and deep areas of the OSPAR region. However, within the coastal zone, embayments and estuarine areas of some parts of the maritime area, particularly the south-eastern part of Region II, there is clear evidence of eutrophication. The disturbance caused by increased nutrient loads in coastal areas may also have an effect on marine ecosystems outside the immediate area. The first step in the Common Procedure is a Screening Procedure to identify the more obvious non-problem areas. The results of the Screening Procedure are illustrated in *Figure 5.4*. Classification of the eutrophication status of the remaining areas into problem areas, potential problem areas or non-problem areas will be made by applying the Comprehensive Procedure, the second part of the Common Procedure (see *Figure 5.4*). However, several of these areas are already being considered as problem areas by the coastal states.

Some of the earlier eutrophication-linked events in the North Sea have been documented in the 1993 North Sea QSR (NSTF, 1993). These include increased production of phytoplankton in the coastal areas of the eastern part of the North Sea, the linking of inputs of nutrients to the extended duration of blooms in the Wadden Sea and changes in phytoplankton and zooplankton structure in the German Bight. In the Celtic Seas, there are indications that the Mersey Estuary / Liverpool Bay area and Belfast Lough may be showing signs of eutrophication and, as a result, reductions in nutrient inputs are probably required. Concern has been expressed over the occurrence of areas of anoxic sediment (‘black spots’) and accompanying mortality of benthos in the Wadden Sea in 1996, which was the result of an exceptional coincidence of meteorological and biological developments (de Jong *et al*., 1999).

Temporarily increased concentrations of nutrients in for example the Ria of Huelva (Spain) may be associated with eutrophication. A further example is the Bay of Vilaine, where oxygen depletion of bottom waters takes place each summer following the phytoplankton blooms. Depending on the level of spring rainfall and the extent of nitrate input through key small rivers, a few hydrodynamically confined areas on the north coast of Brittany can sometimes be affected by ‘green tides’, which deposit thousands of tonnes of the macroalga *Ulva lactuca* onto the beaches. Under certain conditions, algal foams can develop after spring blooms along the Belgian and Dutch coasts.

Figure 5.4 **Parts of the OSPAR maritime area to which the Comprehensive Procedure will be applied to determine their status with regard to eutrophication.**



Areas subject to the Comprehensive Procedure (the Comprehensive Procedure will also be applied to a number of Irish estuaries and to some local areas of possible concern). Areas to which the Comprehensive Procedure will not be applied have been classified as non-problem areas with regard to eutrophication as a result of applying the Screening Procedure. However, located within these non-problem areas may be some local areas of possible concern to which the Comprehensive Procedure will also be applied.

5.3.7 Impact of recreation and tourism

Pedestrian traffic and the use of motorised vehicles have increased pressure on some coastal dune systems, disturbing the natural vegetation and seabird habitats. Coastal habitats are being reduced or disturbed through the construction of recreational housing, caravan parks and golf courses. On some recreational beaches close to population centres the amounts of litter, particularly plastics and drink containers, are a continuing cause for concern. The growing popularity of yachting and boating is increasing demand for new marinas as well as potential for the introduction of non-indigenous species and pollution from antifouling paints.

In the North Sea, bird-breeding areas on sandy beaches have been almost completely lost because of recreational activities. Little tern (*Sterna albifrons*) and Kentish plover (*Charadrius alexandrinus*) are most strongly affected as their breeding success is reduced by human activities. In contrast, cessation of hunting in parts of the Wadden Sea has had a positive effect on the numbers of Brent geese (*Branta bernicla*), barnacle geese (*B. leucopsis*), and curlews (*Numenius arquata*). In Bannow Bay in south-east Ireland, which is designated as a Special Protection Area for birds, motorbike scrambling has weakened the dune systems and shooting has disturbed roosting birds. At other Irish sites, excessive human activity has excluded seabirds from parts of their natural habitat and denied them feeding opportunities. This has led to the initiation of protection schemes, especially along the east coast. Finally, disturbance of small cetaceans occurs as a result of interaction with high-speed boats (e.g. jet skis).

5.3.8 Impact of sand and gravel extraction

Sand and gravel extraction takes place in the inshore areas of the North Sea, particularly the southern part, the Celtic Sea and the French Atlantic coast. Not all of the extracted material is retained on board the vessel. The loss of material produces a temporary increase in turbidity in the water column and benthic organisms outside the dredged area may be impacted by settlement of both this residue and any resuspended material arising from this operation. In the short-term, the main impact on the ecosystem is the disturbance and removal of benthic organisms from the extraction site. There can be damage to sites that act as spawning areas for fish that lay their eggs directly on gravel, for example herring. In the longer-term, the rate of recovery of a site depends on the modifications made to the substrate and the potential of the benthos to re-colonise the area. For example, studies in the Wadden Sea showed that at extraction sites on sheltered intertidal flats, recovery of sediment composition and benthic fauna took more than fifteen years, whereas at sites with greater hydrodynamic activity, recovery was much faster. Studies carried out off the east coast of England, where extraction caused a reduction of approximately 40% and 80% respectively in the number and abundance of benthic species, revealed that a limited re-colonisation had occurred within a year (Kenny and Rees, 1994).

5.3.9 Impact of dredging and dumping of dredged materials

Most dredging serves navigational purposes in coastal approaches to and inside seaports. In some cases, for example near Rotterdam, dredged spoil from ports that is contaminated above certain limits is being deposited in specially built deposits. Slightly or non-contaminated dredged spoil is disposed of at dumpsites in estuaries and coastal waters. The effects of dredging activities are threefold. Increases in suspended matter in the water column can directly affect primary production and the growth of filter-feeding organisms such as bivalve molluscs. Enhanced sedimentation at dumpsites can lead to burial of the resident benthos. Finally, contaminants can be resuspended and remobilised from sediments and taken up into the food chain. However, dredging in the outer parts of estuaries may lead to larger-scale effects on the sediment dynamics, benthic communities and suspended matter regime.

5.3.10 Impact of coastal protection and land reclamation

Coastal protection, land reclamation and development of ports and harbours can affect coastal habitats. In many cases, habitats and associated ecological processes change permanently or even disappear. Examples of the latter are natural transition zones between freshwater habitats and coastal waters along the Dutch coast. At present for much of the OSPAR coastline there is insufficient information on recent rates of habitat loss in relation to habitat types and areas.

5.3.11 Impact of offshore activities and ship-generated oil spills

All oil-related activity in European waters is done under strict licence conditions, with the aim of minimising the effects on marine ecosystems. It should be noted however that this activity and the number of platforms have increased since 1993. Impacts on the benthic community are usually confined to a few kilometres around the platforms. These impacts are largely caused by the disposal of drill cuttings in the immediate vicinity of the platform. There is a reduction in species diversity near to the platform with polychaete worms dominating the biomass. Biological changes are not usually detectable beyond 3 km from platforms, but there are a few cases where effects have been detected out to 5 km. Changes in the regulatory regime governing the use of drilling fluids are expected to contribute to reducing the impact on the benthic communities. There is, however, uncertainty about the possible environmental effects of removing cuttings piles. Some alternatives to oil-based muds also possess properties which could result in adverse impacts on benthic communities.

There is uncertainty about the environmental effects of discharges of produced water. In addition to oil, produced water also contains a range of other natural organic compounds including monocyclic aromatic hydrocarbons (i.e. BTEX), 2- and 3-ring PAHs, phenols and organic acids. This includes added production chemicals, and may also include organic compounds not yet identified. Increased levels of PAHs in caged mussels and passive samplers have been found up to 10 km from produced water discharge sites.

Accidental and illegal oil spills result in the oiling of seabirds, shellfish, other organisms and the coastline, with ecological and often economic consequences. Measured in oiled seabirds, this type of contamination remained at high levels throughout the years in some parts of the North Sea, in others it declined for some time whilst it has again increased in recent years. Even minor accidents with ships can end in disaster as long as heavy fuel oil or its residues are involved. When the ‘Pallas’ grounded in the Wadden Sea in 1998, it lost about 250 m^3 of heavy fuel oil which killed about 16 000 birds overwintering in the area. The 10 000 – 15 000 t of heavy fuel oil spilt when the ‘Erika’ broke apart off the French Atlantic coast in December 1999, killed at least the 80 000 birds collected on the beaches, with estimates running as high as 200 000 – 300 000 birds killed. Slight contamination of fish has been found in the vicinity of platforms. The overall impact on fish stocks by low levels of hydrocarbons is considered to be small, although long-term effects of operational discharges of production water cannot be ruled out. Future increases in shipping traffic may increase the risk of pollution.

5.3.12 Impact of contaminants

The presence of high concentrations of metals and man-made substances in marine seafood could pose a problem for the human consumer, as has been demonstrated for indigenous people in Greenland who have been exposed to high levels of mercury and PCBs in seafood. In view of this, most countries in the OSPAR area have established monitoring programmes for contaminants in seafood to ensure that it is safe for consumption. For example, due to high concentrations of different contaminants in fish and shellfish there is advice against human consumption of seafood from several fjords along the Norwegian coast. Major wastewater discharges to rivers or coastal areas are subject to environment impact assessment and, as appropriate, the control requirements of the EC Directives on urban wastewater treatment and integrated pollution prevention and control.

The situation concerning impacts on marine life is somewhat different. Only in some cases has the impact of contaminants on populations or communities been measured directly in the OSPAR area, although there is much information about effects on individuals (referred to as ‘biological effects’). BRCs and EACs were established to be used as the best available assessment criteria for contaminant levels and their effects, but the caution expressed as to their limited usefulness must be recognised. With respect to EACs it should be noted that they refer primarily to acute toxicity. The derivation of EACs does not include for example the bioavailability of a contaminant under field conditions, the degree of bioaccumulation, carcinogenicity, genotoxicity and hormone balance disturbances (endocrine disruption). In addition, the presence of other hazardous substances in the sea may cause enhanced or combined adverse effects in organisms or even on populations. Therefore, concentrations of a contaminant in the marine environment below the EAC for that contaminant do not guarantee a safe situation. On the other hand, it is not compelling that biological effects occur where an EAC is exceeded. This can only be established through biological investigations in the field.

The biological effects studies run to date within the OSPAR area have identified a number of places where impacts have been observed at the cellular and individual level. Biological effects essentially indicate the presence of contaminants, which are taken up by organisms. Some examples are given in the following paragraphs. An important sub-lethal effect is endocrine disruption, the impact of which may extend to the population level.

Tributyltin is one of the rare examples in the marine environment where effects can be attributed to a single substance. Exposure to TBT, originating for example from antifouling paints, produces distinctive responses in a number of organisms. These include shell thickening in Pacific oysters and imposex/intersex (the imposition of male characteristics in female gastropods). TBT is also found in seabirds, marine mammals, fish and plankton. Effects on hormone, reproductive, immune and certain enzyme systems of fish are reported. An impact to humans via the consumption of seafood might be possible.

Surveys of imposex in British waters during 1997 indicate that biological effects are still evident at all but the most remote coastal sites ten years after enforcement of TBT restrictions. Some estuarine and coastal areas in north-west Spain and northern Portugal have exhibited significant levels of imposex in dogwhelks (*Nucella lapillus*). Although in the former case this has led to female sterilisation, the dogwhelk population in north-west Spain is not considered to be at risk of extinction. Imposex has been documented in dogwhelks and common whelks in harbours in Iceland, Norway and Svalbard and in the North Sea region including the Kattegat. Over a ten-year period of monitoring at twenty sites on the Irish coast those with salmon farming operations and small craft demonstrated a recovery from TBT contamination; as indicated by a reduction in an index of imposex (Relative Penis Size Index).

Imposex still occurs near shipping lanes all over the world, and also in offshore areas, where it correlates positively with shipping intensity and TBT levels in biota and sediments. This is due to the present lack of regulations on the application of TBT to ships larger than 25 m.

The toxicological significance of the elevated concentrations of PCBs in marine organisms is unknown. However, prior to death some of the otters with high PCB body burdens have been reported to have behaved in a manner suggestive of organochlorine poisoning. The previously abundant Swedish otter population has for a long time suffered from PCB pollution. Along the Swedish Skagerrak coast concentrations of PCBs in fish are still too high and no otters are currently found in the Swedish coastal environment (Brunström *et al*., 1998; Roos *et al*., in press). PCBs can disturb reproductive, enzyme and endocrine systems in marine mammals, for example in harbour seals fed experimentally on fish from the Wadden Sea. Such effects are found in certain populations outside the OSPAR area, for example in Baltic grey seal and ringed seal populations (Olsson *et al*., 1992; Roos *et al*., 1998). High levels can affect the immune system of the polar bear (Bernhoft *et al*., in press) and it is possible that similar effects may be occurring in other marine vertebrates.

Various organic contaminants may induce higher activity of the enzyme 7-ethoxyresorufin-*O*-deethylase (EROD) in fish liver. The extent of this activity is used as an indicator of the degree of exposure to a range of compounds, including PCBs and PAHs. Elevated EROD activity has been measured in the livers of flatfish. In UK marine waters, the greatest activity was found in plaice in the area of the Firth of Clyde sewage sludge disposal ground at Garroch Head and near to industrial centres at Hunterston and Irvine Bay.

