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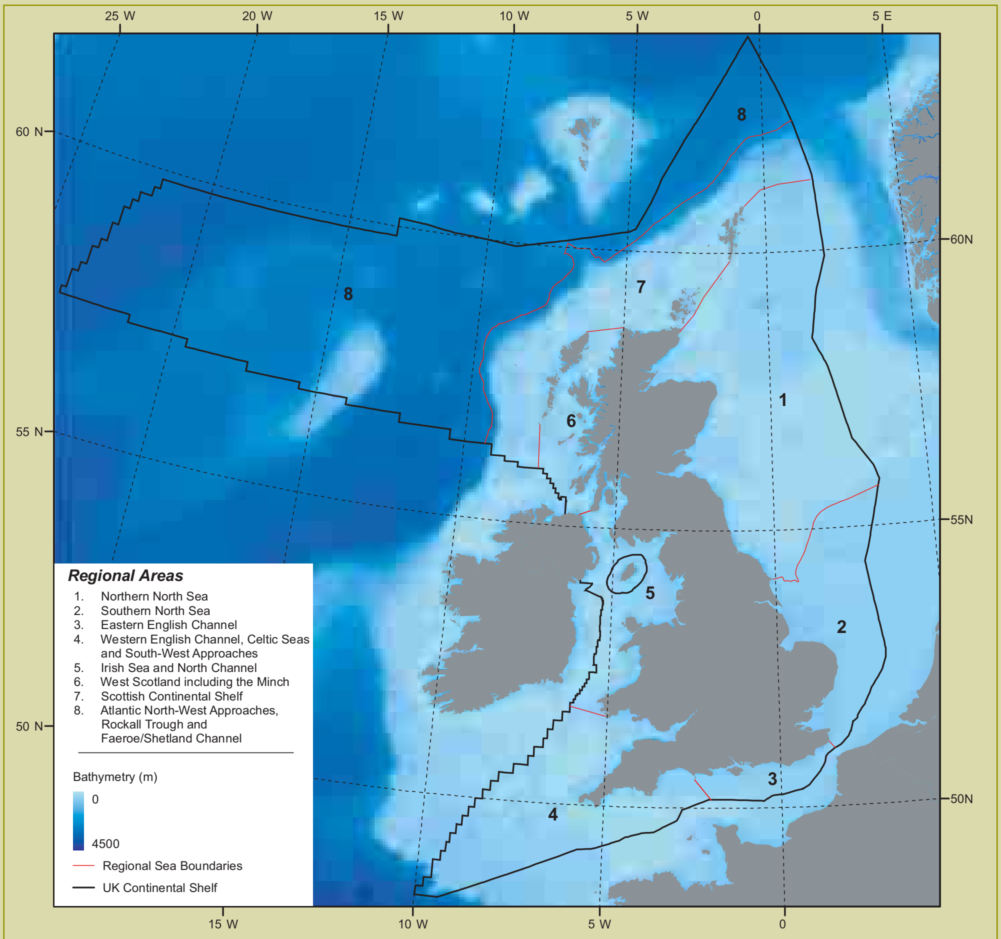
Charting Progress

An Integrated Assessment of the State of UK Seas



Note: The exact limits of the UK Continental Shelf are set out in orders made in Section 1(7) of the Continental Shelf Act 1994.
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SCOTTISH EXECUTIVE

DOE Department of the Environment

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

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Foreword

Charting Progress: An Integrated Assessment of the State of UK Seas

Safeguarding our Seas, published in May 2002, set out our vision for 'clean, healthy, safe, productive and biologically diverse' seas. It described our strategy for the conservation and sustainable development of the marine environment. A key part of that strategy is to develop a robust evidence base to enable an informed and integrated assessment to be made of the state of our seas.

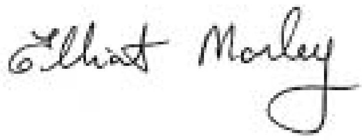
Charting Progress provides the first integrated assessment of the state of the seas across the whole of the UK Continental Shelf. The judgements are based on the evidence of peer-reviewed sector reports which have been agreed by the UK Government and the Devolved Administrations after consultation with representatives of the other contributing organisations. Producing these reports has been a challenging process and I am grateful to those who have contributed both in the provision and interpretation of the information.

The general picture that emerges from the evidence is mixed. The UK seas are productive and support a wide range of fish, mammals, seabirds and other marine life. The open seas are generally not affected by pollution and the levels of monitored contaminants have decreased significantly. The main contamination problems which are identified are in part due to the legacy of the past and are generally observed at higher levels in industrialised estuaries or areas local to the activity.

However, human activity has already resulted in adverse changes to marine life and continues to do so. For example widespread commercial fishing practices threaten many fish stocks by over-exploitation and damage sea floor areas. There is also evidence that the marine ecosystem is being altered by climate change: for example sea temperatures are rising and the distribution of plankton species is changing. These changes pose a real threat to the balance and integrity of the marine ecosystem.

The report highlights a number of gaps both in our knowledge and understanding of the seas and in our arrangements for gathering and co-ordinating information. We have identified a series of steps to address these issues. Cooperation between the many agencies, research institutions and other bodies concerned will be essential for our approach to be effective.

This report will assist with policy development and evaluation. It represents the start of a long process towards the achievement of our vision. In particular it forms a sound basis for taking forward the ecosystem-based approach to management of the seas.



Elliot Morley MP, Minister of State (Environment and Agri-Environment)

On behalf of:
Ross Finnie, MSP, Minister for Environment and Rural Development, Scottish Executive
Carwyn Jones, AM, Minister for Environment Planning and Countryside, Welsh Assembly Government
Angela Smith, MP, Parliamentary Under-Secretary of State, Northern Ireland Office

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Chapter 1:
Overview and Executive Summary

Why this report has been prepared

1.1 The Government's vision of achieving ***clean, safe, healthy, productive and biologically diverse oceans and seas*** was set out in the first Marine Stewardship Report *Safeguarding our Seas*, published in May 2002. This announced the Government's strategy for the conservation and sustainable development of the marine environment and its intention to significantly reduce the threats in one generation. To provide the evidence on which to base and evaluate policies, and to help gauge progress towards achievement of the Government's vision, Safeguarding our Seas promised that the Government would produce this state of the seas report, setting out an integrated assessment of the state of the UK maritime area.

1.2 This report primarily brings together the scientific monitoring data, describing and evaluating what the data says about the current state of UK seas, and some of the trends, which are currently observable, although the report is not a forecast. Nor does it describe or evaluate Government policies. But it provides a firm foundation for future policy-making and for *Charting Progress* towards achieving the vision set out in *Safeguarding our Seas*.

1.3 The integrated assessment in this report is a step towards adopting an ecosystem approach to managing the impact of human activities on the marine environment. Such an approach entails taking into consideration all elements that make up the ecosystem (physical, chemical and biological variables) as well as activities taking place there in order to ensure that the biodiversity, health and integrity of the marine environment is maintained in the longer term.

The Process

1.4 The assessments in this report are based on the detailed work of a range of specialist Government Agencies and Laboratories who undertake the marine monitoring and assessment work. It also draws on other relevant information and research, including that undertaken at universities and by non-governmental bodies (listed in Annex 1). The work has been completed in four stages:

Stage 1: Sector Reports

- Marine Environment Quality (MEQ)
- Marine Processes and Climate (MPC)
- Marine Habitats and Species (MHS)
- Marine Fish and Fisheries (MFF).

Stage 2: Regional Reports

- **Integrated Regional Assessments** (IRA), drawing together the results from the sector reports for each of eight sea areas representing distinct bio-geographical regions. These areas are shown in Figure 1.1; the basis for the division is described in Chapter 5.

Stage 3: Peer Review

- Each of the sector reports and the Integrated Regional Assessments have been peer reviewed by independent experts from outside Government.

Stage 4: Final Report

- This state of the seas report, **Charting Progress**, is a summary, drawing on the comprehensive sectoral and regional reports. It has been prepared jointly by Defra, the Scottish Executive, the Welsh Assembly Government and the devolved administration in Northern Ireland on behalf of the United Kingdom Government. In this report the term "Government" refers to all these bodies.

1.5 All the stage 1 to stage 3 reports can be found on the compact disc enclosed with the printed version of this report, and on the Defra website *(www.defra.gov.uk/environment).* These reports should be referred to for the detailed evidence which underlies the assessments given in this summary report.