There is clear evidence that a diverse range of natural and man-made substances including PCBs, dioxins, TBT and various other organometallic compounds, pesticides, pharmaceuticals and industrial chemicals, have the potential to impair reproduction in aquatic organisms through interference with their endocrine (i.e. hormonal) systems. Studies in freshwater environments have shown that for some substances these endocrine-disrupting effects can occur even at very low ambient concentrations, considerably less than concentrations that are either mutagenic or acutely toxic. To date, it remains unclear which substances or combinations of substances are responsible for the observed effects (e.g. feminisation in male fish) but ethynylestradiol (a contraceptive agent), PCBs and alkylphenols (derived from some industrial detergents) have been positively implicated, as well as natural hormones. Furthermore, it is important to note that many different man-made and natural substances are able to act additively at hormone receptors to produce some of these effects. Although TBT-induced imposex in gastropod molluscs is one of the few confirmed instances of endocrine disruption in marine life at present, many other endocrine-disrupting substances are known to be present in effluents and river water discharged to the OSPAR area. Furthermore, studies in the UK have shown that a number of estuarine waters receiving effluents from sewage treatment plants and industrial sources induce œstrogenic effects (a form of endocrine disruption) in fish. Effects observed in male flounder include production of the yolk protein precursor vitellogenin and induction of intersex, although, to date, no effects at the population level have been demonstrated. Intersex, among other effects, involves the appearance of egg cells in the testis, and it is probable that it is associated with impairment of reproductive output. It is important that effects like these should receive further study, both to uncover the full range of impacts in different species, and to decide whether populations and communities are at long-term risk (as is the case with TBT).

Potential for harm to North Sea organisms from metals includes the effects of dissolved copper on lower trophic levels such as phytoplankton, and the accumulation of cadmium and mercury in top predators and lead in shellfish. These effects are due in large part to the tendency of these metals to bioaccumulate in organisms through trophic interactions. However, these effects are often local and occur most frequently in estuaries and in the coastal zone. Although potential for biological effects due to metals undoubtedly exists at some of the more contaminated sites, particularly those subject to continuing metal inputs, the regional QSRs provide no recent reports of specific effects due to elevated metal concentrations in sea water, sediments or biota.

Certain brominated flame retardants are known to bioaccumulate and are suspected to have developmental or behavioural effects on mammals.

Phthalates are known to persist under marine conditions and to bioaccumulate at lower levels of the food chain, in particular in sediment communities.

Nonylphenols degrade slowly, are known to bioconcentrate in salt-water fish and mussels and have been reported to induce changes in the endocrine system in the course of *in vivo* tests. They are also toxic to marine algae but not at levels usually found in the marine environment.

Short-chained chlorinated paraffins are known to persist in the environment and to bioaccumulate in marine mammals (seals, beluga, and walrus). The levels recently found in different Arctic regions were in the range of 200 to 800 µg/kg ww.

Copepods have been shown to be sensitive to a wide variety of organic contaminants, such as insecticides, organometals and oil. Field studies and mesocosm experiments as well as model simulations have shown that effects on zooplankton may cause increased phytoplankton densities due to reduction of grazing pressure.

Some decreases in numbers of seabirds have been attributed to the effects of organochlorine compounds. In the early 1980s concentrations of DDT in shags in one area of Region III may have resulted in eggshell thinning. More recent data suggest that this is unlikely to still be a problem. In addition, bacterial poisoning associated with feeding on municipal refuse sites in Region III has been highlighted as a possible cause of a reduction in numbers of birds.

Alkylphenols, alkyl-substituted naphthalenes, alkyl-substituted fluorenes and dimethyl benzoquinone were identified as possible causes of toxic effects in UK estuaries. (Thomas *et al*., 1999a,b). This information has been generated by Toxicity Identification Evaluation (TIE) procedures using a variety of bioassays. It is noteworthy, however, that no single contaminant was responsible for observed biological effects in estuaries – effects generally appear to result from the action of complex mixtures.

From mesocosm studies, there is evidence of a correlation between the occurrence of pre-stages of liver tumours in North Sea flatfish and contaminants, particularly PAHs and possibly chlorinated hydrocarbons (Vethaak *et al*., 1996).

Adverse biological effects caused by mixtures of unknown pollutants, tested using oyster embryo water bioassays and whole sediment bioassays with amphipods and annelids, including acute toxicity, have been measured in some UK estuaries, for example the River Tyne and River Tees (Jones and Franklin, 1998). The full ecological significance of these observations is not known, although invertebrate communities in some industrialised estuaries are known to be impoverished.

A further effect of mixtures of pollutants can be to decrease ‘Scope for Growth’ in the mussel *Mytilus edulis*. This is a well established biological effects technique and when combined with the measurement of chemical contaminants in the tissues of mussels provides a tool for assessing spatial changes in environmental water quality. Depression of Scope for Growth was demonstrated in the North Sea UK east coast survey in the early 1990s (Widdows *et al*., 1995). In 1996 and 1997 a further survey was carried out at 37 locations in the Irish Sea, including some sites on the east coast of Ireland. The results indicated reduced Scope for Growth in the Mersey/Liverpool Bay region and in Dublin Bay. High Scope for Growth was recorded along the west coasts of Scotland and Wales. These results indicate that contaminants are interfering with the ability of shellfish to grow normally in southern coastal areas of the North Sea, and also in some coastal areas of the central Irish Sea.

5.3.13 Impact of radioactive disposals

Interest in the behaviour of radionuclides in the marine environment has, until now, been driven by the objective of protecting human health from ionising radiation through the food chain. Whilst the system of human radiological protection has been developed through the adoption of internationally recognised guidelines and standards, there are currently no internationally accepted radiological criteria for the protection of marine flora and fauna. The assumption has been that man is the most radiosensitive organism and that if man is adequately protected, then other living things are also likely to be sufficiently protected. The International Commission on Radiological

Protection states that: ‘the standard of environmental control needed to protect man to the degree currently thought desirable will ensure that other species are not put at risk. Occasionally, individual members of non-human species might be harmed, but not to the extent of endangering whole species or creating imbalance between species’ (ICRP, 1991).

In 1994 OSPAR agreed that more emphasis should be put on assessing biological and ecological effects in the marine environment (including the vulnerability of marine organisms and communities) arising from existing and foreseen future discharges of radioactive substances (PARCOM Decision 94/8). There is now a growing recognition that protection of the environment merits attention in its own right. The International Atomic Energy Agency acknowledges that ‘there is a growing need to examine methods to explicitly address the protection of the environment from radiation. The concept of sustainable development places environmental protection on an equal footing with human protection, on the basis that it is necessary first to protect the environment in order to protect human populations.’ (IAEA, 1999). The OSPAR Strategy with Regard to Radioactive Substances is primarily concerned with reducing concentrations of radionuclides in the marine environment, with dose to man as a supporting consideration. The Strategy requires the OSPAR Commission to undertake the development of environmental quality criteria for protection of the marine environment from adverse effects of radioactive substances and to report on progress by 2003.

5.3.14 Impact of marine litter

Marine litter is derived from both land-based and marine sources and its impact on marine life has been observed. Most victims have been birds and the main culprit has been plastics. The mechanism of damage has either been by entanglement in plastic sheeting, which can lead to the birds being drowned or by ingesting small plastic objects, which can lead to blockages in the stomach or intestines. Autopsies carried out on dead mammals and turtles have also revealed that death in some cases has been linked to the ingestion of plastic waste. Studies have been conducted over ten years (1988 to 1998) on leatherback turtles (*Dermochelys coriacea*) and loggerhead turtles, the two species occurring most frequently in Region IV. Autopsies showed that respectively 58% and 11% of the individuals had ingested plastic waste. Cetaceans can also be significantly affected, and in the few observed cases from several hundred autopsies, the species affected seemed to be those that feed on cephalopods and which might have mistaken plastic bags for their prey. Floating litter also has the potential to act as a vector for the spread of epiphytic organisms beyond their normal ranges.

chapter 6

Overall assessment

6.1 Introduction

This chapter sets out OSPAR's overall assessment of the quality status of the maritime area covered by the OSPAR Convention. Under each main theme, this chapter provides, in summary form, a description of the impact of human activities on the maritime area; an evaluation of the effectiveness of the measures that have been taken, both internationally and at the national level, to safeguard the marine environment against that impact; a statement of the limitations of knowledge which constrain these descriptions and evaluations; and (in accordance with Article 6(b) of the OSPAR Convention) an identification of priorities for action.

The degree of human impact varies enormously between the different Regions of the maritime area. The much greater concentrations of human population in catchments draining into Region II (the Greater North Sea, which includes the Channel) produce significantly different pressures from those affecting Region V (the Wider Atlantic), where the only human population is that of the Azores archipelago. Nevertheless, common types of pressure exist, particularly from intensive (and sometimes conflicting) uses of the coastal zone.

This overall assessment is based upon a common effort by the OSPAR Contracting Parties to interpret and assess the available scientific information. The value of such an assessment depends crucially on the quality of the information available. As this assessment shows, in spite of the major efforts made by OSPAR Contracting Parties over the last twenty-five years, there are still major gaps in understanding of the marine environment. To provide the basis for effective decision-making on the management of the ocean and human activities affecting it, it is necessary both to maintain and update the current marine environmental information and the other information essential for management decisions, and to try to fill the most urgent gaps in knowledge. For this purpose, both cost-effective monitoring systems and other means of gathering information and a better allocation of the available resources to the various needs are essential. Efforts are needed in all fields to improve the efficiency and effectiveness of capturing and analysing data: it is, for instance, regrettable that the assessment of so many time series of contaminant concentrations in biota failed to result in any statistical trend. This is because of imperfections in the nature of the data, even where sufficient quality assurance of those data was available.

Although the OSPAR Convention gives the OSPAR Commission a wide competence, OSPAR does not cover all aspects of the marine environment. As the Convention recognises, questions related to the management of fisheries are appropriately regulated under international and regional agreements dealing specifically with such questions, while others (such as shipping) are by their nature more effectively handled on a global basis. Furthermore, the European Community and the European Economic Area have competence for regulating the marketing and use of products. The identification of priorities for action is therefore not intended to set an agenda for OSPAR, but to draw attention to questions that the OSPAR Contracting Parties should consider the best way to resolve. Some of these questions will be appropriate for consideration by OSPAR, while others will fall to other international bodies, or will best be handled at the national level.

In considering priorities between the various themes covered in this assessment, there is agreement that:

a. the most important issues raised by the assessment in all five Regions are:
   i) the resolution of the questions on the subject of fisheries; and
   ii) the implementation of the OSPAR Strategy with regard to Hazardous Substances (particularly with regard to organotin antifouling treatments and the newly developing concerns about endocrine disrupters);
b. another important issue is that of climate change, which raises questions well beyond those of the marine environment;
c. other generally important issues are, in order of priority:
   i) those covered by the OSPAR Strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area, the OSPAR Strategy with regard to Radioactive Substances and the OSPAR Strategy to Combat Eutrophication;
   ii) the impacts of oil spills and discharges of ballast water from shipping; and
   iii) the improvement of the knowledge base.

Other issues can have great significance in specific Regions. In particular, these include:

a. in Regions I and II, organochlorine pesticides and PCBs;
b. in Regions II and III, issues covered by the OSPAR Strategy on Environmental Goals and Management Mechanisms for Offshore Activities, and the impacts of mariculture; and
c. in Regions III and IV, the impacts of coastal development.

On this basis, the implementation of the OSPAR Strategies should remain a high priority for the Commission.

6.2 Fisheries

6.2.1 Capture fisheries

Description of the impact

Management systems for the exploitation of fisheries resources have been implemented by all OSPAR Contracting Parties. This has led to sustainable practices for about half of the commercially exploited fish species. Among the stocks of the commercially exploited fish species, nevertheless, many are either exploited beyond their safe biological limit or are exploited within that limit to an extent that risks the limit being breached. Fisheries for 40 out of 60 stocks of these species in specific areas are believed to be unsustainable (see *Table 5.1*). Even for stocks that are within safe biological limits, the size composition has been altered by fishing. Age compositions have also become truncated. With fewer age groups in the exploited population, the spawning populations and fisheries become progressively more dependent on incoming recruitment and, consequently, more variable.

Assessments for many of the other species are inconclusive. Assessments are not produced for all exploited stocks. There are few population estimates for stocks of the ~ 1000 non-exploited species found in the maritime area, including sharks, skates and rays. In regions where typical commercial stocks decline, fishing pressure is often transferred to other stocks, or to deep-sea populations where management is particularly difficult. The slow growth rates and low fecundity of many deep-sea fish makes them particularly vulnerable to overexploitation.

By-catch of undersized or unwanted commercial species, mortality of non-target species including benthic animals and marine mammals and high levels of discards are continuing problems in many areas. The discarded fish represent an extra pressure on stocks since they do not normally survive. Since they are usually smaller than landed fish, weight for weight they represent a larger number of fish. Therefore, discarding half the weight of the catch (as happens in fisheries for some stocks) can result in many more fish (in terms of numbers) being discarded than are actually landed. This makes discards a significant source of mortality. The discards also alter the competitive relationships within communities by favouring scavenging species.

Harbour porpoises, dolphins and seals are the most common mammals entangled in fishing gear. Harbour porpoises are particularly vulnerable to bottom-set gillnets. Dolphins are vulnerable to drift nets. There are strong indications that the mortality rates of harbour porpoises caught in fishing nets which have been estimated for Regions II, III and IV are unsustainable.

Increases in seabird populations over the past decades have been attributed to a number of factors (for example, better protection, increases in small prey fish and an increase in fish discards and offal from commercial fishing boats). Periodically, some species have experienced a sharp fall in numbers. Some changes may be due to natural variability; others are directly related to a decrease in fish prey – for example, the decline in some common guillemot and puffin populations in some parts of the Arctic area following the decrease in stocks of capelin and herring, respectively. The decrease in fish prey may be due to natural variability, but may also be caused or aggravated by fishing activities. There has also been an impact from fisheries by-catch.

Disturbance of the seabed by fishing gear can change the species and size composition of the benthos especially where the disturbance is repeated. For example, where bottom trawling has occurred in the North Sea over a long period of time, there has been a shift in benthic diversity and composition from larger, more long-lived benthic species to smaller, more opportunistic species. Recent investigations along the Norwegian coast show that the damage caused to deepwater coral formations by past trawling activities is quite extensive. Information from other areas with such formations is not available, but the situation is likely to be similar where there has been similar bottom trawling.

Effectiveness of measures

With the aim of matching fishing effort to the sustainable exploitation of the fisheries, recent measures taken within the framework of the EU Common Fisheries Policy, and by Norway and Iceland, focus on controlling fishing effort. Among the main regulatory measures used are a reduction of the fishing fleet, the yearly setting of Total Allowable Catches and, in some areas, the setting of Individual Transferable Quotas. Furthermore, technical conservation measures, such as mesh sizes and sorting grids, are widely used to reduce the capture and consequent discarding of juvenile fish. A wide range of national conservation measures has been introduced to protect vulnerable life stages of different stocks. Such measures include permanent inshore nursery areas, temporary closures to protect juvenile fish and spawning-area closures at peak times of the year. In most regions, large trawlers are excluded within 12 nautical miles of the coast.

Although effective in some fisheries, overall these measures have had limited effectiveness, given the existing overcapacity of some European fishing fleets. Since most regulatory measures imply a short-term economic loss, there is an incentive on the part of the fishing industry either to improve fishing efficiency in order to compensate, or simply not to comply with regulations. This makes the enforcement of management measures extremely difficult, both because of the costs of policing at sea and because of the dispersed nature of the activity. For socio-economic reasons, TACs set by international bodies have often been set above scientifically recommended limits. In view of uncertainties in total stock assessments, such high TACs have frequently contributed to the exploitation of stocks beyond safe biological limits.

Limitations in knowledge

There are a number of topics where understanding is relatively poor and towards which research should be directed in the future:

a. more accurate fish-catch statistics, including improvements in the monitoring and reporting of by-catch and discards;
b. information to establish sustainable catch rates for those fish stocks (including deep-water fish species) which are being exploited commercially despite insufficient data and knowledge to assess their status reliably;
c. better knowledge of the reproductive capacity and population dynamics of commercially exploited fish species, including the effects of climatically driven variability, fishing, and biological (multi-species) interactions;
d. information on the effects of fishing on non-target species such as benthic organisms, sharks, rays, turtles, seabirds and marine mammals, and on benthic habitats, including deep-sea environments; and
e. information on the socio-economic factors which influence the behaviour of fishermen and fishing fleets, and ways to incorporate the knowledge and experience of fishermen into assessment and management.

Identification of priorities for action

It is generally recognised that fisheries management and environmental policies must be further integrated, within the framework of the ecosystem approach. It is also important that the scientific basis for fisheries management should be continually improved and that the application of the Code of Conduct for Responsible Fisheries be further promoted. With a view to achieving stock sizes and exploitation rates that are within safe biological limits and to minimise ecological damage, action on the following issues could be considered by the appropriate authorities:

a. excessive fishing effort and overcapacity in the fishing fleet in some regions;

b. lack of precautionary reference points for the biomass and mortality of some commercially exploited stocks;
c. how to address the particular vulnerability of deep-sea species;
d. the risks posed to certain ecosystems and habitats, for example, seamounts, hydrothermal vents, sponge associations and deep-water coral communities;
e. adverse environmental impacts of certain fishing gear, especially those leading to excessive catches of non-target organisms and habitat disturbance; and
f. the benefits for fisheries and/or the marine environment of the temporary or permanent closure or other protection of certain areas.

6.2.2 Mariculture

Description of the impact

During the last few decades intensive forms of mariculture have increased considerably, in particular salmon farming. In some countries, mariculture production has become comparable in economic value to that of the demersal and pelagic fishing. It is now a major industry in many areas, and is likely to expand in the future both in the volume and range of fish species cultivated. On the national level, licensing systems and associated monitoring systems have been established to limit the areas and the extent of environmental changes inherent in mariculture. Concerns exist over the extent to which diseases and parasites, such as sea lice, are transferred from cultured to wild stocks, and *vice versa*. Interbreeding from escaped cultured salmonids can affect the genetics of wild stocks. Mariculture is also one of the sources of unintentional introduction of non-indigenous species, because the introduction and transfer of marine organisms create risks of transporting competitors, predators, parasites, pests and diseases. A few non-indigenous species were deliberately introduced to the maritime area, mainly for mariculture purposes. In addition, the release of nutrients, organic matter and chemicals (such as antifouling agents, biocides, antibiotics and other therapeutants and colouring agents) may cause local pollution, particularly of sediments.

Effectiveness of measures

Lack of information on the implementation by Contracting Parties of PARCOM Recommendation 94/6 concerning Best Environmental Practice for the Reduction of Inputs of Potentially Toxic Chemicals from Aquaculture Use prevents an assessment of the effectiveness of this measure. Nevertheless, progress has been made in eliminating the use of the pesticide dichlorvos. Further work is needed to assess the effect of implementation of the ICES Code of Practice on the Introductions and Transfer of Marine Organisms and its consequent effectiveness.

Limitations in knowledge

Gaps remain in the understanding of the environmental effects of mariculture, in particular regarding:
a. better documentation of the effect of escaped salmon on the genetic composition of wild salmon stocks; and
b. knowledge of the risk of spread of diseases from mariculture to wild stocks and *vice versa.*

Identification of priorities for action

Given the combination of risks posed by escape of cultured stock and the high degree of uncertainty surrounding the impacts of escapees on wild populations, there is a need to develop more appropriate management measures, taking account of what has been achieved through EC Directives such as 91/67/EEC on aquaculture animals and products. Furthermore, efforts to fill the gaps in knowledge should continue.

6.3 Land and sea use

6.3.1 Use of the coastal zone and continental shelf

Description of the impact

Sparsely populated areas (for example, in Iceland, Norway, the Azores and parts of the west coasts of Scotland and Ireland) have relatively little pressure from coastal development. However, in other areas there is considerable pressure for more extensive use of coastal land for industry, housing and tourism. At the same time, the land available for coastal development has decreased as the number of areas recognised for their conservation interest has increased. The main developments offshore are those relating to the established offshore oil and gas sector, to the emerging offshore wind power generation industry, and possibly to wave power developments.

Densely populated urban developments are found in a band along much of the coasts of Regions II, IV and part of Region III. During the summer the population rises substantially because of tourism. These high concentrations of people lead to complex interactions between environmental, economic and social needs, with the potential for serious conflicts of interest.

In all OSPAR Regions tourism has been growing steadily. In spite of planning controls and sensible development policies, many of the habitats and locations that attract visitors are jeopardised by the sheer number of visitors, increased traffic and growing demands for accommodation and improved services. In the North Sea, bird-breeding areas on sandy beaches have been almost completely lost because of recreational activities.

Coast protection, land reclamation and development of industries, ports and harbours affect coastal habitats. In many cases habitats and associated ecological processes have been changed and, occasionally, destroyed. There is a growing awareness that proper management of coastal protection measures can result in the creation of new habitats.

In some countries, energy is increasingly generated from coastal wind power stations. There are extensive searches in progress for new sites with sufficient wind energy, where human population would not be disturbed. Apart from the space required, the impact of this activity includes some visual and acoustic disturbance and the presence of rotating blades that may be dangerous to birds.

The development of offshore power generation may involve the construction of many installations of a range of sizes, which can either be built on artificial islands or placed directly on the seabed, and which will have land links (for example, cables). Depending upon the relative cost/benefits of the different power generation options for the future, offshore wind and wave power generation may be a significant, long-term prospect. Several countries have wind power generation parks (for example, Ireland) or have plans to build them (for example, Belgium, Denmark, Germany, the Netherlands and the UK).

Oil and gas activities are widespread in the OSPAR area ***(Figure 3.10)***, although the majority of offshore installations are located in the North Sea. There is scope for considerable expansion in the future. In other regions, for example, the Arctic, the wider Atlantic and in Irish waters, offshore exploration is at an early stage of development but it is anticipated that the sector will continue to expand there in future.

Offshore oil and gas activities can cause impacts at all stages of exploration, development and operation. Discharges of oil and other chemicals are the main problems (see Section 6.7). Habitat modification by the introduction of artificial hard substrates and physical disturbance is also a problem, although more localised in extent. The introduction of artificial hard substrates is a complex issue. For example, hard substrates may benefit organisms that use them for shelter, but hard substrates may also attract and concentrate predators that prey on organisms in surrounding habitats.

About 800 offshore platforms are currently operating in OSPAR waters. It is anticipated that over the next ten to twenty years, as fields become unproductive, an increasing number of structures will need to be decommissioned. Decommissioning will ensure that disused installations do not become a danger to navigation or the fishing industry, or a potential source of pollution. Only a small number of installations have been decommissioned to date. These have mainly been from the shallow waters of the southern North Sea and have been returned to land. No large fixed installation has so far been decommissioned.

As a result of an initiative of the Fourth International Conference on the Protection of the North Sea (1995), the 1998 Ministerial Meeting of the OSPAR Commission adopted Decision 98/3 on the Disposal of Disused Offshore Installations, prohibiting the dumping and the leaving wholly or partly in place of disused offshore installations within the maritime area. Subject to assessment and consultation under agreed procedures, derogations are possible for the footings of steel installations weighing more than 10 000 t, and for concrete installations.

Effectiveness of measures

Many coastal areas are recognised as important for conservation and are designated with various levels of legal protection. National legislation, international conventions and EC Directives, especially the Bird Directive (79/409/EEC) and Habitat Directive (92/43/EEC), are important instruments, although the implementation of these directives is behind schedule. All OSPAR Contracting Parties have established conservation areas and more areas are being identified. The European Community has developed a demonstration programme on coastal zone management. In 1998 OSPAR adopted a new Annex to the 1992 OSPAR Convention concerning the protection and conservation of the ecosystems and biological diversity of the maritime area covered by the Convention.

Although these measures have established a general framework for the protection of coastal areas, their effectiveness depends on local implementation. It is difficult to obtain comprehensive and consistent information on such implementation. With regard to coastal areas, what is particularly lacking is comparable information on sensitive or unique habitats and on human activities in such areas.

Identification of priorities for action

The economic, environmental and social issues involved are often complex. Careful consideration is needed to avoid serious conflicts of interest between the need to protect designated conservation areas and pressure of human requirements for housing, leisure etc. There is a need for the application of codes of good practice in Coastal Zone Management to identify sensitive coastal areas and apply effective control regimes to minimise human impact. In the future, these problems could be exacerbated by global sea level rise as a result of climate change. In light of increasing sea levels, future coastal protection policies will have to address the question of how to guarantee adequate coastal protection in a way that is compatible with the needs of conservation.

The environmental impact of the present plans both for more land-based power generators at a number of coastal sites and for wind and possibly wave power generation systems offshore needs to be carefully considered. In addition, new developments should minimise interference with other users of the sea, particularly fishing and shipping.

The expansion of the offshore oil and gas industry may increase the scale of habitat modification and disturbance. Consequently, an assessment is needed of these possible impacts, both for existing and new installations.

6.3.2 Mineral exploitation

Description of the impact

Sand and gravel are essential materials for private and industrial construction work, for coastal protection and beach replenishment. Annually, 43 million m^3 are extracted from the OSPAR area. By far the largest amount is taken from the North Sea, where extraction increased from 34 to 40 million m^3 in the period 1989 to 1996. Along the Atlantic coast of France annual extractions amount to around 4 million t. Maërl banks (calcarean algae) which support fragile ecosystems and shell sands are exploited mainly along the Brittany coast.

The exploitation of marine aggregates can have negative effects on the marine environment. Turbidity is temporarily increased during operation. The main impact on the ecosystem is the disturbance and loss of benthic organisms from the extraction site. There can be damage to sites that act as spawning areas for fish that lay their eggs directly on gravel (for example, herring). In addition, extraction activities can increase the instability of shallow banks and increase the potential for coastal erosion. The rate of recovery of a site depends on the modifications made to the substrate and the potential of the benthos to recolonise the area. This may take from a few months to more than a decade.

Effectiveness of measures

Various measures have been introduced at national and international levels to minimise the environmental impact of marine aggregate extraction (for example, the ICES Code of Practice on Commercial Extraction of Marine Sediments (ICES, 1992)). Nevertheless, extraction continues at high rates and in some areas there is only limited control on quantities removed. Although some countries are developing more stringent licensing systems, in many cases the overall aim of national approaches to the regulation of this practice appear unclear and need to be considered in relation to the national policy on land-based exploitation of aggregates. The OSPAR Strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area will also cover the impacts of mineral exploitation on benthic habitats.

Limitations in knowledge

There is limited information on short-term and long-term effects of exploitation of marine aggregates, especially of shells and maërl. Such information is necessary to set controls and quotas to ensure sustainable exploitation.

Identification of priorities for action

As demands are gradually increasing, more widespread and effective implementation of the ICES Code of Practice on Commercial Extraction of Marine Sediments is required, in particular through national licences. In addition, effective controls should be established and the assessments of short- and long-term impacts of extraction should be improved. The areas concerned should also be considered in relation to the measures referred to in the section on the use of the coastal zone (Section 6.3.1).

6.3.3 Dredging and dumping

Description of the impact

Dredging activities cause physical disturbance and may result in the redistribution, and possibility of changing the form, of contamination (see Chapter 4 and section 6.5). Physical disturbance includes increases in suspended matter, which affects primary production and growth of filter-feeding organisms, burial of benthic organisms, and changes in substrate character, which may affect benthic communities. These effects appear to be of a localised nature. Dredging may change the balance of natural coastal processes, sometimes accelerating coastline erosion and changing the morphology of natural channels and affecting habitats on a larger scale. Dredging of ship channels (capital dredging) has been necessary over recent years to accommodate larger vessels.

Effectiveness of measures

With the entry into force of the OSPAR Convention, dumping has in practice ceased, with the exception of the dumping of dredged material and fish waste from industrial fish processing operations. In general, dumping of dredged material is well managed by licences and controls on contaminant levels but not on total loads. According to the OSPAR Dredged Material Guidelines, measures to keep the volume of dredged material to a minimum are regarded as Best Environmental Practice for minimising the effects on the environment. The impacts of these activities will be considered under the OSPAR Strategy on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area.

Identification of priorities for action

In future, maintenance dredging may increase, but natural variability (the number of storms) also has an effect on the total amount of dredging required from year to year. It will be necessary to assess and mitigate the possible impacts. Existing management systems will also need careful monitoring to ensure that they continue to be effective.