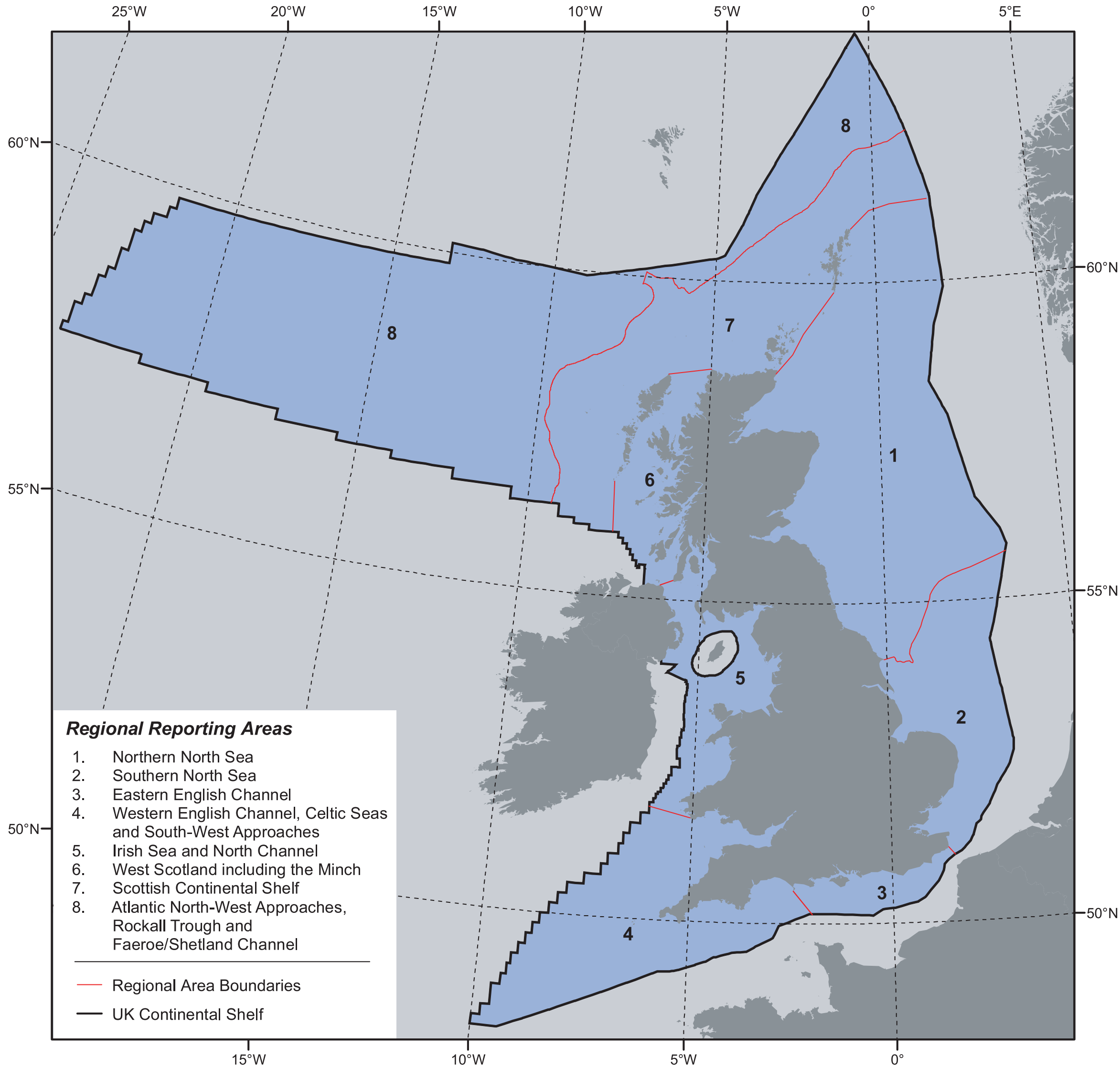
What this report covers

1.6 This report covers the waters, sediment and biota of the UK Continental Shelf – see Figure 1.1. Coastal areas are considered where appropriate but a fuller analysis of the human pressures on the coastal zone is being undertaken in the context of the UK's implementation of the EU Water Framework Directive (WFD). This report does not cover the social and economic issues that need to be taken into account in ensuring that marine resources are managed in a sustainable way.

1.7 An indication of the effects of climate change in the marine environment are given in Box 3A and details are included in the text where known. However, a detailed evaluation of the effects of climate change has not been carried out in this report because there is insufficient information at this stage. However, in the longer term, climate change could pose the greatest impact to marine ecosystems, our coastline and maritime activities and this is recognised in the specific actions (Box 6A).

1.8 Chapter 2 describes the state of progress with the development of ecosystem indicators, which might provide the best means of assessing the state of our seas.

Figure 1.1: Regional Reporting Areas in UK waters*



Note: The exact limits of the UK Continental Shelf are set out in orders made in Section 1(7) of the Continental Shelf Act 1994.

* Based on RMNC. The boundaries between the regional areas are indicative only and not sharp lines.

1.9 Chapters 3 and 4 summarise the evidence collated in the four sector reports and Chapter 5 summarises the main issues identified in each of the eight Regional Areas. Chapter 6 is the first integrated assessment of the state of UK seas as shown by the evidence summarised in the preceding chapters. The key messages are set out in Table 6.1 where we have used a "traffic light" system to indicate whether progress is acceptable, unacceptable or has room for improvement. Finally the lessons learnt from the state of the seas process and the specific actions identified are outlined in Box 6A.

What the evidence tells us

1.10 The general picture that emerges from the evidence (Table 6.1) is that the UK seas are productive and support a wide range of fish, mammals, seabirds and other marine life. The open seas are generally not affected by pollution and the levels of monitored contaminants have decreased significantly. The main contamination problems which are identified are in part due to the legacy of the past and are generally observed at higher levels in industrialised estuaries or areas local to the activity.

1.11 However, human activity has already resulted in adverse changes to marine life and continues to do so. For example widespread commercial fishing practices threaten many fish stocks by over-exploitation and damage sea floor areas. There is also evidence that the marine ecosystem is being altered by climate change: for example sea temperatures are rising and the distribution of plankton species is changing. These changes pose a real threat to the balance and integrity of the marine ecosystem.

1.12 Generally the evidence summarised in this report, which mainly derives from existing monitoring programmes, is insufficient to enable an assessment to be made of the status of many elements of the marine ecosystem. Nevertheless, based on current information, we are confident that the major threats and issues have been identified.

Follow up work

1.13 This is the first time the Government has sought to make an integrated assessment to measure progress towards the vision set out in *Safeguarding our Seas*. This assessment is provisional and represents part of a continuing process of understanding our seas and our impacts on it. Further UK marine science initiatives are set out in Box 6A. These include:

- Developing and regularly publishing indicators of state, as described in Chapter 2 in conjunction with the OSPAR and EU works programmes. (Action 1)
- Ensuring the lessons learnt about making these sorts of holistic assessments are fed directly into the proposed UK Marine Monitoring Strategy. (Action 2)
- Continuing to develop research programmes to address the gaps in knowledge. (Action 3)
- Forming a partnership to provide a national lead in the management and stewardship of marine data and information (MDIP). (Action 5)
- Creating a Marine Climate Change Impact Partnership (MCCIP) in which the Government will work together with research and monitoring organisations to increase understanding of the impacts of climate change in the marine environment. (Action 6)

1.14 Internationally, this report will form the basis of the UK's participation in a wider assessment of the status of the whole North East Atlantic within the framework of the OSPAR Commission and ICES. It will also form the basis of the UK's participation in a Europe-wide assessment; which is likely to be undertaken as part of the developing European Marine Strategy and input to the UN commitment from the World Summit on Sustainable Development held in Johannesburg in September 2002 to launch a Global Marine Assessment.

1.15 *Charting Progress* will help guide the implementation of an ecosystem approach to stewardship of our seas.

Chapter 2:
Measuring State: Indicators of Change

Assessing the state of our seas and measuring progress through the use of Indicators

2.1 This chapter outlines how we are using science to assess the state of the marine environment and to determine whether we are moving towards our vision of clean, healthy, safe productive and biologically diverse oceans and seas. It describes how we are using and developing marine indicators that can be used to measure the extent that particular human activities affect the environmental status and health of our seas.

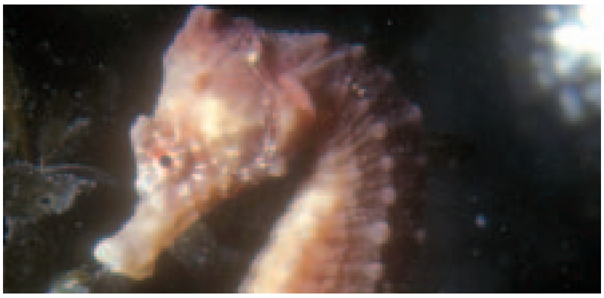
The traditional approach to monitoring the marine environment using performance indicators

2.2 Our attitude to the marine environment began to change in the 1970s with the realisation that human activities in a number of sectors were causing serious harm to marine ecosystems. As a result, various national and international policies, environmental targets and objectives were subsequently agreed to protect the marine environment. In order to demonstrate compliance many regulations now require that particular parameters are measured and compared to values judged to be acceptable.

2.3 These measurements generally fall into the category of performance indicators, because they show, through a direct cause and effect relationship, whether the management actions needed to control the particular activity are achieving the desired performance or protection (Figure 2.1). For example, if coliform bacteria (which originate from sewage) are present in bathing waters above a certain threshold then swimmers could get certain infections. Therefore, regular monitoring is carried out and if the threshold is regularly exceeded, it will be necessary for management actions to be taken to find the cause of the contamination and to take remedial measures, such as improving the sewage treatment in the area.

2.4 A wide range of such performance indicators associated with the protection of the marine environment are commonly measured by various organisations from a number of sectors, for example, hazardous substances in water, sediments and biota, quantity of fish stocks, and quality of dredged material disposed of at sea. Some of these measurements are mandatory and must be reported under national or international frameworks. Many of the monitoring results are published, both in sector-based national reports e.g. the 2nd National Marine Monitoring Programme Report (2004), in international reports such as the OSPAR Quality Status Report (2000) or in national reports required under relevant EC directives (e.g. the EC Bathing Water Directive, Shellfish Directives and more recently the WFD). Other data are collected on a more voluntary or local scale and may or may not be reported regularly. None of these statutory monitoring programmes cover the spatial scales of the entire UK seas and the offshore areas in particular are under sampled.

Figure 2.1: Measuring the marine environment with performance and state indicators: conceptual examples

Performance Indicators	Indicators of State
Example 1a: Concentrations of contaminants in water, sediment or biota  To meet international monitoring requirements and comply with European Directives, levels of contaminants must remain below pre-determined thresholds, e.g. the concentration of mercury in seawater should fall below 0.03ug per litre.	Example 1b: Good ecological status of water  (Image courtesy Sue Daly) Levels of discharges as in 1a do not tell us about the overall water quality. A sea horse will only live in waters which are clean and therefore sea horses are an indicator of good ecological state. An overall indicator for the marine ecosystem has yet to be established.
Example 2a: Fish stock assessments  The population numbers of fish stock species are assessed. The proportion of fish stocks fished within safe biological limits reflects management effectiveness and should be increased for the long term sustainability of fisheries.	Example 2b: Fish diversity  Fish stock assessments do not tell us about the state of the unexploited or non-target fish. Indicators describing the number of fish species and their abundance can be used to describe the health of the entire fish community. Work is underway to develop tools to make these sorts of assessment of state.