6.3.4 Litter

Description of the impact

Sources of marine litter (for 95% consisting of non-degradable plastics) are mainly related to waste generated by shipping (fishing and commercial) and tourist and recreational activities. Floating litter and sunken pieces have been found in large quantities in all regions of the OSPAR maritime area. Impacts on marine life include the drowning of birds entangled in plastic sheeting, and the death of birds, turtles and cetaceans caused by ingested plastic objects. Litter has also been found to carry a variety of epiphytic organisms to sea areas that these organisms would not normally reach. Economically, the recreational and commercial fishing sectors are likely to be most affected by litter. As tourism, urban development and industrial pressure for development in the coastal zone increase, the problem of litter may also increase.

Effectiveness of measures

Under MARPOL Annex V, which entered into force on 3 December 1988, the discharge to sea from ships of all plastics is prohibited. An amendment to this Annex, adopted in 1995, requires all ships of 400 t and above, or transporting more than 15 people, to file a plan for garbage management. The North Sea (1991) and the Baltic Sea (1988) have been designated as MARPOL Special Areas for the purpose of Annex V, and the dumping of all garbage and litter from ships is therefore prohibited. However, there seems to have been no subsequent improvement in the situation with regard to litter. Within the OSPAR Strategy on Marine Biodiversity and Ecosystems attention will be given to the ecological impacts of litter.

Limitations in knowledge

Improved and more standardised methodologies, including the establishment of reference areas, will be needed to assess properly the scale and impact of litter both on coasts and offshore. These, in turn, will provide a basis for assessing trends in the quantities and significance of litter throughout the OSPAR area.

Identification of priorities for action

The following actions should be considered by the appropriate international, national and local authorities:

a. adequate enforcement of the requirements of MARPOL Annex V;
b. rapid adoption, implementation and adequate enforcement of the (draft) European Parliament and Council Directive on port reception facilities for ships-operated waste and cargo residues (OJ C10/4, 13 January 2000);
c. consideration of the designation of a larger part of the OSPAR maritime area as MARPOL Special Areas (Annex V);
d. campaigns to educate the public and those involved in tourism, fishing and shipping industries; and
e. relocation and/or improved management of coastal landfill sites from which garbage may escape to the sea.

6.4 Shipping

Description of the impact

Shipping can impact upon the marine environment in a number of ways. In the OSPAR maritime area, such impacts are mainly the result of either accidental or intentional inputs of noxious substances and/or organisms to the environment. These inputs can include the introduction of non-indigenous species in ballast water, the use of antifouling paints (see Section 6.5), litter (see Section 6.3.4), air pollution emissions, operational discharges, or the loss of a vessel and/or cargo. In recent years, cargo lost from ships has included phosphorus ore, pesticides and both mineral and vegetable oil. Discharges of the latter group of substances, although permitted in some cases, have still caused the death of many seabirds and continue to be a major concern.

The greatest potential for damage from shipping disasters lies in the spilling of hazardous materials close to ecologically sensitive areas (e.g. spawning grounds, bird colonies, nature conservation areas), or centres of human activities (e.g. mariculture sites, tourist centres). Oil spills from tanker accidents do have major economic and biological impacts, including effects on mariculture and loss of wildlife. Clean-up efforts to protect tourist interests and temporary restrictions on fixed fisheries are often required, particularly in the short-term.

Since August 1999, discharges of oil or oil mixtures from shipping are prohibited in the North West European Waters Special Area (established by the IMO under MARPOL Annex 1 (oil)). There have also been improvements in the availability of harbour reception facilities in many ports. However, there are still many ships cleaning tanks or discharging bilge water with an oil content of more than 15 ppm at sea, resulting in the oiling of seabirds, shellfish, other organisms and the coastline. Pollution from such illegal activities remains at an unacceptably high level, so far without a clear downward trend.

In the OSPAR maritime area, over 100 non-indigenous species have been recorded, mainly in the North Sea, the Celtic Sea, the Bay of Biscay and along the Iberian coast. The main vectors of such unintentional introductions are ships' ballast water and associated sediments, and fouling on ships' hulls, although mariculture is also a significant vector (see Section 6.2.2).

Effectiveness of measures

Several IMO Conventions address the issue of ship safety, while traffic separation schemes have significantly reduced the risk of ships colliding on passage. Loss of cargo or vessel is far harder to manage. Marked increases in the size of vessels and the volume of goods being transported have not led to an increase in the number of accidents. The number of incidents involving losses of vessels at sea has stabilised. However, the potential for accidents, damage or the requirements for emergency response across the North-east Atlantic as a whole is difficult to assess because data on the type of movement and cargoes involved are difficult to access.

No effective methods to control unintentional introductions of non-indigenous species are in place. The means of preventing such introductions are under review by IMO, which is preparing regulations for ballast water management.

Insufficient time has elapsed since the introduction of the MARPOL Annex 1 Special Area in August 1999 to determine the effectiveness of this new regulation. In order to improve the effectiveness of prosecution for violations, in 1999 the Bonn Agreement adopted Guidelines on International Co-operation on Facilitating Effective Prosecution of Offenders (Bonn Agreement, 2000).

Despite improvements, adequate waste reception facilities in ports are still not widely available. The charges levied and pressure of time discourage a minority of operators from using the facilities that are available, often resulting in illegal discharges. The EU Common Position 1/2000 on (draft) European Parliament and Council Directive on port reception facilities for ships-operated waste and cargo residues (OJ C10/4, 13 January 2000) could be a major step forward in the reduction of waste discharges.

Limitations in knowledge

It is very difficult to identify and assess the impact of the introduction of non-indigenous species. One of the reasons is that knowledge of the geographical distribution of indigenous species is limited. Better inventories are needed to identify rare species and unique habitats. More strategically targeted studies are needed to determine which species are indigenous/non-indigenous to each OSPAR Contracting Party.

Identification of priorities for action

With a view to reducing further the impact from shipping, Contracting Parties should consider taking action, individually and/or jointly as appropriate, with the view to:

a. establishing reception facilities for litter and oily wastes where such facilities are not yet available, providing incentives for the use of such facilities and improving the enforcement of compliance with existing rules and regulations with regard to litter and oil (including the application of chemical finger-printing and tagging of oil);
b. reducing the risk of collisions and related impacts from accidental spills and losses of cargo through:
    i) improving the effectiveness of traffic separation schemes and promoting their introduction, measures to ensure that routing measures are complied with and the installation of collision warning devices;
    ii) ensuring that ships are operated to the highest safety standards, including checks of the structural integrity of the ships and regular training of the crews;
    iii) improved access to advance information on the movements of ships and on their cargo; and
    iv) the promotion of measures in international fora to recover lost cargo by for instance tags and transponders;
c. improving, through appropriate IMO regulations, the fuel quality in order to prevent both the risk of engine failure (and consequent risk of the loss of vessels) and problems arising from the environmentally hazardous combustion residues of bunker oil;
d. developing, within the framework of IMO, global and regional measures for the prevention of the spreading of non-indigenous species via ballast water and promoting the development of globally intercompared sampling techniques as well as monitoring programmes for the most likely points of entry of non-indigenous species, and to consider whether there is need for complementary action by OSPAR; and
e. establishing within the framework of IMO the legal basis for the intended global prohibition on the application of organotin compounds which act as biocides in antifouling systems in ships by 1 January 2003, and the requirement to remove organotin compounds acting as biocides on ships by 1 January 2008.

6.5 Hazardous substances

6.5.1 Introduction

OSPAR adopted in 1998 a Strategy with regard to Hazardous Substances (OSPAR ref. no. 1998-16). This sets out, *inter alia*, the objective of

> 'prevent[ing] pollution of the maritime area by continuously reducing discharges, emissions and losses of hazardous substances…, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances'

within a time frame of making every endeavour to move towards the target of the cessation of discharges, emissions and losses of hazardous substances by 2020. This Strategy is also incorporated into the OSPAR Strategy for the offshore oil and gas industry (see Section 6.7).

An important element of the strategy is the OSPAR list of chemicals for priority action (i.e. Annex 2 of the Strategy, which will be updated from time to time). Several of the substances mentioned in this section are already included in this list (i.e., mercury, lead, cadmium, PAHs, PCBs, organotin compounds, lindane (and isomers), nonylphenols, dioxins). Others are being considered in the current revision. Background documents for individual substances or groups of substances on the list will be prepared which will provide an overview of existing information on sources, pathways, inputs and concentrations in the environment, and on existing measures. This will provide a basis on which to take forward the development of appropriate action. The Ministerial Statement arising from the OSPAR Ministerial Meeting in Sintra (Portugal) in 1998 contains a commitment to such action within three years of the identification of a substance for priority action.

Point sources of these substances are generally controlled by the application of Best Available Technology and/or the setting of discharge and emission limit values, whereas diffuse sources are controlled by applying Best Environmental Practice and controls on the marketing and use of products.

Discharges, emission and losses of most of the substances in this section are the object of various EC Directives (many of which also apply in states which form part of the European Economic Area). These Directives include Council Directive 76/464/EEC of 4 May 1976 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (which is intended to be replaced by the forthcoming Directive establishing a framework for Community action in the field of water policy), Council Directive 76/769/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations, Council Directive 79/117/EEC of 21 December 1978 prohibiting the placing on the market and use of plant protection products containing certain active substances, Council Directive 91/414/EEC of 15 July 1991 concerning the placing of plant protection products on the market, Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control and Council Directive 98/8/EC of the European Parliament and of the Council of 16 February 1998 concerning the placing of biocidal products on the market.

These directives, as well as work within OSPAR and under the UN Economic Commission for Europe's Convention on Long-Range Transboundary Air Pollution (UNECE-LRTAP) provide an international regulatory framework for the application of BAT and BEP.

6.5.2 Description of impacts

There are a number of metallic and organic substances which OSPAR has identified as being of concern, on account either of their intrinsic properties of toxicity, persistence and liability to bioaccumulate or of other effects such as endocrine disruption or of both.

Metals

Heavy metals can pose a risk to the marine environment in a number of ways. Dissolved copper can affect lower trophic levels such as phytoplankton. Other metals, such as cadmium, mercury and lead, can accumulate in shellfish and in top predators (including man). The trends found in levels of metal contamination are generally downward. The effects are normally localised and occur most frequently in estuaries and in the coastal zone. In these areas, metal concentrations in water and sediments can exceed the ecotoxicological assessment criteria, indicating concern for effects on biota. This is the case for cadmium concentrations in the water of some estuaries in the North Sea and mercury in near shore areas in Region IV. Cadmium, lead, mercury and copper in sediments have been found to exceed the EACs in certain specific areas close to current or past inputs. Furthermore, several heavy metals have been observed to travel long distances in the atmosphere, causing transboundary pollution in pristine areas such as the Arctic.

Organic substances

Apart from their intrinsic properties of toxicity, persistence, and liability to bioaccumulate, there is clear evidence that a diverse range of natural and man-made substances (including TBT and various other organometallic compounds, PCBs, dioxins, and certain pesticides, pharmaceuticals and industrial chemicals), have potential to impair the reproductive process in aquatic organisms, for example through interference with their endocrine (hormonal) systems. Studies have shown that these endocrine-disrupting effects can occur even at very low ambient concentrations, considerably less than concentrations that are either mutagenic or acutely toxic.

Exposure to TBT, originating from antifouling treatments, produces distinctive endocrine-disrupting responses in a number of organisms, including shell thickening in Pacific oysters and 'imposex' (development of the sexual characteristics of the other sex) in gastropods. Significant levels of imposex in dogwhelks are found in those estuarine and coastal areas of the Convention area with the heaviest concentrations of shipping and ship-related activity. Imposex has been documented in dogwhelks and common whelks in harbours in northern Portugal, north-west Spain, Iceland, Norway and Svalbard, as well as in British and Irish waters and the North Sea region, including the Kattegat. Surveys of imposex in Region III during 1997 indicate that because of the very low levels of TBT at which they occur biological effects are still evident at all but the most remote coastal sites ten years after enforcement of TBT restrictions on small vessels (< 25 m in length).

There is a significant correlation between shipping intensity and TBT levels in biota/sediments and the occurrence of imposex. This suggests that vessels with a length of more than 25 m using TBT-based antifouling paints represent the main source of TBT for the marine environment.

PCBs emitted and deposited during the years of intensive production and use are still a diffuse source of pollution and contamination of the global environment, despite a ban on the production of, and the introduction of controls on the marketing and use of, PCBs in many countries. As a consequence of their hydrophobic and persistent character, PCBs are bioaccumulated. High concentrations are found in biota, especially in the fatty tissues of piscivorous birds and marine mammals. Concentrations in mussels exceeding the EAC have been reported in all Regions, except Region V. PCBs can disturb enzyme and endocrine systems in marine mammals as, for example, observed in harbour seals (*Phoca vitulina*) in the Wadden Sea. High levels have also been shown to affect the immune system of the polar bear.

Sources of PAHs include domestic and industrial combustion of fossil fuels, oil spills, emissions from offshore installations and ship exhausts. Sediments represent the most important reservoir of PAHs in the marine environment. Concentrations in sediments often exceed the EACs, especially in some estuaries in Region II. PAHs are less prone to bioaccumulation or biomagnification than organochlorine compounds. Fish and organisms higher in the food chain tend to metabolise and excrete the compounds quite rapidly. From mesocosm studies, there is evidence of a correlation between the occurrences of pre-stages of liver tumours in North Sea flatfish and of contaminants, particularly PAHs and possibly chlorinated hydrocarbons.

Organochlorine pesticides enter the marine environment mainly through diffuse inputs from water and air as a result of their use in agriculture or on amenity areas and through transboundary pollution resulting from their use outside the Convention area. Various studies indicate that some organochlorine pesticides are detected in various marine species at low levels which may give rise for concern. However, levels are generally decreasing and restricted to local situations but further work is needed on toxaphenes. Although the use of most organochlorine pesticides has been phased out for sometime (for example, DDT since 1979 see Council Directive 79/117/EEC), they are still detected in the marine environment, due to their extreme persistence, to illegal use or to use elsewhere. Concentrations of DDE, a metabolite of DDT, still exceed EACs in mussels and fish in some areas.