A new integrated approach to marine assessment and the need for indicators of state

2.5 The evolving ecosystem approach to management of the marine environment means that it is essential to take account of the cumulative effect of all relevant human activities. Whilst performance indicators play an important and essential role in environmental protection, these indicators are not sufficient to enable us to say with confidence whether our seas are in a healthy state overall. A further category of indicators, known as "indicators of state", are needed which can demonstrate whether the desired state of specified components of the physical and biological ecosystem has been reached. This is a big challenge because it involves being able to assess with some degree of certainly what the state of a particular component of the ecosystem is, in relation to the objectives set for that component. Within the framework of sustainable development we also need to assess how a number of different pressures act together on a specific ecosystem.

2.6 Figure 2.1 illustrates the difference between performance indicators and indicators of state. Indicators of state are currently being developed both nationally and internationally. OSPAR is focused on developing objectives and measures of ecological quality (EcoQO) whilst the WFD requires coastal and transitional waters (e.g. estuaries) to achieve good ecological status, which includes an assessment of the quality of the biological communities, the hydromorphological characteristics and the chemical characteristics of these waters. The England Biodiversity Strategy has selected indicators for the coasts and seas, and a pilot project in the Irish Sea has examined the integration of nature conservation objectives into marine environmental management at a regional sea scale. An overview of these broad scale ecosystem indicators can be found in Rogers and Greenaway (2005).

Indicators in this Report

2.7 The evidence base for this report, as found in the sector reports (See section 1.4) and summarised in Chapters 3 and 4 draws mainly on the marine monitoring results. There are very few ecosystem indicators developed or at a stage that can be reported here and therefore the Tables 3.1, 3.2 and 4.2 rely on expert judgement for a descriptions of state of each biological or physical component.

Lessons learned and next steps on indicator development

2.8 During the preparation of this report it has become clear that whilst the traditional performance indicators provide useful information and offer some degree of protection for the marine environment, they can only ever provide a partial picture of the real state of our marine environment because they were developed for quite specific purposes. We still therefore need more and better indicators of state to be able to say with confidence that our seas are clean, healthy and productive.

2.9 The goal of defining state indicators, which are simple but effective, offers a key challenge to Government and the marine science community. Government have a role to play in ensuring that the development of new indicators is coordinated across sectors and disciplines, and that when established, these can be backed up with practical, robust monitoring programmes and associated analytical quality assurance procedures.

2.10 As we move to a more integrated approach for assessing the overall state of the marine ecosystem we need to develop a framework in which both performance indicators and indicators of state can be combined to best effect. This framework will need to embrace the measurements usefully carried out under existing sector monitoring programmes, develop and incorporate those required under new legislation, and develop new indicators to fill the gaps. Together this integrated set will help us to assess more objectively whether our seas are in an acceptable state.

2.11 The necessary framework for coordinating and taking forward this new work on indicators will be addressed during the development of the UK Monitoring Strategy and through national marine research programmes.

Chapter 3: Physical and Biological Status of the Seas

3.1 This chapter describes both the physical and biological components of the marine ecosystem. These components interact with each other as well as with the effects of human activities as described in Chapter 4. Physical components include: weather and climate, sea temperature, waves, salinity, sea level, circulation, sediment transport and turbidity, and coastal change. Biological characteristics described are: habitats, benthos, plankton, fish, seals, cetaceans, and seabirds.

3.2 The physical and biological effects of climate change, where known, are described in this chapter and not Chapter 4 because even though the evidence is that much of climate change is caused by human activities, these are not necessarily marine activities.

Physical Characteristics of the Seas

3.3 The sea area considered in this report is from the coast of the UK to the edge of the UK Continental Shelf (see Figure 1.1). The sea reaches a maximum depth of only about 50m in the southern North Sea, but is 300m deep to the southwest of England and is more than 1,000m deep to the west and north of Scotland where the continental shelf drops away into the abyssal plain of the North-East Atlantic.

3.4 There have been many changes to the sea floor and water depth over geological timescales and particularly over the last 18,000 years. For instance, sea level has varied by up to 130m in the North Sea and reached present levels in the English Channel and Celtic Seas only 5,000 years ago.

3.5 Normal seawater temperature varies with season, depth and proximity to the land, but is typically in the range 5 to 22°C. Typical salinity away from the influence of freshwater runoff from the land is around 35ppt, but is lower in enclosed estuaries influenced by freshwater inputs.

3.6 Whilst surface water is always on the move due to waves and tidal currents, there are also longer-term ocean currents that influence our seas. For example, the Gulf Stream system brings warm waters from the Gulf of Mexico clockwise around the Atlantic via the North Atlantic Current (Figure 3.3).

General Weather and Climatic Conditions

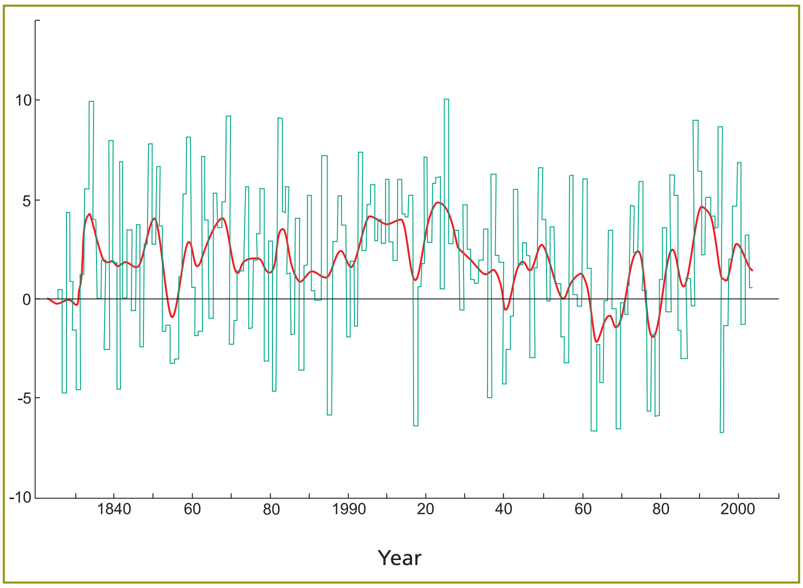
3.7 Three main weather parameters, wind speed and direction, air/sea heat exchange, and evaporation/precipitation alter the distribution of sea surface temperature and salinity on both broad and local scales. The combined influence of these three features is controlled or modified by the North Atlantic Oscillation (NAO). This is a natural weather pattern involving the atmospheric pressure differences between the north and south of Europe. It affects the strength, and direction of wind flows over the North Atlantic and has a major influence on whether winters in northern Europe will be predominantly wet and warm or cold and dry.

Measurement of the NAO

3.8 The NAO intensity is defined using a monthly, seasonal or annual index calculated as the atmospheric sea level pressure difference between the subtropical high pressure (Gibraltar/Lisbon/Azores) and the polar low pressure (Iceland). Further information on the NAO Index compiled by the Climate Research Unit can be found at: ***http://www.cru.uea.ac.uk/cru/data/nao.htm.***

The UK Meteorological Office makes predictions of the NAO Winter Index available at:
http://www.metoffice.com/research/seasonal/regional/nao/index.html.

Figure 3.1: NAO Winter index*



* Figure 3.1 NAO Winter index (Based on the pressure difference between Gibraltar and Reykjavik. (Courtesy of the CRU, UEA.) This shows the strong natural variability in the marine environmental climate).

Trends in the NAO

3.9 The NAO (and hence our weather systems), undergoes considerable variability so any long-term trends are masked by annual or even decadal variations. However, the most extreme and statistically significant change has occurred in the winter index, which rose sharply from about 1960. It is thought that this is due in part to forcing from volcanic aerosols, anthropogenic influences on the atmospheric composition, forcing from variations in sea surface temperature or atmospheric variability.

3.10 The UK Meteorological Office co-ordinates the monitoring networks for physical oceanographic variables such as atmospheric or land temperature, wind speed and precipitation. The data provided are essential for our reporting purposes even though they have not been established directly for marine related studies. The work relies heavily on numerical models to assimilate the data collected in real time and provide simulations. These models also provide a basis to look at future weather and climate patterns.

3.11 The patterns observed in UK weather records are:

- The annual mean Central England Temperature has increased by about 0.5°C during the 20th Century. The 30-year mean of annual mean temperature in Northern Ireland and Scotland increased by about 0.3°C from 1873–1902 to 1961–1990.
- The average number of storms in October to March at UK stations has increased significantly over the past 50 years. However, the magnitude of storminess at the end of the 20th century was similar to that at the start.
- There is a tendency towards wetter winters in north-east England and drier summers in south-east England. There were no statistically significant trends in precipitation in Northern Ireland for the period from 1931–2000.

3.12 The influence of the NAO on the marine area to the east of the UK is less than that seen to the north and west. For example, stronger or more frequent westerly winds over the North Atlantic will drive a greater influx of Atlantic water into UK waters and bring more rainfall and warmer air temperatures. Higher rainfall will result in lower salinities in coastal waters due to increased river runoff. This will enhance density driven coastal flows. Warmer air temperatures will warm the shallower areas of UK waters. These changes in turn have a significant influence on the recruitment and productivity cycles of many species.

3.13 Changes in atmospheric pressure and wind speed and direction, particularly during storms, enhance the generation of surge levels, waves and associated currents; thus enhancing coastal erosion, flooding and mixing processes. Increased rainfall affects the input of inorganic and organic terrestrial material from the land to the sea via rivers.

3.14 Around the UK a strongly positive NAO Index is associated with higher surface water and bottom water temperatures. The reverse is true for a negative NAO Index. Changes in the NAO contribute up to half the variability in sea surface temperature, in winter in the southern North Sea. The NAO also influences the circulation and the type and volume of water masses in the ocean adjacent to the UK. These changes may have impacts on the biology of the UK seas.

The effects of climatic changes on the biological component of the ecosystem are discussed in Box 3A.

Sea Temperature

3.15 The role of the world's oceans is critical in the global climate system because they can store and transport vast amounts of heat energy. The differences in temperature and salinity between water masses sets up density currents which cause ocean circulation. Temperature is one of the major environmental variables defining the type of marine life in our waters and is driven by global weather and climate patterns.

Implications of Change in the Marine Environment

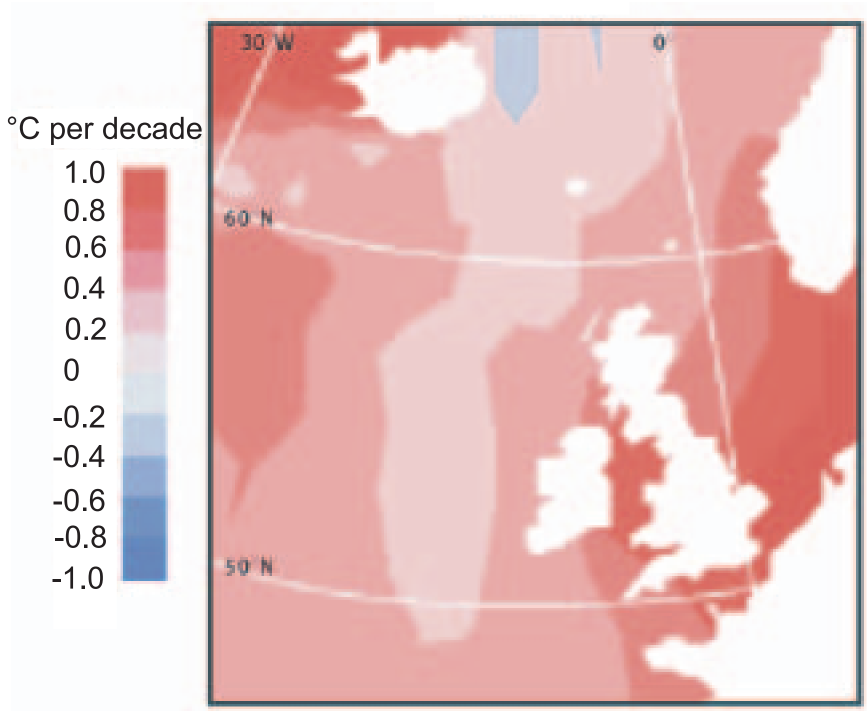
3.16 Changes in sea temperature cause sea level changes, e.g. a warming causes sea level rise through thermal expansion. Changes in sea temperature also induce shifts in the geographic distribution of marine biota and can have direct effects on the species composition, breeding and population dynamics of plankton, benthos, fish and other species.

Evidence and State

3.17 Monitoring programmes indicate that the offshore sea surface temperatures around the UK vary from 6°C (northern North Sea, March) to 17°C (July/August English Channel). More extreme values are found in shallow areas.

- Most of the waters around the UK have been warming since the 1980s, with the trend more pronounced in the southern North Sea and the Irish Sea than elsewhere.
- Global sea surface temperature warmed from c.1910 to c.1940, remained steady and then began warming again during the 1970s. However, for UK waters there is no clear trend in summer SST in the eastern North Atlantic since the 1950s, but a warming in winter SST since the early 1990s is indicated.
- Sea surface temperature at the continental shelf edge warmed by between 0.12°C and 0.29°C over the past century.
- Annual sea surface temperature averaged around the UK coastline has increased by about 0.5°C for the period 1871 to 2000, with most coastal sites showing a warming trend.
- Winter bottom (near bed) temperatures at all North Sea fishing grounds show a long-term warming trend since the 1970s. The winter temperature is now up to 1.5°C warmer.

Figure 3.2: Sea Surface Temperature Trend for 1981–2000*



* Red shading indicates warming (increasing temperature) and blue shading indicates cooling. (Courtesy of FRS.)

Waves

3.18 The height of offshore waves depends on the strength of the wind and the distance and length of time over which the wind has acted on the ocean surface. Waves approaching the UK coastline could have been generated locally or in the north-east or north-west Atlantic Ocean, and even from the south Atlantic. Coastal waves are influenced by local water depth and by the nature of the seabed.

Implications of change in the Marine Environment

3.19 Large offshore waves can cause safety risks to oil and gas platforms and disruption to routine marine operations. Estimates of likely extreme waves are essential for the design of ships and offshore structures such as oil platforms.

3.20 At the coastline, waves can affect coastal development – larger waves can damage seawalls, cause coastal flooding and lead to increased rates of erosion of soft coastlines such as the cliffs in East Anglia and Yorkshire. The most serious coastal flooding events are often caused by a combination of high tides, storm-surges and waves.

Evidence and State

3.21 There are two significant monitoring programmes in UK waters operated by the Met Office for weather forecasting and by WaveNet, to improve the management of flood and coastal erosion risk and offshore operations. The latter provides real time wave data from a network of buoys located in coastal areas in England and Wales.

3.22 We know from the monitoring and research that in UK waters, wave climate is strongly seasonal with mean wave heights peaking around January. The NAO is responsible for most wave height variability year on year particularly in the North Sea and English Channel. There is some evidence that offshore wave height has been increasing over recent years (e.g. 2.4cm/year during the period of 1960 to 1985 measured at the Seven Stone Light Vessel in the English Channel).

Future Research and Monitoring

3.23 There are programmes of work underway to ensure that the statistically based analysis of waves measured by a variety of means all indicate the same (physical) wave height as presently the mean wave height from satellites may be different to that measured by a wave buoy. This correlation is important for continuity of data sets and long time series as well as spatial coverage.

Salinity

3.24 The salinity of water affects its density. This, in turn, drives the circulation. Salinity is typically in the range (33.0–35.5ppt) at the sea surface. In nearshore waters and shallow areas of the North Sea and Irish Sea, the input of fresh water coming from rivers can greatly reduce salinity. The NAO also affects salinity at the sea surface. The NAO is correlated with sea surface salinity in the North Sea: low summer surface salinity is experienced with a low index; high surface summer salinity occurs when the NAO Index is negative.

Implications of Change in the Marine Environment

3.25 Salinity controls many chemical and biological reactions in the sea. One example is the release of nitrogen from sediments in estuaries. The amount of nitrogen controls the amount of primary productivity (new marine life) and therefore, in a highly saline environment, low levels of nitrogen usually lead to low productivity rates. Many species have quite specific salinity tolerances, with significant numbers not able to live in either the low salinity of coastal waters or variable salinity environments of estuaries. Additionally the egg and larval stages of some fish species have specific salinity ranges in which they can survive.

3.26 On a broader scale the variations in temperature and salinity, through their control of density, drive part of the ocean circulation. In particular, the system of currents in the North Atlantic that are a key component in the ocean-atmosphere system and the NAO are driven by cold saline water sinking in the sub-polar North Atlantic.

Evidence and State

3.27 Measurements of salinity are usually taken in combination with other parameters. There are a few long time series that collect measurements though no overall trend can be confirmed, as the results are highly variable.

3.28 Over the past 3 decades the system of deep water overflow and entrainment in the North Atlantic has been seen to become less saline. Studies have shown that previous dramatic climate changes have been associated with ocean circulation changes caused by freshening of the surface of the northern North Atlantic. If there was a large scale freshening of the North Atlantic this would have serious implications. As the global water cycle accelerates, the tropical regions become more saline and the water at the poles become less saline. This will affect the strength and position of the ocean currents. Numerical models have shown that there is a very low risk of this freshening reversing the current Gulf Stream (see 3.29). More monitoring needs to be undertaken to clarify the risks.

Circulation

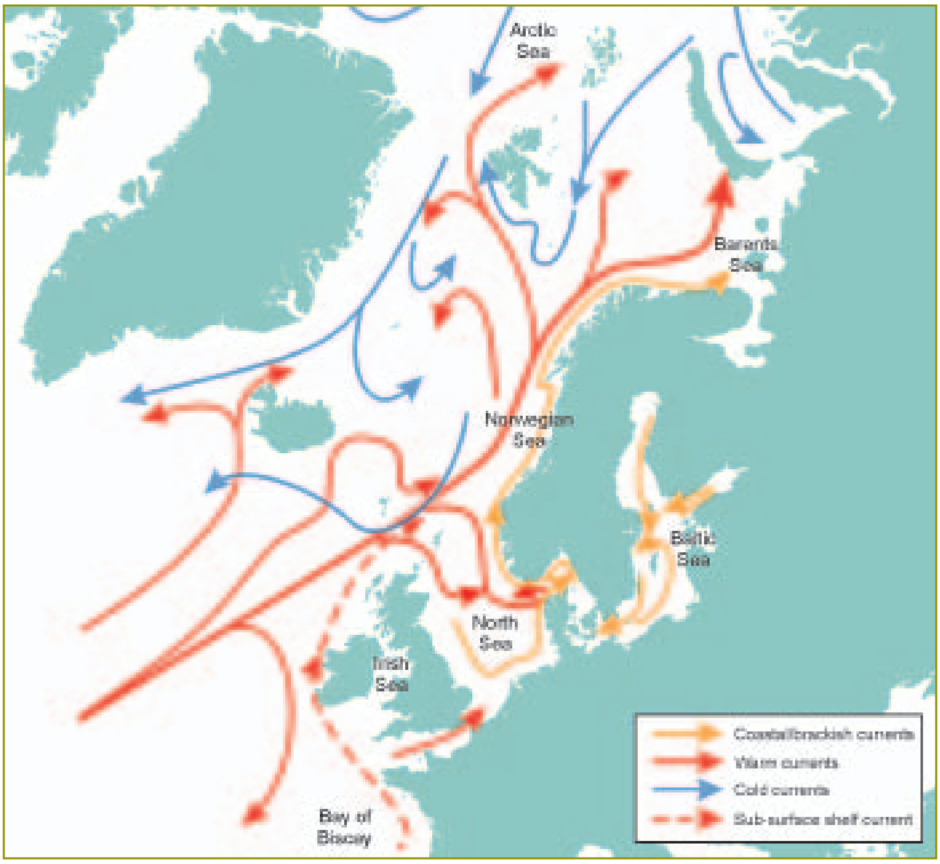
3.29 The net movement of water, (or circulation), is driven by 'residual' currents resulting from a combination of tides, weather and the mean salinity/temperature (density) distribution. Circulation is variable in space and time; especially on short-term (daily and monthly), seasonal and inter-annual timescales but the longer-term ocean currents that influence our seas are shown in Figure 3.3. The Gulf Stream system brings waters from the Gulf of Mexico clockwise around the Atlantic via the North Atlantic Current. As this warm water travels north it cools, becomes denser and sinks. The cooler water then joins the deep currents travelling southbound from the Arctic. This forms part of the ocean conveyor belt, which blends the warm and cold waters, mixes nutrient poor with nutrient rich waters, and generally helps to support the rich marine ecosystem that we have around the UK.