Other persistent organic substances identified for action by OSPAR are not yet included in any OSPAR long-term monitoring programmes. Occurrence in the marine environment can either be predicted on the basis of information about their production and use, or has been demonstrated in various national studies or one-off surveys, either of actual concentrations in water or biota, or of biological effects on particular species.

These substances include:

- brominated flame retardants, used as additives to polymers and textiles;
- chlorinated paraffins that are used as plasticisers, flame retardants and as additives in metal working fluids and the leather industry;
- synthetic musks, used as fragrances in cosmetics, soaps and detergents;
- octyl- and nonylphenol ethoxylates (which are known endocrine disrupters), used in industrial detergents and in the textile and leather industry; and
- dioxins, which are highly toxic chemicals, but which are not manufactured but rather produced as combustion by-products, or during the production of certain chlorinated chemicals and pulp bleaching.

Just as spills of oil from shipping can directly impact on the sea, so can discharges and losses of oil from refineries and land-transport accidents have an impact, through riverine inputs and sewage discharges.

6.5.3 Effectiveness of measures

Metals

Point source discharges and emissions are the most amenable to control. A number of measures have been taken at international level to reduce discharges, emissions and losses of heavy metals (e.g. various OSPAR Decisions and Recommendations and EC Directives). As a result, inputs of metals have generally decreased. Future regulations arising from the UNECE-LRTAP Convention will complement this. Diffuse inputs from the use of products containing heavy metals and the consequent run-off into rivers and the sea are now the main challenge.

The presence of high concentrations of metals and man-made substances in marine seafood could pose a problem for the human consumer. To protect consumers, OSPAR countries have established regulations and monitoring programmes for contaminants in seafood.

Organic substances

The application of TBT on ships less than 25 m in length was prohibited in 1990. IMO has decided to develop a binding international instrument to ban the use of organotin compounds in antifouling treatments on ships longer than 25 m. The target is to prohibit their application from 2003 and to require the removal of TBT from ships' hulls by 2008. Within the EC, the control on other TBT applications has been intensified with the 1999 amendment of Annex I of Council Directive 76/769/EEC (on the marketing and use of dangerous substances). This has resulted in a shift to the use of other harmful chemicals for antifoulant treatments. Recent studies have predicted that copper and booster biocides might be present in certain areas of the marine environment at concentrations that might cause an adverse impact on biota.

Many areas still show the legacy of historic TBT inputs. However, in countries where effective regulations were introduced, concentrations have decreased substantially over the past decade and biological recovery has been observed in areas of small-boat use. This is an indication that implementation of control measures can be effective.

The production of PCBs is banned. Several countries have phased out all PCB usage in large installations. However, substantial quantities of PCBs still remain in use in smaller installations. Spills from such installations and from electrical equipment are still important. Concentrations in marine biota at several locations have decreased considerably. However, the rate of reduction decreased in the 1990s, and concentrations appear to have levelled out.

Since 1976, uses of PCBs, PCTs and preparations including waste oils, with a PCB or PCT content higher, currently, than 0.005% by weight, have been prohibited on the basis of Council Directive 76/769/EEC. Certain use categories have been exempted until 30 June 1986. PARCOM Decision 92/3 on the Phasing Out of PCBs and Hazardous PCB Substitutes requires, *inter alia*, that Contracting Parties take measures to phase out and to destroy in an environmentally safe manner all identifiable PCBs (i) by 1995, or by the end of 1999 at the latest, for Iceland and the Contracting Parties which are riparian to the North Sea and (ii) by 2005, or by the end of 2010 at the latest, for the remaining Contracting Parties. The overview assessment of the reports on implementation of PARCOM Decision 92/3 showed that implementation (compliance only) was not yet complete in 1997. The controlled disposal of PCBs, the decontamination or disposal of equipment containing PCBs and/or the disposal of used PCBs in order to eliminate them completely has been regulated on the basis of Council Directive 96/56/EC. Further elimination of production and use of PCBs has been agreed under the UNECE-LRTAP Convention.

In parallel with other international organisations, and focusing on the marine environment, an OSPAR approach to addressing endocrine disrupters is being developed.

OSPAR has agreed on a number of measures relevant to the control of PAHs. These include PARCOM Recommendation 96/4 on one-component coal-tar coatings on ships, PARCOM agreement 1997-10 on two-component coal-tar coatings on ships, and OSPAR Recommendation 98/2 on limit values for the aluminium industry. Proposals are currently being developed for the control of PAH releases from domestic combustion and for the use of creosote on timber. The effectiveness of these measures is under evaluation within OSPAR.

The use of most organochlorine pesticides has now been phased out (for example, lindane in 1981,see Council Directive 79/117/EEC), and only some uses are still authorised. The protocol to the UNECE-LRTAP Convention on Persistent Organic Pollutants has identified a number of organochlorine pesticides as being persistent organic pollutants, and the development of binding measures to deal with these at a global level is under way. The dynamic selection and prioritisation mechanism (DYNAMEC) under the OSPAR Strategy with regard to Hazardous Substances will identify any further pesticides of possible concern for the maritime area on the basis of their intrinsic properties regarding persistence, bioaccumulation and toxicity for the development of further measures. All pesticides which are still subject to authorisation will be reviewed in the coming years under Council Directive 91/414/EEC (on the placing of plant protection products on the market). In order to restrict inputs of pesticides, a number of codes of practice have been developed. Recommendations on codes of practice concerning integrated crop management and the use of pesticides on amenity areas were adopted by OSPAR in June 2000.

OSPAR has already adopted measures on chlorinated paraffins (PARCOM Decision 95/1 on the Phasing Out of the use of Short-Chained Chlorinated Paraffins), and nonylphenol ethoxylates (PARCOM Recommendation 92/8 on Nonylphenol-Ethoxylates), and has set limit values for dioxins in several measures controlling point sources either directly (OSPAR Decision 98/4, manufacture of Vinyl Chloride Monomer) or indirectly by the use of the AOX parameter (PARCOM Decision 92/1, production of bleached kraft and sulphite pulp), or by phasing out the use of molecular chlorine (PARCOM Decision 96/2 on the bleaching of kraft and sulphite pulp). Reports of OSPAR Contracting Parties on the implementation of these measures show that, in general, there is a reduction in the use of these substances, and that limit values are being respected. These substances are all on the OSPAR List of Chemicals for Priority Action. Background documents are being prepared which will identify the main sources and pathways to the marine environment with a view to taking forward appropriate control measures by 2001.

Except for dioxins, all of these substances are the subject of risk assessments under the EC Existing Substances Regulation (Commission Regulation (EC) No 1488/94). This will in many cases lead to binding risk reduction measures, mainly under the EC Directive on the marketing and use of dangerous substances (Council Directive 76/769/EEC). With respect to dioxins, emissions are being restricted by the application of BAT to several industrial processes and by EC Directives on combustion and incineration (Council Directives 88/609/EEC on large combustion plants, Council Directive 89/369/EEC on new waste incineration plants, Council Directive 89/429/EEC on municipal waste incineration plants, Council Directive 94/67/EC on the incineration of hazardous waste and Council Directive 96/61/EC on integrated pollution prevention and control).

Measures to reduce discharges of oil from refineries (PARCOM Recommendation 89/5) have been very effective (a reduction of over 90% between 1981 and 1997).

6.5.4 Limitations in knowledge

There are a number of topics where understanding is relatively poor and which should be considered for future investigation or research:

a. there is a lack of reliable data on emissions, discharges and losses, and on concentrations and effects, for several of the hazardous substances which are currently on the OSPAR List of Chemicals for Priority Action (see Annex 2 of the OSPAR Strategy with regard to Hazardous Substances). The same is true for many of the substances that are currently being considered for inclusion in this list. Furthermore, the application of the OSPAR DYNAMEC is hampered by lack of such information;
b. there is only limited information available on the range and concentrations of anthropogenic chemicals released to the marine environment that may cause endocrine disruption in marine organisms. Furthermore, the way in which potential endocrine-disrupting chemicals affect organisms is not fully understood. More information is needed on endocrine-disrupting effects other than œstrogenic effects; and
c. little is known about the degradation products of PAHs in the sea, such as their sulphone, hydroxy and nitro analogues, which are often appreciably more toxic than their parent compounds. Some of these can be expected to have a greater persistence than their precursors.

6.5.5 Identification of priorities for action

With sufficient resources to underpin the ambitious programme of work it implies, the OSPAR Strategy with regard to Hazardous Substances will provide a comprehensive and coherent approach to:

a. identifying the hazardous substances of concern in relation to the OSPAR maritime area, ranking the priorities for action on them;
b. identifying their sources and the pathways by which they reach the marine environment; and
c. developing programmes and measures to achieve the aims of the strategy where adequate action is not being taken elsewhere.

It will also be important to ensure that there is a corresponding effort in observing developments in the marine environment of the maritime area and in inputs to it, in order to chart the progress of the Strategy with regard to Hazardous Substances towards its objective. Innovation will be required to develop quality-assured monitoring techniques for the hazardous substances newly identified for priority action as well as strategies for the collection of information on such substances, to monitor new types of source (especially diffuse sources) and to establish baselines against which to measure progress. Since resources will inevitably be limited, it will be necessary to revise monitoring and assessment programmes to ensure that:

a. resources are concentrated on monitoring the aspects that are of most significance;
b. monitoring for specific substances is proportionate to the need and is reduced after appropriate goals have been reached; and
c. the benefits of these programmes are optimised in relation to their costs.

The programmes and measures adopted by OSPAR contain provisions for reporting on implementation, both on the arrangements adopted and on effectiveness. There is a need to improve coverage of reporting and to ensure that the information collected in this way on the effectiveness of measures is brought together with programmes for monitoring and assessment.

In addition, actions should be considered on certain specific points:

a. in relation to antifouling treatments,
   i) the measures in PARCOM Recommendation 87/1 (on the use of tributyl-tin compounds) and PARCOM Recommendation 88/1 (on docking facilities) should be completed with the development of a measure on BAT for the disposal of organotin wastes resulting from the removal of such antifouling treatments from ships;
   ii) monitoring should be urgently undertaken on the impacts of alternatives to organotin antifouling treatments (for example, copper and booster biocides);
b. a review of action at the national level to implement PARCOM Decision 90/3 (emissions from mercury-cell chlor-alkali plants) and, if need be, OSPAR measures to facilitate this implementation;
c. an assessment of the implementation of PARCOM Decision 92/3 (phasing out of PCBs); and
d. carrying forward work under the UNECE-LRTAP Convention on Persistent Organic Pollutants and completing the negotiations on a global convention on this topic under the aegis of the UN Environment Programme.

6.6 Radioactive substances

Description of the impact

Nuclear weapons testing, the dumping of wastes in deep water, the foundering of a nuclear submarine, accidents during transportation and discharges from coastal installations have all added to the radionuclides present in the marine environment. The majority of these inputs have been drastically reduced. Remaining inputs are largely due to ongoing releases from nuclear-fuel reprocessing plants. The greatest threats in the future are accidents in the civilian and military nuclear sectors. Releases from dumpsites are considered to pose negligible radiological risk to man, although it is difficult to draw firm conclusions about environmental impacts.

The question of radioactive contamination, particularly that arising from the Cap de la Hague and Sellafield nuclear-fuel reprocessing plants, is a matter of public concern. This stems from the higher levels of radioactivity discharged in the past and from recent increases in the discharge of certain less radiologically significant radionuclides, particularly technetium-99. There are now more sophisticated detection systems and there have been substantial net reductions in the levels of some more harmful radionuclides over the last decade. Low concentrations of some man-made radionuclides are found in seaweeds, shellfish and wildlife far from the sources. Impacts of radionuclides on wildlife have not been assessed. There are no internationally agreed standards for the assessment of the impact of man-made radionuclides on wildlife.

Fallout of caesium-134 and caesium-137, a major fraction from the Chernobyl accident in 1986, made an additional contribution to radionuclide contamination. Generally, since then the levels of these artificial radionuclides have been decreasing. However, in sediments, which have been particularly affected, there have been increases due to run-off from land, as well as redistribution within the ecosystem.

The entry into force of OSPAR Decision 98/2 has made permanent for all Contracting Parties the ban on the dumping of low-level and intermediate-level radioactive substances, including wastes, in the maritime area.

Effectiveness of measures

OSPAR adopted in 1998 a Strategy with regard to Radioactive Substances (OSPAR ref. no. 1998-17). This sets out, *inter alia*, the objective of

> ‘prevent[ing] pollution of the maritime area from ionising radiation through progressive and substantial reductions of discharges, emissions and losses of radioactive substances, with the ultimate aim of concentrations in the environment near background values for naturally occurring radioactive substances and close to zero for artificial radioactive substances.’

within a time frame of ‘ensure[ing] that discharges, emissions and losses of radioactive substances are reduced to levels where the additional concentrations in the marine environment above historic levels, resulting from such discharges, emissions and losses, are close to zero by 2020’.

Recent commitments made within the framework of OSPAR, in particular in the context of the implementation of the OSPAR Strategy with regard to Radioactive Substances, indicate that a process for reducing anthropogenic emissions, discharges and losses of radioactive substances (including reductions in technetium) has started and will continue and that radioactivity levels associated with routine discharges will continue to decline.

Identification of priorities for action

Within the framework of the implementation of the OSPAR Strategy with regard to Radioactive Substances, it is important to develop environmental quality criteria for the protection of the marine environment from adverse effects of radioactive substances and to report on progress by 2003.

The investigations of the significance of possible leakage from the sunken nuclear submarines and from old dumpsites should be continued. If appropriate, an adequate policy to prevent pollution from such sources should be developed and implemented.

6.7 Offshore oil and gas

Description of the impact

Anthropogenic sources of oil to the marine environment include operational and accidental releases from oil and gas production platforms.