Implications of Change in the Marine Environment

3.30 The high density and specific heat of water means that it can store and transport large amounts of heat, so the world's ocean circulation plays a critical role in the global climate system.

3.31 Circulation also controls the overall movement and distribution of passive objects like eggs, larvae, nutrients, contaminants, flotsam and sediments. For example, the circulation flow off the north east coast of England may provide a pathway for material and fish larvae from coastal regions to the central North Sea. On a smaller scale, the dispersal of herring larvae in the Blackwater estuary is dependent on the circulation in the area. Conversely, where there is slow movement from a region, contaminants and nutrients can become trapped, e.g. Liverpool Bay area and Langstone Harbour, which may increase the risk of eutrophication.

Figure 3.3: Simplified map of the surface currents of the North-east Atlantic*



* (Modified from an original source: Institute of Marine Research, Bergen)

Evidence and State

3.32 Most long-term circulation patterns in UK waters have been estimated from the distribution of tracers like salinity or radionuclides or from numerical hydrodynamic models, validated with any available observations. The general overall circulation is shown in Figure 3.3.

3.33 The models show some consistencies in the pattern of long-term climatological circulation of the North Sea and English Channel, in broad agreement with those inferred from observations, (the north-easterly flow of the North Atlantic to the west of Ireland and Scotland, the north-easterly flow from the Dover Straits into the North Sea and the mean flow northwards through the Irish Sea). However, there is poor agreement among the models in the deeper water regions of the northern North Sea (due to density changes) and the Irish Sea because of model limitations and they show large variability in the day-to-day or month-to-month currents. Further development of 3-Dimensional advection-dispersion models is needed to deliver robust estimates of long-term circulation patterns.

Sea Level

3.34 The height of the water or sea level is a combination of tidal height, surge level, and mean sea level and waves and their interactions.

Implications of Change in the Marine Environment

3.35 Any change in mean sea level can also modify tide, surge and wave propagation and dissipation by changing the water depth. Any overall long-term increases in tidal level, surge or waves will increase the frequency of flooding along a coastline, reduce beach width and increase coastal erosion. A rise in sea level can cause the loss of salt marsh and mudflats, thus having an effect on ecosystems, particularly on intertidal habitats.

Evidence and State

3.36 There are national and international tide gauge networks to measure sea level regularly. These networks and geological indications show that overall:

- Global Mean Sea Level (MSL) has risen by about 120m since the last ice age around 20,000 years ago and by 1.0 to 2.0mm per year during the 20th Century. The main contributions to an increase in the ocean volume, and hence sea level rise, in the 20th Century, have been a reduction in density due to ocean warming (i.e. a thermal expansion) and an increase in the ocean mass due to the melting of glaciers, ice caps and ice sheets. It is considered that these changes in mean sea level are a consequence of increases in global temperature. Human-induced increases in greenhouse gases are increasingly implicated in this.
- The UK is still re-adjusting from the weight of ice on land during the last ice age. The south-east is sinking whilst the north-west of Scotland is rising relative to the sea surface. This means there are regional differences in the impact of global sea level rise and hence a continuing need for monitoring and research on sea level changes and their effects.
- The amplitude and phase of tidal constituents continue to show local short-term variations in but no long-term trends. There is no evidence of a trend in sea level surges.

3.37 Various shortcomings in tide gauge data have meant that there is as yet no consistent estimate of the rate of change of mean sea level for Northern Ireland.

Natural Coastal Changes

3.38 The UK coastline consists of cliffs, sandy or rocky beaches, dunes, saltmarsh, mudflats, sandflats and coastal grassland. The coastal region is generally an extremely dynamic environment, which is reshaped continually due to both natural physical forces (erosion and accretion) and human intervention (building sea walls, ports, harbours etc). The reshaping occurs over periods varying from hours to decades.

3.39 Erosion of the coast is mainly the result of wave attack. As sea levels rise and climate change increases storm frequency, the size and therefore the energy of waves is likely to be augmented. There are also pressures exerted on coastal habitats by man from development, land reclamation, etc. These are described in the habitat section 3.55.

Implications of Change

3.40 Eroded material is transported by tidal and current movement and eventually deposited elsewhere on the coastline or offshore. The changes can impact upon the natural ecosystem by, for example, reducing or removing habitat types, supplying loose material to the sea and increasing sediment transport. Human use of the coast is also affected. The risk of being flooded can either reduce or increase as the shape of the coastline changes. Many coastal habitats have been lost as a result of development and land use, particularly land reclamation, drainage and coastal defence. Rising sea levels are now leading to a further loss as intertidal habitats such as saltmarshes and sand dunes, are squeezed between the encroaching sea and hard defences.

Evidence and State

3.41 At present the main reason for measuring morphological coastal change is to assess flood risk. Further monitoring is conducted at sites of conservation importance.

3.42 The UK coastline is highly variable and managed for coastal erosion on a local and regional basis. The rapidly eroding areas are described in the regional sector reports:

- **Scotland:** Much of the coastline is rocky and eroded only in small beach areas. With the exception of the Tay Estuary, coastal sediment transport is not dependent on the inputs of sediments from rivers.
- **England & Wales:** More than half of the coastline changes by 10cm per year, with 25% of cliffs eroding by between 10cm to 2m per year. In terms of cliffs the north-east England and Yorkshire coasts are the most vulnerable to erosion but the greatest issues occur in the south and east of England where sea level rise is most rapid and where there are larger populations vulnerable to flooding.
- **Northern Ireland:** The coast is principally composed of hard rock, minimising coastal erosion problems.

Sediment Concentration & Transport

3.43 Sedimentary processes affect the coastal and marine environments in a variety of ways. The evolution of the coast foreshore and seabed habitat structure is primarily governed by the sediment type. The transport of sediment depends on the size of the particles and the energy of the currents. Small particles (mud) can move most easily with the water flow whilst larger particles of sand and gravel may just be "pushed" along the seabed when the forces are strong enough. Sometimes this is on every tide or with waves but generally only by large waves such as those generated by storms. Large particles simply roll when all other material is washed away.

3.44 Erosion generates new material, which can be re-suspended from the sea floor or input from rivers. When there is mobile material in the water column, it reduces the clarity (i.e. makes it more turbid). Suspended particulate matter includes inorganic (mineral) as well as organic (from living and dead organisms) particles. High turbidity reduces the amount of light in the water column. This in turn affects the biological processes such as the growth of planktonic algae and the depth to which kelp forests and associated seaweeds can grow.

Evidence and State

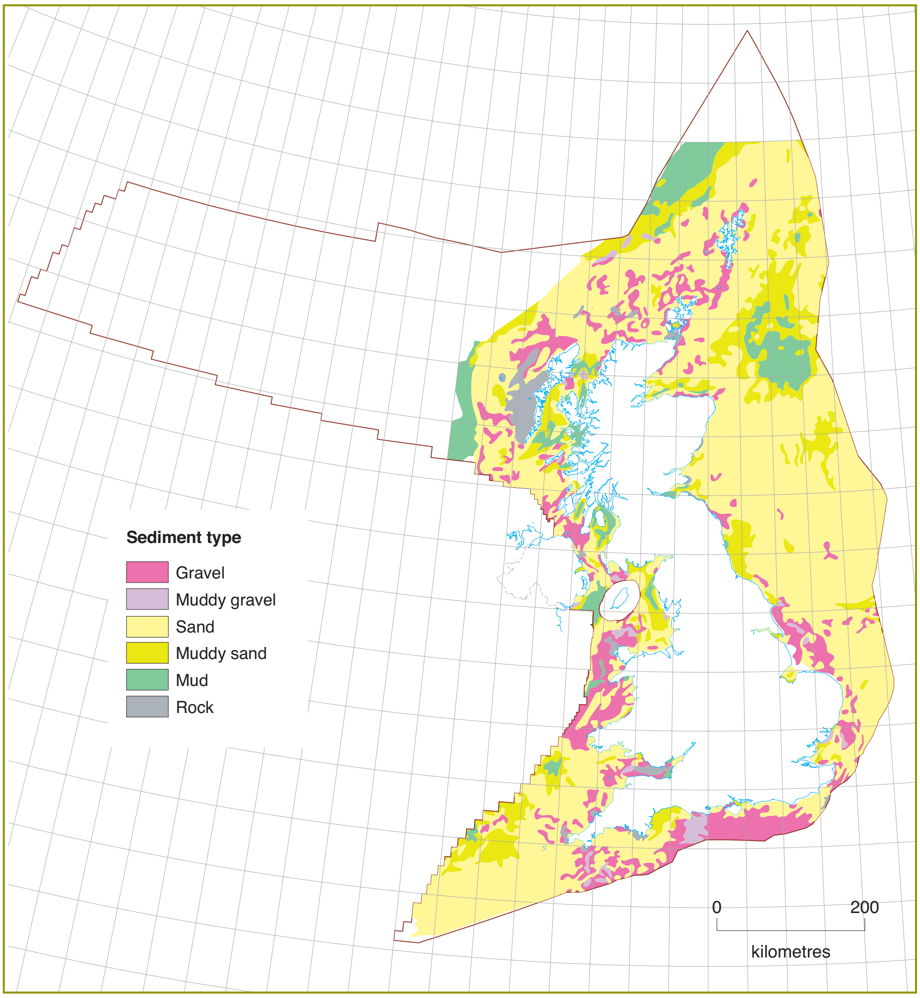
3.45 Sediment in UK waters is distributed by wave and tidal currents. The shelf sea sediments are mainly sands and gravels in water up to 200m deep (Figure 3.4). On the continental margin wedges of sandy and muddy sediments extend down to the deep-sea basin. These sediments can be up to 10m thick but, because they have not been mapped on a national scale, they are not shown in Figure 3.4. Waters close to the shore and in the shallower areas like the southern North Sea often appear very murky due to a high-suspended sediment load.