Oil inputs from produced water from offshore installations have increased progressively as oil fields have matured and the number of installations has increased, particularly in the North Sea. They now constitute the largest source of oil for the oil and gas sector. Leaching from old drill cuttings is a possible source of oil, but quantities released will be very small if the cuttings are not disturbed.

Changes to benthic communities have been identified over areas surrounding established oil and gas production platforms. Impacts are largely caused by past disposals of cuttings contaminated with oil and chemicals in the immediate vicinity of some platforms. There is a consequent reduction in species diversity near platforms, with opportunistic species dominating the biomass. Biological changes from this cause have been detected up to 3 km from such installations.

Discharges of produced water from the offshore oil and gas industry are increasing. In addition to ‘oil’, produced water also contains a range of other natural organic compounds including monocyclic aromatic hydrocarbons (i.e. BTEX), 2- and 3-ring PAHs, phenols and organic acids. Any toxicity of produced water is likely to arise from these compounds as well as from residues of production chemicals (including biocides) whose environmental fate and effects have been determined in advance by regulatory agencies. In the case of the relatively small discharges of produced water from gas platforms, the discharge of aromatics may exceed the discharge of dispersed oil. Total amounts of chemicals introduced from this source are projected to rise in parallel with an expected increase in the volume of produced water. There is uncertainty over the environmental effects of produced water.

Offshore oil and gas activities are expanding into deeper waters and into environments seasonally covered by ice. The risk of accidental releases of oil, and the potential effects of such releases, will increase because of the depth of operations and the difficulties of taking remedial actions in cold environments.

Effectiveness of measures

The target standard for oil of 40 mg/l in produced water from offshore installations (set by PARCOM Recommendation 92/6) was met by 90% of the installations in 1997. Oil discharged as part of the disposal of cuttings contaminated with oil-based drilling muds ceased at the end of 1996 (as a result of PARCOM Decision 92/2). Overall, inputs of oil from the offshore oil and gas sector have reduced by over 60% in the period 1985 to 1997.

In 1996, OSPAR adopted Decision 96/3 on a Harmonised Mandatory Control System for the Use and Reduction of the Discharge of Offshore Chemicals. This Decision is a key element in the international control of chemicals intended for use on offshore installations. It sets out, *inter alia*, what data and information relating specifically to substances or preparations must be notified to the competent national authorities and gives advice to be taken into account by the authorities with a view to harmonising the approach taken by all OSPAR Contracting Parties in their relevant authorisation and permitting procedures. Following a trial period its effectiveness was reviewed in the light of experience and a package of new OSPAR measures was established. These were adopted in June 2000 and supersede the previous OSPAR measures with respect to offshore chemicals. These new OSPAR measures take into account the provisions and requirements set out in the various OSPAR strategies and are one of the most advanced international agreements for the protection of the marine environment from the use of chemicals in the offshore oil and gas industry.

Limitations in knowledge

There are a number of issues that limit an assessment of the impact of the offshore oil and gas industry:

a. possible effects of disturbance of cutting piles;
b. lack of ecotoxicological assessment criteria and/or background/reference concentrations for oil; and
c. long-term impacts of the chemicals found in produced water.

Identification of priorities for action

In accordance with the OSPAR Strategy on Environmental Goals and Management Mechanisms for Offshore Activities (OSPAR ref. no. 1999-12), OSPAR should actively pursue the development and implementation by the offshore industry of environmental management mechanisms, including elements for auditing and transparent reporting, aimed at fulfilling the objective of this strategy. Furthermore, competent authorities and the oil industry should continue efforts aimed at a greater public openness regarding their activities.

6.8 Eutrophication

Description of the impact

The OSPAR Common Procedure for the Identification of the Eutrophication Status of the Maritime Area (‘Common Procedure’ (OSPAR ref. no. 1997-11)) is being used to characterise the maritime area in terms of problem areas, potential problem areas and non-problem areas with regard to eutrophication. Preliminary results from the application of the Common Procedure and from Regional QSRs show that eutrophication, for example as indicated by periodically low oxygen levels, is confined to parts of Region II and to some coastal embayments and estuaries within Regions III and IV.

In Region II eutrophication is widespread in particular estuaries and fjords, coastal areas of the eastern part of the North Sea, the Wadden Sea, the German Bight, the Kattegat, and the eastern Skagerrak. Within the Irish Sea and some estuaries of Region III concentrations of nitrate and phosphate are elevated and oxygen depletion may occur at times as a result of human activity. There are indications that the Mersey Estuary / Liverpool Bay area and Belfast Lough may be showing signs of eutrophication. In Region IV, oxygen depletion has been recorded in some restricted areas of estuaries of coastal lagoons (for example, the Bay of Vilaine).

The majority of harmful algal blooms are natural events. However, in some circumstances, enhanced nutrient inputs and/or changes in the N/P ratios of the inputs, as well as inputs of micronutrients may have changed the phytoplankton community structure towards an increased likelihood of the occurrence of toxic species. Such effects have been suspected, and in some cases proven, to be responsible for the recent increases in space and time of blooms of such toxic species. The human health and economic consequences of harmful blooms and the accumulation of toxins in shellfish and other biota are a cause for concern. The presence of toxin-producing species does not always lead to the presence of toxins in shellfish and other biota, or to harm to fish and other marine life. On the other hand, algal toxins have been detected in shellfish in the presence of very low cell concentrations of toxic phytoplankton species.

Water rich in nutrients and with a high organic content may be transported outside eutrophication-affected areas to cause downstream reductions in water quality (for example, water of coastal southern North Sea origin impacting on waters of the Norwegian coastal Skagerrak).

Effectiveness of measures

OSPAR adopted in 1998 a Strategy to Combat Eutrophication (OSPAR ref. no. 1998-18). This sets out, *inter alia*, the objective of:

> 'combat[ing] eutrophication in the OSPAR maritime area, in order to achieve and maintain a healthy marine environment where eutrophication does not occur.'

within a time frame of making every effort to achieve this objective by the year 2010. Actions to achieve this comprise integrated target-orientated and source-orientated approaches.

The 1987 North Sea Ministerial Conference agreed that nutrient inputs (nitrogen and phosphorus) to areas affected, or likely to be affected, by eutrophication should be reduced by the order of 50% between 1985 and 1995. This aim was endorsed by OSPAR in 1988 for the whole maritime area and subsequently incorporated by OSPAR within the Strategy to Combat Eutrophication.

The 50% reduction commitments by North Sea states were substantially achieved for phosphorus, but reductions for nitrogen were estimated to be of the order of 25% between 1985 and 1995, based on discharges and losses at source. Efforts to collect and treat urban and industrial wastewater have resulted in reductions in direct inputs of nitrogen of 30% and of phosphorus of 20% between 1990 and 1996. However, because of fluctuations in river flow over the same period, no consistent reductions in riverine or atmospheric inputs to the North Sea were detected. Little success has been reported in reducing inputs from other diffuse sources such as the leaching of fertilisers and slurry from agricultural land.

While there are no clear trends in nutrient levels from the North Sea as a whole, this is not so for smaller coastal areas directly influenced by anthropogenic inputs. In Danish coastal waters, the Wadden Sea and German Bight there has been a significant downward trend (especially for phosphorus) between 1989 and 1997. In Danish waters the reductions are due to a decrease in loads from sewage, industry and detergents (80% for phosphorus).

Measures taken by the EC including the Urban WasteWater Treatment Directive (91/271/EEC) and the Nitrates Directive (91/676/EEC) of 1991 as well as a range of initiatives at national level are providing further impetus to the reduction of nutrient inputs. The Urban WasteWater Treatment Directive required a reduction of nutrients to eutrophication-sensitive areas by 1998 and the Nitrates Directive required the establishment of 'Action Programmes' to reduce agricultural inputs to 'Nitrate Vulnerable Zones' to be in place by the end of 1998. As these directives have yet to be fully implemented, their benefits have yet to be realised.

Limitations in knowledge

There are a number of topics where understanding is relatively poor and which should be considered for future investigation or research:

a. the response of the marine ecosystem (for example, through the formation of harmful algal blooms, changing algal community structure and succession) to inputs of nutrients, especially the impact of changing nutrient ratios (N/P) and the contribution of dissolved and particulate nitrogen and phosphorus;

b. the appropriate form of ecological quality objectives with respect to eutrophication;
c. natural variability in nutrients and ecosystem response, including the measurement and assessment of long-term trends;
d. the causes of occurrence of toxin-forming algal species linked to oceanographic events and the implications for toxin presence in shellfish; and
e. reliable modelling tools to underpin investigations of environmental variability and consequences of management action.

Identification of priorities for action

Within the framework of implementing the Strategy to Combat Eutrophication, OSPAR Contracting Parties should give particular attention to pursuing, without delay, the target-orientated and source-orientated approaches of the strategy, and in particular:

a. implementation of existing measures aimed at reducing emissions, discharges and losses of nutrients from agriculture and urban sources. In this respect, emphasis should be placed on:
    i) increased effectiveness of the implementation of the Urban WasteWater Treatment Directive and the Nitrates Directive; and
    ii) mechanisms to reduce input from diffuse sources, particularly agricultural fertilisers, livestock and atmospheric deposition; and
b. the further development and application of the Common Procedure and the development and adoption of ecological quality objectives.

The existing monitoring activities should be harmonised throughout the maritime area in order to establish links between nutrient enrichment and eutrophication effects. Work to model the consequences of various reduction scenarios should continue in parallel with spatial surveys and laboratory experiments to obtain necessary data for validation and testing. There is a need for further research on a range of topics to improve understanding of the causes and dynamics of blooms, their potential links to eutrophication, toxin production by phytoplankton, and the accumulation of toxins in shellfish and other biota.

6.9 Climate change and climate variability

Description of the impact

There is general agreement by the IPCC that increases in greenhouse gases are contributing to global warming. Work by the IPCC using Global Circulation Models predicts that, by 2100, the surface air temperature of the North-east Atlantic will have increased by approximately 1.5 °C, the sea level will have risen by 25 to 95 cm, mean precipitation will have risen and there will be an increased frequency and intensity of extreme events such as storms. Projections of future climate indicate that precipitation in high latitudes of Europe may increase, with mixed results for the other parts of Europe. Water supply may be affected by floods in northern Europe and by droughts in southern Europe. These changes may lead to major climate system changes with resulting impacts on the ocean and its biota.

Potential consequences of climate change are far reaching. Changes may occur in ocean current strength and transport, water mass formation rates, sea level height, the strength and frequency of weather systems, and rainfall and run-off with downstream effects on ecosystems and fisheries. Predicted rises in sea level are of particular concern especially for the Dutch coastal zone, other low-lying areas and intertidal habitats of the OSPAR region. The formation of North Atlantic Deep Water in Region I constitutes one of the deepest branches of the thermohaline circulation of the world’s oceans; any changes in the level of formation of this water in the Arctic may change the thermohaline circulation and result in a colder climate in Europe.

Existing measures

The United Nations Framework Convention on Climate Change (UNFCCC) was signed in 1992 by 166 countries and entered into force March 1994. The Convention provides a mechanism for agreeing international action, with the ultimate objective of the ‘stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system’.

Thirty-eight developed nations, including European countries, Japan, the Russian Federation and the United States, have accepted their historical responsibility for climate change. In December 1997, as part of the Kyoto Protocol, these countries agreed to individual emission reduction commitments, which, as a whole, would reduce overall emissions to 5% below levels emitted in 1990 by 2008 to 2012. These reductions are intended to be achieved through the ‘Kyoto flexibility mechanisms’ that aim to maximise economic efficiency through trading in carbon credits.

Limitations in knowledge

There are a number of topics where understanding is relatively poor and towards which research should be directed in the future:

a. a lack of knowledge exists concerning the relationship between climate variability and changes in physical conditions and how this might influence patterns of water circulation and biological production;

b. the mechanisms behind the observed strong relationship between the NAO and fluctuations in sea surface temperature are unclear;
c. the source and cause of observed multi-annual oceanic anomalies is not known;
d. the extent to which changes in the volume of deep water formed in the Arctic may affect the North Atlantic thermohaline circulation and weather needs clarification;
e. the interaction of mesoscale features such as eddies with larger entities such as the Gulf Stream as a response to atmospheric oscillations such as the NAO and climate variability is not clear; and
f. a greater emphasis needs to be placed on understanding the relative contributions of natural and anthropogenic forcing to climate variability in the North Atlantic.

Identification of priorities for action

Long-term monitoring of key atmospheric and oceanic indices and a resolution of mesoscale and synoptic patterns of change through the development of operational monitoring and modelling is needed to resolve this situation. Such monitoring could be included in the developing plans of the Global Ocean Observation System (GOOS).

A high priority should be given to improving scientific understanding of the factors governing climate change so that uncertainty is removed concerning the anthropogenic contribution, timing and severity of climate change impacts.

The possibility of sea level rise needs to be considered when planning coastal defences or development and when considering measures to protect species and habitats.

6.10 Other issues

6.10.1 Microbiological contamination

Description of the impact

Bacteria and viruses associated with (treated and untreated) discharges of sewage in all coastal regions of the OSPAR Convention area and other sources such as agricultural run-off can affect marine biota, including invertebrates, fish, and seals. The most important possible concerns in the OSPAR area in respect of microbiological contamination are the quality of bathing water and of shellfish for human consumption. There are still a number of beaches where the standards of the EC Directive for bathing water quality (76/160/EEC) are not met. Contamination of shellfish with *E. coli* has led to restrictions on marketing shellfish (in accordance with the EC Directive for shellfish hygiene (91/492/EEC)). The associated increased processing costs have caused concern within the shellfish industry.

Effectiveness of measures

Since monitoring work began there has been a marked improvement in quality of bathing water throughout the region and the vast majority of bathing waters in the OSPAR area now meet the standards under the EC Directive for bathing water quality (76/160/EEC). Where standards are not met, action has been initiated by the responsible authority within each country to improve bacterial quality of the bathing water.

Due to limitations inherent in the existing standards for the microbiological quality of bathing water and shellfish, compliance with these standards, although important in the protection of public health, may not protect all individuals against the entire range of human pathogens to which they might be exposed either through bathing or seafood consumption.

Limitations in knowledge

Current information is restricted to compliance with standards for the microbiological quality of bathing water and seafood. No assessment can be made of ecological effects due to the lack of knowledge. For example, little is known about the risk to mammals and seabirds from human pathogens in the marine environment.

Identification of priorities for action

If sewage discharges continue to affect bathing waters or shellfish growing waters further action (for example, the disinfecting of effluents or relocation of discharge points) should be taken by the responsible authorities to improve the bacterial quality of these waters. Furthermore, there is a need to take greater account of exceptional events such as primary rainwater run-off from combined sewage systems (where rainwater and sewage are collected together) after storm events, these being highly polluting.

6.10.2 Dumped ammunition

From time to time munitions such as incendiary devices and smoke bombs are washed up on beaches along the east coast of Ireland, the Isle of Man and the west coast of Scotland. This presents a hazard to the public. OSPAR is considering a course of action for dealing with dumped munitions.

6.11 Conclusion

The efforts of the OSPAR Contracting Parties since the adoption in 1972 of the Oslo Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft, and in 1974 of the Paris Convention for the Prevention of Marine Pollution from Land-based Sources have produced a significant effect in improving the protection of the marine environment of the North-east Atlantic. The trends towards worsening pollution have been reversed, and in a substantial number of significant cases the source of the pollution has been stopped.

Nevertheless, a number of important actions remain to be undertaken. The OSPAR Strategies have, however, established a framework for pursuing these. If the necessary resources can be made available, these Strategies offer the possibility for making real improvements over the next generation in the condition of the marine environment of the North-east Atlantic.

SPECIES

Reference list of species mentioned in this report (sorted by common (English) name within categories)

Common (English) name	Scientific name
Mammals	
Atlantic spotted dolphin	*Stenella frontalis*
Atlantic white-sided dolphin	*Lagenorhynchus acutus*
Bearded seal	*Erignathus barbatus*
Beluga (white whale)	*Delphinapterus leucas*
Blainville's beaked whale	*Mesoplodon densirostris*
Blue whale	*Balaenoptera musculus*
Bottle-nose dolphin	*Tursiops truncatus*
Bowhead whale	*Balaena mysticetus*
Bryde's whale	*Balaenoptera edeni*
Common dolphin	*Delphinus delphis*
Cuvier's beaked whale	*Ziphius cavirostris*
Dwarf sperm whale	*Kogia simus*
False killer whale	*Pseudorca crassidens*
Fin whale	*Balaenoptera physalus*
Gervais' beaked whale	*Mesoplodon europaeus*
Grey seal	*Halichoerus grypus*
Harbour porpoise	*Phocoena phocoena*
Harbour seal	*Phoca vitulina*
Harp seal	*Pagophilus groenlandicus*
Hooded seal	*Cystophora cristata*
Humpback whale	*Megaptera novaeangliae*
Long-finned pilot whale	*Globicephala melaena*
Melon-headed whale	*Peponocephala electra*
Minke whale	*Balaenoptera acutorostrata*
Killer whale	*Orcinus orca*
Narwhal	*Monodon monoceros*
Northern bottlenose whale	*Hyperoodon ampullatus*
Northern right whale	*Eubalaena glacialis*
Polar bear	*Ursus maritimus*
Pygmy killer whale	*Feresa attenuata*
Pygmy sperm whale	*Kogia breviceps*
Ringed seal	*Phoca hispida*
Risso's dolphin	*Grampus griseus*
Rough-toothed dolphin	*Steno bredanensis*
Sei whale	*Balaenoptera borealis*
Short-finned pilot whale	*Globicephala macrorhyncha*
Sowerby's beaked whale	*Mesoplodon bidens*
Sperm whale	*Physeter macrocephalus*
Striped dolphin	*Stenella coeruleoalba*
True's beaked whale	*Mesoplodon mirus*
Walrus	*Odobenus rosmarus*
White-beaked dolphin	*Lagenorhynchus albirostris*
Birds	
Brent goose	*Branta bernicla*
Barnacle goose	*Branta leucopsis*
Cory's shearwater	*Calonectris diomedea*
Curlew	*Numenius arquata*
Fulmar	*Fulmarus* sp.
Gannet	*Sula bassanus*
Great skua	*Catharacta skua*
Guillemot	*Uria aalge*
Kentish plover	*Charadrius alexandrinus*
Kittiwake	*Rissa tridactyla*
Little auk	*Alle alle*
Little tern	*Sterna albifrons*
Madeiran petrel	*Oceanodroma castro*
Manx shearwater	*Puffinus puffinus*
Oystercatcher	*Haematopus ostralegus*
Puffin	*Fratercula arctica*
Shag	*Phalacrocorax aristotelis*
Storm petrel	*Hydrobates pelagicus*
Yellow-legged gull	*Larus cachinnans*
Reptiles	
Leatherback turtle	*Dermochelys coriacea*
Loggerhead turtle	*Caretta caretta*
Fish	
Anchovy	*Engraulis encrasicolus*
Anglerfish	*Lophius budegassa*
Anglerfish	*Lophius piscatorius*
Arctic char	*Salvelinus alpinus*
Atlantic bluefin tuna	*Thunnus thynnus*
Blue whiting	*Micromesistius poutassou*
Capelin	*Mallotus villosus*
Cod	*Gadus morhua*
Dab	*Limanda limanda*
Eel	*Anguilla anguilla*
Flounder	*Platichthys flesus*
Four-spot megrim	*Lepidorhombus boscii*
Haddock	*Melanogrammus aeglefinus*
Hake	*Merluccius merluccius*
Greenland halibut	*Reinhardtius hippoglossoides*
Halibut	*Hippoglossus hippoglossus*
Herring	*Clupea harengus*
Horse mackerel	*Trachurus trachurus*
Long-finned tuna (albacore)	*Thunnus alalunga*
Mackerel	*Scomber scombrus*
Megrim	*Lepidorhombus whiffiagonis*
Norway pout	*Trisopterus esmarki*
Plaice	*Pleuronectes platessa*
Rainbow trout	*Oncorhynchus mykiss*
Saithe	*Pollachius virens*

Common (English) name	Scientific name
Salmon	*Salmo salar*
Sandeel	*Ammodytes tobianus*
Sardine (pilchard)	*Sardina pilchardus*
Sea bass	*Dicentrarchus labrax*
Sea bream	*Diplodus* sp.
Sole	*Solea solea (Solea vulgaris)*
Sprat	*Sprattus sprattus*
Swordfish	*Xiphias gladius*
Turbot	*Psetta maxima*
Whiting	*Merlangius merlangus*
Lower animals	
Augershell	*Turritella communis*
Banded wedge shell	*Donax vittatus*
Basket shell	*Corbula gibba*
Barnacle	*Elminius modestus*
Bay barnacle	*Balanus improvisus*
Bivalve mollusc	*Tellimya ferruginosa*
Blue mussel	*Mytilus edulis*
Bristle worm	*Nephtys hombergii*
Bristle worm	*Spiophanes bombyx*
Brown shrimp	*Crangon crangon*
Clam	*Spisula subtruncata*
Clam	*Spisula* sp.
Cockle	*Cerastoderma edule*
Copepod	*Calamus finmarchicus*
Copepod	*Calamus helgolandicus*
Dead man's fingers	*Alcyonium digitatum*
Northern prawn	*Pandalus borealis*
Deep water coral	*Lophelia* sp.
Dogwhelk	*Nucella lapillus*
Edible crab	*Cancer pagurus*
Great scallop	*Pecten maximus*
Heart urchin	*Echinocardium* sp.
Hermit crab	*Eupagurus* sp.
Iceland scallop	*Chlamys islandica*
Lobster	*Homarus gammarus*
Masked crab	*Corystes* sp.
Native/flat oyster	*Ostrea edulis*
Norway lobster	*Nephrops norvegicus*
Ocean quahog	*Arctica islandica*
Pacific oyster	*Crassostrea gigas*
Polychaete worm	*Lanice conchilega*
Polychaete worm	*Marenzelleria viridis*
Queen scallop	*Chlamys opercularis*
Razor clam	*Ensis directus*
Scallop	*Placopecten* sp.
Sea mouse	*Aphrodite aculeata*
Sea urchin	*Psammechinus miliaris*
Sea potato	*Echinocardium cordatum*
Slipper limpet	*Crepidula fornicata*
Smooth artemis	*Dosinia lupinus*
Soft-shell clam	*Mya arenaria*
Starfish	*Asterias rubens*
Striped venus	*Chamelea gallina*
Tellin	*Abra alba*
Tubeworm	*Pectinaria* sp.
Tunicate	*Mactra corallina*
Whelk	*Buccinum undatum*
Plants	
Common cord grass	*Spartina anglica*
Eelgrass	*Ruppia* sp.
Eelgrass	*Zostera* sp.
Green alga	*Ulva* sp.
Japanese seaweed	*Sargassum muticum*
Kelp (oarweed)	*Laminaria digitata*
Kelp	*Laminaria hyperborea*
Knotted wrack	*Ascophyllum nodosum*
Micro alga	*Alexandrium* sp.
Micro alga	*Alexandrium tamarense*
Micro alga	*Chattonella antiqua*
Micro alga	*Chattonella marina*
Micro alga	*Chattonella verruculosa*
Micro alga	*Coscinodiscus* sp.
Micro alga	*Chrysochromulina* sp.
Micro alga	*Dictyocha speculum*
Micro alga	*Dinophysis* sp.
Micro alga	*Fibrocapsa japonica*
Micro alga	*Gymnodinium catenatum*
Micro alga	*Gyrodinium aureolum*
Micro alga	*Heterosigma akashiwo*
Micro alga	*Noctiluca* sp.
Micro alga	*Phaeocystis* sp.
Micro alga	*Phaeocystis pouchetii*
Micro alga	*Prymnesium parvum*
Micro alga	*Pseudo-nitzschia australis*
Maërl	*Lithothamnion* sp.
Sea lettuce	*Ulva lactuca*
Wrack	*Fucus* sp.
Other organisms	
Bacteria	*Escherichia coli*
Parasitic protozoan	*Bonamia ostrea*

ABBREVIATIONS

µ (prefix)	micro, 10^{-6}
∑PCB	Sum of concentrations for individual chlorinated biphenyl congeners
∑ (prefix)	Sum (of concentrations)
°C	Degrees Celsius
5NSC	Fifth International Conference on the Protection of the North Sea due to be held in 2002
ACG	Assessment Coordination Group (OSPAR)
AHTN	7-acetyl-1,1,3,4,4,6-hexamethyl-1,2,3,4-tetrahydronaphtalene
AMAP	Arctic Monitoring and Assessment Programme
ASCOBANS	Agreement on Small Cetaceans of the Baltic and North Sea
ASMO	Environmental Assessment and Monitoring Committee (OSPAR)
ASP	Amnesic Shellfish Poisoning
atm	1 atmosphere = 1.013 x 10^5 Pascal
AzC	Azores Current
BAT	Best Available Techniques
BC	Before Christ
BEP	Best Environmental Practice
Bq	Becquerel (1 disintegration per second)
BRC	Background / Reference Concentration
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
CB	Chlorinated Biphenyl
CBD	Convention on Biological Diversity
CCMS	Centre for Coastal and Marine Science, Plymouth Marine Laboratory
cm	Centimetre
CPUE	Catch Per Unit Effort
DDD	pp'-dichlorodiphenyldichloroethane
DDE	1,1-dichloro-2-(2-chlorophenyl)-2-(4-chlorophenyl)ethene
DDT	4,4'-dichlorodiphenyl-1,1,1-trichloroethane
DeBDE	Decabromodiphenylether
DSP	Diarrhetic Shellfish Poisoning
dw	Dry weight
EAC	Ecotoxicological Assessment Criteria
EBC	Eastern Boundary Current
EC	European Commission
EEA	European Environment Agency
EEZ	Exclusive Economic Zone
EGC	East Greenland Current
EQS	Environmental Quality Standard
EROD	Ethoxyresorufin-*O*-deethylase
EU	European Union
FAO	UN Food and Agriculture Organization
fw	Fat weight
G (prefix)	Giga, 10^9
GDR	German Democratic Republic
GOOS	Global Ocean Observation System
HAB	Harmful algal bloom
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
HHCB	1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethylcyclopenta-(*g*)-2-benzopyrane
IAEA	International Atomic Energy Agency
ICCAT	International Commission for the Conservation of Atlantic Tuna
ICES	International Council for the Exploration of the Sea
ICN	Instituto da Conservaçao da Natureza (Portugal)
ICRP	International Commission on Radiological Protection
IMM 1997	Intermediate Ministerial Meeting on the Integration of Fisheries and Environmental Issues (5NSC)
IMO	International Maritime Organization
IPCC	UN Intergovernmental Panel on Climate Change
IPCS	International Programme on Chemical Safety
ITQ	Individual Transferable Quota
IWC	International Whaling Commission
JAMP	Joint Assessment and Monitoring Programme (OSPAR)
kg	Kilogramme
km	Kilometre
km^2	Square kilometre
km^3	Cubic kilometre