3.46 Sediment transport pathways are generally investigated by research projects rather than being monitored directly unless they are related to a human activity such as depositing material at sea or beach management. There are many tools available to measure sediment transport but since sediment concentration in the water depends on very local conditions, which vary over very short time scales (minutes/seconds); an overall picture is therefore difficult to produce. Long time series data are essential to provide this. Satellite images are valuable to provide spatial coverage.

Physical Parameters – Summary of Evidence

3.47 Water depth, ocean currents and weather and climate are the dominant controlling influences on the marine environment. Weather and climate are highly variable over both spatial and temporal scales. Many uses of the sea require the measurement and information presented in this section (and more comprehensively in the MPC sector report). Table 3.1 below is a summary of this evidence.

Figure 3.4: National Map of Sea Bed Sediments*



* (from 'Britain beneath our Feet' British Geological Survey 2004)

3.48 These measurements are also useful for managers of the marine ecosystem but as yet we have not set indicators or objectives for the state of these physical conditions or what degree of physical environmental change is acceptable. However, the overall objective that the seas must be healthy, productive and biologically diverse implies that there must be suitable habitats in which marine life can thrive.

3.49 Superimposed on the short-term variability, are clear trends in the longer term datasets, which show that sea temperature and sea levels appear to be rising. The impact of this long-term climate change is an un-quantified pressure on species and ecosystems. Table 6.1 shows that climatic variability change affects coastal habitats, plankton species, marine mammals, seabirds and the presence of non-native species. Hence it is reasonable to conclude that with the natural atmospheric and hydrographical variability of the oceans, climate change is a major contributory factor to ecosystem change in the shelf seas of north-west Europe.

3.50 There is the clear need for the continued collection of long-term datasets, numerical modelling capability and greater coordination and use of the existing datasets in analysis and interpretation of ecosystem change.

Table 3.1: Summary of the physical processes and climate evidence

Categories	Associated measurements	Examples of what the measurements and observations show	Assessment Confidence*	Reference in Sector Report
Weather and Climate	NAO Index	Our weather systems (temperature, winds and rain) are often represented by the pressure difference between the north and south of Europe. The NAO Index has a major influence on ocean temperature, salinity and circulation.	III	MPC Chapter 2
	Air Temperature	The annual mean Central England Temperature has increased by about 0.5°C during the 20th Century. The 30-year mean of annual mean temperature in Northern Ireland and Scotland increased by about 0.3°C from 1873–1902 to 1961–1990.	III	MPC Chapter 2
	Weather Patterns	The average number of winter storms have increased in past 50 years. However, the magnitude of storminess at the end of the 20th century was similar to that at the start. Some trends in precipitation have been recorded on a regional and seasonal basis	II	MPC Chapter 2
Sea Temperature	Ships, buoys and satellites observations of sea temperature	UK Sea Surface Temperature varies between 6°C to 17°C. Annual sea surface temperature averaged around the UK coastline has increased by about 0.5°C for the period 1871 to 2000, with most coastal sites showing a warming trend.	II	MPC Chapter 3
Waves	Ships, buoys and satellites observations of waves	Wave climate is strongly seasonal. The mean winter wave height in the northeast Atlantic increased significantly between the 1960s and 1980s. Satellite data confirm that this increase continued into the early 1990s. In the northern North Sea, there was an upward trend of about (0.2–0.3 m) in mean significant wave height for January–March for the period 1973–1995, but a decrease thereafter. In the central North Sea, the trend for January–March was upwards until 1993/94, with a decrease thereafter. In the southern North Sea, there is no discernible trend from 1973 to date. In the English Channel, an increase of 0.02 m/yr in mean wave height over a period of about 25 years was seen. This trend persisted into the early 1990s, although recent winters have suggested a levelling off.	III	MPC Chapter 6
Salinity	No routine sampling but associated with measurement of other variables	Variation of salinity from fresh water inshore to saline offshore. Salinity and temperature, winds and tides control water circulation patterns. Sea surface salinity (SSS) averaged over the northern North Sea from 1950 to 2002 shows decreasing salinity since the 1970s. There is no discernible trend in the English Channel from 1900 to the early 1980s. Irish Sea SSS shows a decrease in both winter and summer from 1950 to 2002.	II	MPC Chapter 4
Circulation	Measured on all scales from wave induced hourly variations to global ocean decadal patterns	High frequency waves, tides, etc cause the ocean surface to be constantly on the move. Long term patterns of circulation can be described by combining measurements and numerical modelling. Two pulses of inflow into the North Sea in 1988/89 and 1998 coincided with unusually strong northward transport of anomalously warm water through the Rockall Trough. Coastal flow conditions from the Irish Sea to Scottish coastal waters changed considerably after 1977, with a further change in Irish Sea outflow during 1980 to 1981, after which the flow pattern returned to that of 1977–1980.	III	MPC Chapter 7
Sea Level	National Tide Gauge Network	Global absolute sea level has risen by 1 to 2mm per year throughout the 20th Century; due to thermal expansion and melting ice as a result of climate change. The magnitude of sea level rise against our coastline varies around the UK, since the south-east is sinking and the north rising as a result of post-glacial readjustment. There is no evidence for an increase in storm surge height.	III	MPC Chapter 5
Sediment Concentration and Transport	Sediment Transport Pathways and Turbidity	The sea floor is composed predominantly of sands and gravels with some mud patches. The loose material can be transported by waves and currents in all regions. When there are high concentrations of particles in the water, clarity is reduced and these are said to be 'turbid'. Many of the waters close to our shores and in the North Sea often appear murky due to the high suspended load. Turbidity in the Menai Strait (Irish Sea) increased from the mid 1960s to the late 1980s.	III	MPC Chapter 8
Coastal Erosion	Monitoring for flood management and beach protection purposes.	The energy of the sea and the geology of the coastal cliffs and beaches makes much of the coastline vulnerable to erosion. Hard defences exist around much of the coastline. Some areas such as the South-East England are very vulnerable to sea level rise and low lying topography. The northern coastline of Northern Ireland is principally hard rock, so coastal erosion is minor and localised. In Scotland, as elsewhere, some areas erode while others build up over time.	III	MPC Chapter 9

*** Confidence in the statements we are making from the available evidence.**

Confidence assessment   **III** High   **II** Good/Satisfactory   **I** Low   **0** No assessment possible

Box 3A Climate Change and the Marine Environment

In the long-term, the greatest threat to the planet, including the marine environment, could be the impacts of climate change. More generally referred to as global warming, climate change could significantly affect the physical, biological and biogeochemical characteristics of the oceans and coasts, modifying their ecological structure and functions. The study of the possible impacts of climate change in the marine environment is in its infancy and the picture is complicated by natural variations. Bearing this in mind, the following describes some of the possible impacts.

Increases in air and water temperatures are associated with global sea level rise. It is predicted that sea levels could increase by about 0.5m over the next century. The UKCIP scenarios also indicate that severe winter depressions are likely to become more frequent. Since these would increase the height of the storm surge, greater erosion and flooding risk along our coastline can be expected. Locally, this increased water depth would expose our coastal defences to greater impact of wave action, thus compounding the effects of more intense storms. These impacts affect not only human life in the coastal zone but the habitats and species there too. Coastal flooding and loss of salt marsh areas has potential consequences for ground nesting seabirds through loss of nesting sites, and for general loss of habitats and species diversity. Seabirds could also potentially be affected by increased storminess. Severe winter storms are known to cause large scale mortalities known as "wrecks" and a severe summer storm can wash whole breeding colonies from their cliff nesting sites.

On a wider scale, higher temperatures would increase the amount of melt water from the ice caps. As noted in Chapter 3, this could reduce the salinity and thus the density of marine waters in certain areas. There is a small risk that this in turn could adversely affect global oceanic circulation patterns such as the Gulf Stream which regulates the UK climate. If storminess increases and rainfall patterns change, the altered supply of nutrients and sediment from the land may alter marine life.

As the climate alters, causing the physical parameters (temperature and salinity) of the marine environment to change, this will change the habitats available for marine species perhaps causing them to adapt or change distribution.

Changes in sea water temperature is changing the species composition of phytoplankton, the microscopic plants which respond to temperature, light and nutrients and form the lowest level in the food web. Such changes could also affect the life forms higher up the food web. More directly, sea temperature changes could affect the reproductive success of species at a given latitude and, thus, affect the abundance of animals and plants of any size.

The changes in plankton have been considered so large since around 1987 that they have been described as a regime shift. There has been increased primary productivity, merging of the spring and autumn blooms and a switch in the dominant species. This has been accompanied by the northward movement of plankton species by about 10 degrees of latitude.

Most of the observed warming in the world's climate over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations, including carbon dioxide (CO_2). The ocean acts as a sink for the gas by absorbing it at the surface and through a series of natural processes it is stored in the sediments at the bottom of the sea. However, increased levels of CO_2 may not be able to be 'processed' out of the water as quickly as it is being input; this could, over a period of centuries, significantly increase the acidity of marine waters. The surface layers would be the most affected. We have limited understanding of the effect acidification might have on marine biota, but coral reefs, calcareous plankton and other organisms whose skeletons or shells contain calcium carbonate may be particularly affected in the long-term, as could the ability of the sea to absorb further CO_2 and hence regulate climate. Acidity is also a key factor and in influencing chemical processes so the impact of pollutants on biota may change.

What is the government doing about it?

The government is taking action at national and international levels to address the challenges of climate change by reducing CO_2 levels and by understanding the impacts and developing strategies for adaptation. In relation to the marine environment, more specific action is now being taken to investigate the possible impacts of climate change, and new industrial activities harnessing offshore renewable energy are being promoted as opposed to those burning fossil fuel and thus increasing atmospheric CO_2.

- The Government and the UK Climate Impacts Programme (UKCIP) are establishing a Marine Climate Change Impact Partnership in order to develop a long-term, multidisciplinary approach to understanding the implications for the marine ecosystem.
- Within the UK Marine Monitoring Strategy, relevant indicators will be identified to monitor and evaluate the effects of climate change on marine ecosystems. See Action 4 in Box 6A.
- Around the coastline the Government is seeking to take account of climate change by maintaining and working with natural processes and avoiding development in areas at risk of coastal flooding and erosion.
- Renewable energy targets will be met by generating energy offshore using wind, waves or the tides. Several wind farms are now being built just off the UK coast and harnessing wave and tidal energy could follow. The local impacts of the associated structures are important and considered as part of the licensing process.
- Around the UK, depleted oil and gas reservoirs and deep saline aquifers at sea are potential sites under consideration for storage, in liquid form, of substantial amounts of captured CO_2. In considering the feasibility of capture and sub seabed storage of CO_2, the government will consider any associated risks of gradual or catastrophic release into the marine environment.

Biological Indicators of State

3.51 The following information on the status of key habitats and species in our seas is based primarily on the evidence presented in the Marine Habitats and Species sector report (see section 1.4). The species and habitats chosen represent a range of wildlife from different levels of the marine food chain from plankton to mammals. They are impacted by the human activities described in Chapter 4.

Marine Habitats

3.52 Marine habitats are an essential component of our seas because they provide the environmental conditions that the many types of marine life need to survive. Marine habitats can be divided into those of the seabed and those of the water column. Each species needs a particular set of habitat conditions (e.g. seabed sediment or rock type, salinity or temperature regime) to survive, with suites of species frequently occurring together as communities in particular habitat types (e.g. on a rocky shore), Sometimes habitats are formed by the species themselves (e.g. the biogenic reefs formed by mussels or tube worms).

3.53 The flora and fauna living on or in the seabed constitute the benthic communities, as distinct from the pelagic species that swim or drift in the water column (plankton, fish and marine mammals). Benthic marine habitats are complex, dynamic multi-dimensional entities, which can include a wide variety of species. However, in the context of this report it refers mainly to invertebrate species that live in or on the seafloor habitats. Vertebrates that live on the sea floor, such as benthic fish, are discussed in the fish section.

Impacts of Change in the Marine Environment

3.54 Benthic community structure and composition depends very strongly on the nature of habitat conditions at both local and broader scales (e.g. seabed type, salinity, temperature) but can also be affected by human activities which have the effect of modifying the physical, biological or chemical environment (see Chapter 4).

- Impacts on the seabed structure depend on the spatial extent, duration, frequency and type of activity ranging from intense dredging, frequent bottom trawling, permanent construction, removal of the substratum such as gravel and maerl beds or adding material such as that from dredging activities.
- Chemical threats to habitats may originate from water or sediment quality issues and the presence of contaminants, oil and hazardous substances.
- Habitat loss can also be caused by sea level rise.
- Invasion by non-native species can cause displacement of indigenous species.

3.55 A summary of the factors affecting marine priority habitats) are available from *www.ukbap.org.uk/habitats.aspx*

Habitat Protection

3.56 The traditional approach to habitat protection has been on a site-by-site basis where activities can be controlled or prohibited to protect or improve habitat status. UK National legislation provides for the designation of marine protected areas – areas as Sites of Special Scientific Interest (SSSI) and Marine Nature Reserves (MNR), whilst international Directives and agreements lead to the designation of Special Areas of Conservation (SAC) and Special Protection Areas (SPA). OSPAR and the Ramsar Convention also require the designation of protected sites. These Directives and conventions usually provide specific lists of species and habitats to be protected in this way. The SPA areas are designated for the protection of birds, not for their habitats per se, but they are afforded some protection from damaging activities that may directly or indirectly affect the bird populations, which depend upon the habitats for their survival.

3.57 Establishing 'protected areas' has been a very useful approach for conservation management although it is now generally recognised that a site-based approach to conservation will not necessarily deliver internationally agreed targets for stopping the decline in marine biodiversity and whole ecosystem health. This is principally because the protected areas represent a tiny proportion (1.8%) of the UK seas.

3.58 The EC Habitats Directive has required the establishment of a 'coherent European ecological network of protected areas' that incorporates 9 Annex I marine habitats. These protected areas include SACs, along with SPAs, to form what is known as the Natura 2000 network. The OSPAR MPA mechanism has taken a more holistic approach and requires the full range of marine biodiversity to be included in a network of sites (see Box 3B). In addition, it requires the establishment and management of a system of marine protected areas by 2010. It is expected that the Natura 2000 network will make a significant contribution to OSPAR's MPA requirements.

Box 3B National and International Legislation for Habitats: What is protected?

Wildlife and Countryside Act 1981 (as amended, for Sites of Special Scientific Interest (SSSIs) in Britain) and the Environment (Northern Ireland) Order 2002 (for Areas of Special Scientific Interest (ASSIs) in Northern Ireland) allow for the designation of a representative range of intertidal habitats down to low water.

Relevant European Directives are the 1979 EC Birds Directive (for Special Protection Areas, SPAs) and the 1992 EC Habitats Directive (for Special Areas of Conservation, SACs). Legislative texts adopted by the European Community for conserving species and habitats of European community importance are transposed by the UK into national law in order to meet its obligations under these agreements.

The Habitats Directive is applicable over the entire extent of UK waters out to 200 nautical miles or to the limit of the UK Continental Shelf designated area. The listed habitat types and species are those considered to be most in need of conservation at a European level. For our marine waters these include: lagoons; estuaries; large shallow inlets and bays; mudflats and sandflats not covered by sea water at low tide; reefs; sandbanks which are slightly covered by sea water all the time; submerged or partially submerged sea caves; submarine structures made by leaking gases.

The Ramsar Convention promotes the conservation of internationally important wetlands and their flora and fauna. Ramsar sites are, as a matter of policy, subject to the same strict legal protection as European designated nature conservation sites, but without recourse to the EU courts.

The OSPAR Convention has a long-term strategy for protection of ecosystems and biodiversity which includes the establishment and management of a network of marine protected areas (MPA) by 2010. The network may have particular reference to an initial list of species and habitats considered to be under immediate threat or subject to rapid decline was approved in 2004. It includes the following 14 habitat types:

Carbonate mounds; deep-sea sponge aggregations; oceanic ridges with hydrothermal vents/fields; ***Lophelia pertusa reefs; Ostrea edulis beds;*** Seamounts; Seapens & burrowing megafauna communities; Zostera beds; Intertidal mudflats; Littoral chalk communities; Maerl beds, Modiolus modiolus beds, Sabellaria spinulosa reefs, Intertidal Mytilus edulis beds on mixed and sandy sediments.

The Convention on Biological Diversity (CBD) 1992 was the first international treaty to provide a legal framework for biodiversity conservation through the development of national biodiversity action plans (BAP) to halt the worldwide loss of animal and plant species. BAP Marine priority habitats for the UK are: saline lagoons; tidal rapids; littoral and sublittoral chalk; mudflats; mud habitats in deep water; sheltered muddy gravels; sublittoral sands and gravels; biogenic habitats of maerl; ***Sabellaria alveolata reefs; Sabellaria spinulosa reefs; Lophelia pertusa reefs; Serpulid reefs; Modiolus modiolus beds; seagrass beds.***

Evidence and State

3.59 The ecological objectives for marine habitats i.e. the desired 'state' is currently undergoing renewed consideration and is being developed in relation to the objectives set out in the EC Habitats Directive, the WFD and the OSPAR work on ecological quality objectives. At present there are numerous ways to describe the state of habitats, for example:

- From the measurements taken with regard to environmental quality,
- An assessment of how well we are doing against the objectives set by legislation

  or
- The level of adverse anthropogenic activity on a habitat.