LC	Labrador Current
lw	Lipid weight
M	Molar mass
M (prefix)	Mega, 10^6
MAGP	Multi-Annual Guidance Programme (For Fisheries)
MARPOL	International Convention for the Prevention of Pollution from Ships (1973/1978)
MEPC	Marine Environmental Protection Committee (IMO)
mm	Millimetre
MPA	Marine Protected Area
n (prefix)	nano, 10^{-9}
NAC	North Atlantic Current
NAMMCO	North Atlantic Marine Mammal Commission
NAO	North Atlantic Oscillation
NEA	Nuclear Energy Agency
NEAFC	Northeast Atlantic Fisheries Commission
nm	Nautical mile
NOx, NO_x	Oxidised Nitrogen
NPE	Nonylphenol ethoxylate
NSTF	North Sea Task Force
OBMs	Oil-based muds
OECD	Organisation for Economic Cooperation and Development
OPE	Octylphenol ethoxylate
OSPAR Commission	The term ‘OSPAR Commission’ is used in this report to refer to both the OSPAR Commission and the former Oslo and Paris Commissions. The 1972 Oslo Convention and the 1974 Paris Convention were replaced by the 1992 OSPAR Convention when it entered into force on 25 March 1998
p (in pCO_2)	Partial pressure
p (prefix)	pico, 10^{-12}
PAHs	Polycylic Aromatic Hydrocarbons
PARCOM	Paris Commission (now part of the OSPAR Commission)
PBDEs	Polybrominated diphenyl ethers
PCBs	Polychlorinated Biphenyls
PCDD	Polychlorodibenzodioxins
PCDF	Polychlorodibenzofurans
PCT	Polychlorinated terphenyls
POP	Persistent organic pollutant
PRAM	Programmes and Measures Committee (OSPAR)
PSP	Paralytic Shellfish Poisoning
PVC	Polyvinyl chloride
QSR	Quality Status Report
QSR 2000	Quality Status Report for the entire OSPAR maritime area published by OSPAR in 2000
RTT	Regional Task Team (OSPAR)
s	Second (time)
SAC	Special Area of Conservation (EU Designation)
SPM	Suspended Particulate Matter
Sv	Sievert (1 J kg^{-1} x (modifying factors))
t	Tonne
T (prefix)	Tera, 10^{12}
TAC	Total Allowable Catch
TBT	Tributyltin
TCDD	Tetrachlorodibenzodioxins
TDI	Tolerable Daily Intake (WHO)
TPT	Triphenyltin
UNCED	UN Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNECE–LRTAP	UN Economic Commission for Europe's Convention on Long Range Transport of Air Pollution
UNESCO	UN Educational Scientific and Cultural Organization
W	Watt
WHO	World Health Organization
ww	Wet weight
yr	Year

GLOSSARY

Abyssal plain	The more or less flat region of the deep ocean floor below 4000 m, excluding ocean trenches, formed by deposition of pelagic sediments and turbidity currents that obscure the pre-existing topography
Advection	The transfer of heat or matter by horizontal movement of water masses
Anoxia	A complete absence of oxygen
Anthropogenic	Caused or produced by human activities
Background concentrations of natural compounds	The concentration of a natural compound that would be found in the environment in the absence of human activity. Natural compounds are those produced by biosynthesis from natural precursors or by geochemical, photochemical or chemical processes
Background/Reference Concentrations (BRCs)	The following operational definitions have been used by OSPAR to determine Background/Reference Concentrations (BRCs): concentrations reflecting geological times (obtained from layers of buried marine sediments) or concentrations reflecting historical times (obtained from measurements carried out prior to significant anthropogenic inputs of the respective substance; relevant for nutrients only) or concentrations from pristine areas (preferably areas far from known sources and normally having very low concentrations)
Benthos	Those organisms attached to, living on, or in the seabed. Benthos is categorised by its diameter into: - nanobenthos: passes through 63 µm mesh - microbenthos: passes through 100 µm mesh - meiobenthos: within the 100 – 500 µm range - macrobenthos: passes through 1 cm mesh but is retained on 1000 – 500 µm mesh - megabenthos: visible, sampled using trawls and sieves
Bioaccumulation	The accumulation of a substance within the tissues of an organism. This includes 'bioconcentration' and uptake via the food chain
Bioassay	The use of an organism for assay purposes. Generally referring to a technique by which the presence of a chemical is quantified using living organisms, rather than chemical analyses
Bioavailability	The extent to which a substance can be absorbed into the tissues of organisms. Possibly the most important factor determining the extent to which a contaminant will enter the food chain and accumulate in biological tissues
Biomagnification	The process whereby concentrations of certain substances increase with each step in the food chain
Biomass	The total mass of organisms in a given place at a given time
Biosynthesis	The production of organic compounds by living organisms
Biota	Living organisms
Bloom	An abundant growth of phytoplankton, typically triggered by sudden favourable environmental conditions (e.g. excess nutrients, light availability, reduced grazing pressure)
By-catch	Non-target organisms caught in fishing gear
Climate	The long-term average conditions of the atmosphere and/or ocean
Contaminant	Any substance detected in a location where it is not normally found
Continental margin	The ocean floor between the shoreline and the abyssal plain, including the continental shelf, the continental slope and the continental rise
Continental rise	The gently sloping seabed from the continental slope to the abyssal plain
Continental shelf	The shallowest part of the continental margin between the shoreline and the continental slope; not usually deeper than 200 m
Continental slope	The steeply sloping seabed from the outer edge of the continental shelf to the continental rise
Crust	Rocks overlying the Earth's mantle; in the oceans, crust is formed along mid-ocean ridges
Discards	Fish and other organisms caught by fishing gear and then thrown back into the sea
Diversity	The genetic, taxonomic and ecosystem variety in organisms in a given marine area
Dumping	The deliberate disposal in the maritime area of wastes or other matter from vessels or aircraft, from offshore installations, and any deliberate disposal in the maritime area of vessels or aircraft, offshore installations and offshore pipelines. The term does not include disposal in accordance with MARPOL 73/78 or other applicable international law of wastes or matter incidental to, or derived from, the normal operations of vessels or aircraft or offshore installations (other than wastes or other matter transported by or to vessels of offshore installations for the purpose of disposal of such wastes or other matter or derived from the treatment of such wastes or other matter on such vessels or aircraft of offshore installations)
Ecotoxicological assessment criteria (EAC)	The concentrations that, according to existing scientific knowledge, approximate to concentrations below which the potential for adverse effects is minimal
Ecosystem	A community of organisms and their physical environment interacting as an ecological unit
Ecosystem approach	The ecosystem approach (to fisheries management) involves a consideration of all the physical, chemical and biological variables within an ecosystem, taking account of their complex interactions. In the management of living resources this means that the decisions are based upon the best available scientific knowledge of the functions of the ecosystem, including the interdependence of species and the interaction between species (food chains) and the abiotic environment of the ecosystem. It could therefore imply a widening of the multi-species approach, currently used in fisheries, to encompass not only fish but also other organisms which directly or indirectly depend on fish or on which fish depend, as well as other significant biotic and abiotic environmental factors
Emission	A release into air
Endemic	Native, and restricted, to a particular locality or specialised habitat
Endocrine disrupter	An exogenous substance that causes adverse health effects in an intact organism, or its progeny, consequent to changes in endocrine function. In applying this definition to the marine environment it will be necessary to consider substances that are likely directly or indirectly to affect the hormonal regulation in whole organisms by the mimicking of hormones or by affecting enzyme systems responsible for hormone equilibria
Epipelagic	The depth zone of the oceanic water column extending from the surface to about 200 m. Also an adjective describing species and organisms that live in the epipelagic zone
Eutrophication	The enrichment of water by nutrients causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned, and therefore refers to the undesirable effects resulting from anthropogenic enrichment by nutrients
Exclusive Economic Zone (EEZ)	An area in which a coastal state has sovereign rights over all the economic resources of the sea, seabed and subsoil (see Articles 56 – 58, Part V, UNCLOS 1982)
Fisheries management	In adopting Annex V to the 1992 OSPAR Convention, on the Protection and Conservation of the Ecosystems and Biological Diversity of the Maritime Area, OSPAR agreed that references to 'questions relating to the management of fisheries' are references to the questions on which action can be taken under such instruments as those constituting: - the Common Fisheries Policy of the European Community; - the corresponding legislation of Contracting Parties which are not Member States of the European Union; - the corresponding legislation in force in the Faroe Islands, Greenland, the Channel Islands and the Isle of Man; or - the North East Atlantic Fisheries Commission and the North Atlantic Salmon Commission; whether or not such action has been taken. For the avoidance of doubt, in the context of the OSPAR Convention, the management of fisheries includes the management of marine mammals
Food web	The network of interconnected food chains along which organic matter flows within an ecosystem or community
Fossil fuel	Mineral fuels (coal and hydrocarbons) rich in fossilised organic materials which are burnt to provide energy
Fronts	The boundary zone between two water masses differing in properties, such as temperature and salinity. Fronts can be either convergent or divergent
Harmful Algal Blooms (HAB)	Blooms of phytoplankton that result in harmful effects such as the production of toxins that can affect human health, oxygen depletion and kills of fish and invertebrates and harm to fish and invertebrates e.g. by damaging or clogging gills
Hazardous substances	Substances which fall into one of the following categories: (i) substances or groups of substances that are toxic, persistent and liable to bioaccumulate; or (ii) other substances or groups of substances which are assessed by OSPAR as requiring a similar approach as substances referred to in (i), even if they do not meet all the criteria for toxicity, persistence and bioaccumulation, but which give rise to an equivalent level of concern
Hydrography	The study of water characteristics and movements
Hydrothermal	Related to the circulation of fluids in the crust driven by pressure and geothermal heat. In the ocean this results in the discharge from underwater vents of chemically modified and often superheated water
Imposex	A condition in which the gender of an organism has become indeterminate as a result of hormonal imbalances or disruption, as in the case of the effect of tributyltin on gastropods
Inshore waters	Shallow waters on the continental shelf, a term usually applied to territorial waters within 6 miles of the coasts

London Convention	The 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter. The Convention is administered by the International Maritime Organization
MARPOL 73/78	The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto
Meteorology	The study of weather and climate
Mid-ocean ridge	A continuous topographical feature of the ocean floor comprising rifts and mountain ridges; it is a broad, fractured swell with a central rift valley and unusually rugged topography; the ridge is the place where new oceanic crust is formed by volcanic activity
Multi-species approach	A form of management that takes into account interaction between the different components in the food webs of the ecosystems
Nordic Seas	Collective term for the Norwegian, Iceland and Greenland Seas
North Atlantic Oscillation (NAO)	The North Atlantic Oscillation index is defined as the difference in atmospheric pressure at sea level between the Azores and Iceland and describes the strength and position of westerly air flows across the North Atlantic
Nutrients	Dissolved phosphorus, nitrogen and silica compounds
Ocean Conveyor	A popular term for the global ocean circulation pattern, which results in the exchange of water between all the major oceans
Organohalogens	Substances in which an organic molecule is combined with one or more of the halogen group of elements (i.e. fluorine, chlorine, bromine, iodine)
Overflow waters	Cold high density waters that spill over the relatively shallow sills that lie between Greenland, Iceland and Scotland, or flow through the deep channels dissecting these sills
Phytoplankton	The collective term for the photosynthetic members of the nano- and microplankton
Plankton	Those organisms that are unable to maintain their position or distribution independent of the movement of the water. Plankton is categorised by its diameter into: - picoplankton: < 2 µm - nanoplankton: 2 – 20 µm - microplankton: 20 – 200 µm - macroplankton: 200 – 2000 µm - megaplankton: > 2000 µm
Pollutant	A substance (or energy) causing pollution
Pollution	The introduction by man, directly or indirectly, of substances or energy into the maritime area which results, or is likely to result, in hazards to human health, harm to living resources and marine ecosystems, damage to amenities or interference with other legitimate uses of the sea
Quaternary Period	A geological period of the Cenozoic Era (1.6 million years ago to the present) that is subdivided into the Pleistocene (the glacial age) and the Holocene (10 000 years ago to the present) epochs
Radionuclide	Atoms that disintegrate by emission of electromagnetic radiation, i.e. emit alpha, beta or gamma radiation
Recruitment (fisheries)	The process by which young fish enter a fishery, either by becoming large enough to be retained by the gear in use or by migrating from protected areas into areas where fishing occurs
Safe biological limits	Limits (reference points) for fishing mortality rates and spawning stock biomass, beyond which the fishery is unsustainable. Other criteria which indicate when a stock is outside safe biological limits include age structure and distribution of the stock and exploitation rates. A fishery which maintains stock size within a precautionary range (a range within which the probability of reaching any limits is very small) would be expected to be sustainable
Salinity	A measure of the total amount of dissolved salts in sea water
Seamount	An elevated area of limited extent rising 1000 m or more from the surrounding ocean floor, usually conical in shape
Seismic activity	Earthquake events that result from sudden releases of energy related to volcanic activity or rock movements caused by crustal movements
Shelf break	The outer margin of the continental shelf marked by a pronounced increase in the slope of the seabed; usually occurring at around 200 m in depth along European margins
Terrigenous	Derived from land
Thermocline	A boundary region in the sea between two layers of water of different temperature, in which temperature changes sharply with depth
Thermohaline circulation	Oceanic circulation caused by differences in density between water masses, which is itself determined primarily by water temperature
Topography	The land forms or surface features of a geographical area
Total allowable catch (TAC)	The maximum tonnage, set each year, that may be taken of a fish species within an area. In the EU, the TAC is a central part of the Common Fisheries Policy. It establishes the total amount of each species that may be caught in EU waters annually. Each year the Council of Ministers establishes TACs for each species, and then each Member State is allocated a quota for each species.
Toxaphene	A chlorinated insecticide with an average chemical composition of $C_{10}H_{10}C_{18}$. Primarily used in cotton farming
Toxin	A biogenic (produced by the action of living organisms) poison, usually proteinaceous
Trophic	Pertaining to nutrition
Upwelling	An upward movement of cold, nutrient-rich water from ocean depths; this occurs near coasts where winds persistently drive water seawards and in the open ocean where surface currents are divergent
Vitellogenin	A protein in blood plasma used as a biomarker for exposure to endocrine disrupters that promote the development of female sex characteristics
Water column	The vertical column of water extending from the sea surface to the seabed
Water mass	A body of water within an ocean characterised by its physicochemical properties of temperature, salinity, depth and movement
Zooplankton	The animal component of the plankton; animals suspended or drifting in the water column including larvae of many fish and benthic invertebrates

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