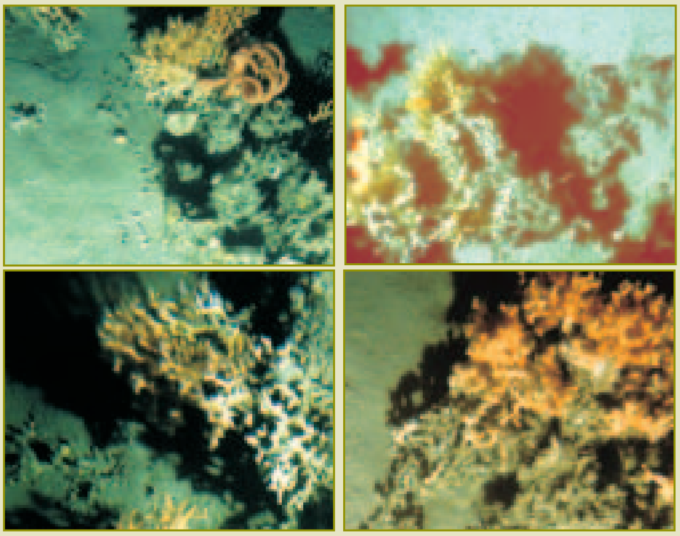
3.60 Monitoring programmes are essential to assess state, evaluate priorities and address emerging issues. There are programmes monitoring the sea floor, compliance monitoring under the Food and Environmental Protection Act (FEPA) licensing scheme (all deposits in the sea) and the data from chemical, biological and biological effects samples taken as part of the National Marine Monitoring Programme (NMMP) (see Box 4B).

3.61 The UK also has a long history of surveying benthic habitats and species in its waters. In the past this has mostly been done from a research science perspective. During the past 30 years, the statutory nature conservation agencies have commissioned many surveys, which increased our knowledge from an environmental management perspective but until recently this was largely confined to inshore waters. This information has also supported the selection and designation of marine protected areas (e.g. SACs).

3.62 In recent years the habitat monitoring undertaken by the conservation agencies has been directed towards the condition of designated sites. The survey effort by government conservation agencies has declined in the past 10 years despite an increase in pressure on the marine environment and since these sites cover only 1.8% of the marine areas, it is very difficult to make an assessment on the state of habitats as a whole in UK marine waters. There remains poor understanding of the distribution of habitat types on the UK sea floor and far less is known about the overall state. Recent initiatives to produce habitat maps are described in Box 3D.

3.63 The spatial distribution of benthic habitats and communities, primarily but not exclusively within SAC boundaries are the focus of current monitoring effort. There are standardised recording methods. All marine sites in the current suite of SACs around the UK have a coastal element but designation of SACs away from the coast are currently being considered as a step towards meeting the full requirements of the Habitats Directive. The total area of SACs so far designated is approximately 13,000km^2 and accounts for about 8% of the seabed within 12 nautical miles or 1.8% of the UK continental shelf designated area. The status of all these habitat features for SACs and SPAs has not yet been assessed but government agencies are actively establishing monitoring programmes, which will establish the baseline and the status of the sites for reporting in 2006.

Box 3C The Darwin Mounds: conservation in the offshore areas



Deep-water corals (*Lophelia pertusa*) and associated fauna from the Darwin Mounds (Photographs courtesy of Dr Brian Bett, Southampton Oceanography Centre (c) 1999, DTI and (c) 2000, SOC)

The Darwin Mounds is the first site to be proposed as a Special Area of Conservation in UK offshore waters. This is an area of sediment mounds which are capped with coral thickets formed primarily by the cold water coral Lophelia pertusa. The entire expanse of mounds covers c.545km^2, in the area to the north-west of Scotland (the boundary of Regions 7 and 8). Bottom trawling has been banned over an area of 1,380km^2 using EU Common Fisheries Policy emergency measures, which came into force on the 20th August 2003 and were extended on the 16th February 2004. On the 22nd March 2004 a permanent ban on bottom trawling was agreed which provides essential protection for the fragile coral communities and their associated fauna. Designation of the site as a Special Area of Conservation will follow as soon as regulations are in place to implement the EC Habitats Directive in UK offshore waters.

3.64 The status of SSSI/ASSIs for the UK as a whole is also currently unknown. The Joint Nature Conservation Committee (JNCC) will compile a report on the status of all UK SSSIs by the end of 2005 based on the information provided from the conservation agencies; it will be summarised by broad habitat SSSI feature types. There are seven reportable condition categories: favourable maintained; favourable recovered; unfavourable-recovering; unfavourable-no change; unfavourable declining; partially destroyed and destroyed.

3.65 English Nature has a target that requires all SSSIs to be in favourable condition by 2010. They reported in 2003 on the current state of England's best wildlife and geology sites and identified action to achieve their recovery. Further reports of this nature will be produced on a regular basis. To date the information collected for England show that 74% of the sandy and muddy shores and 87% of sea cliffs and rocky shores designated as SSSIs are considered to be in a favourable or recovering condition. Wales and Scotland will have completed information gathering for their sites by July 2005 and Northern Ireland by 2007.

3.66 To date only three Marine Nature Reserves (MNRs) have been designated – Lundy Island in the Bristol Channel, Skomer Island off west Wales, both in Region 4, and Strangford Lough in Northern Ireland (Region 5). The current status of Lundy Island MNR and Skomer Island MNR is unknown. An assessment of Lundy Island MNR status will be completed by English Nature in 2005 and reported in 2006; the intertidal areas are covered under the SSSI reporting mechanism (see above). An extensive diving survey (commissioned by EHSNI) demonstrated that the horse mussel biogenic reef feature within Strangford Lough was in unfavourable condition (see Figure 3.5). The damage was thought to be linked to seabed disturbance and a temporary ban on all mobile fishing gear within the confines of Strangford Lough was introduced in December 2003. Efforts now will focus on the options for restoration of the horse mussel beds back to favourable condition.

3.67 In January 2003 a 3.3km^2 area on the eastern side of the Lundy Island MNR and SAC was designated as the first statutory No-Take Zone (NTZ) for marine conservation in the UK. No-take zones are areas where all fishing is prohibited and no living natural resources, including lobsters, crab and fish can be taken from the area. A 3–5 year programme of monitoring will compare the status of the seabed within the NTZ with surrounding areas of the reserve to evaluate its effectiveness in protecting marine habitats and species. The NTZ is already showing promising results after its first year of monitoring (press release, Defra, October 2004).

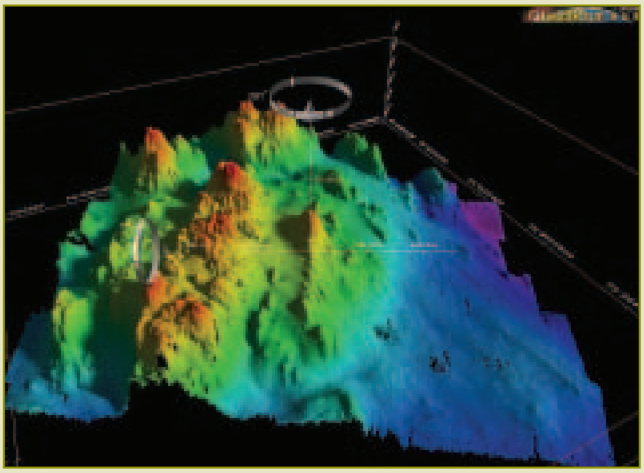
3.68 There are 64 Ramsar sites with a marine/coastal component in the UK (not including those also present in the UK Overseas Territories and Crown Dependencies). This makes up 44% of the overall total number of Ramsar sites designated in the UK; there is no information on the state of these sites. Likewise the implementation of the OSPAR MPAs is at an early stage, and as yet there are no UK sites.

3.69 The UK has identified and drafted Biodiversity Action Plans for 14 priority marine habitats as part of its implementation of the Convention on Biological Diversity. Although information on the full distribution of these habitats is incomplete; the locations of the most important examples of these priority habitats have been identified. The status of the BAP habitats as reported in the 2002 UK Biodiversity Action Plan is based on a change in habitat area but in the absence of systematic survey data the status of these 14 marine habitat types is based on an "informed view". For 9 of these 14 habitats the status is described as unknown, maerl is described as stable, three habitats (tidal rapids, sheltered muddy gravels and ***Lophelia pertusa*** reefs), are declining in status and another (***Sabellaria alveolata*** reefs) is fluctuating with no trend.

3.70 Estuary habitat quality is assessed by the environmental protection agencies namely the Environment Agency (England and Wales); the Scottish Environmental Protection Agency (Scotland); and the Environment and Heritage Service (Northern Ireland) and information is available from the Water Quality Division of Defra ***(www.defra.gov.uk/environment/water/quality)***. Since 1995 some differences in the monitoring and reporting have emerged between the agencies. This report has not specifically looked at the status of estuaries. There is much ongoing work under the WFD that will focus on habitats in coastal and estuarine waters.

Box 3D Habitat Mapping: an update

Advances in remote sensing techniques (e.g. acoustic seabed survey techniques) in recent years have led to a substantial increase in habitat mapping studies to meet the demands from industry, fisheries, coastal developers and conservation managers. However, standards and coordination for this work are not in place, leading to considerable difficulties in compiling integrated habitat maps from the data available and very patchy coverage across UK and adjacent European waters.



Multibeam survey image from rocky pinnacles in the Irish Sea by DARD and JNCC.

MESH, a 3-year EU funded programme (www.searchmesh.net), aims to overcome these shortfalls through the collation and harmonisation of available data to produce the first seabed habitat maps for north-west Europe, together with the development of standards and protocols for future mapping studies and modelling tools to help fill gaps in our knowledge.

The more 'fine-scale' mapping within the MESH project is being integrated with the development of a broadscale marine landscape map for the entire UK shelf in a national project.

The two projects aim to deliver much needed habitat mapping information at a variety of scales to give regional, national and international perspectives on the seabed resource, which will be important for developing monitoring strategies, informing strategic marine resource use and feed into spatial planning needs.

These maps will be the framework to which localised mapping and survey work can be linked.

Habitat mapping

3.71 There is a real need to understand and define the distribution of habitats for many reasons but particularly to provide a baseline for a monitoring programmes and a framework or context within which to understand the results of the monitoring effort and to assess the status of habitats generally.

3.72 A classification system for marine habitats to support mapping and environmental management is in place and an EU funded project which aims to produce standards for seabed mapping and seabed habitat maps for north-west Europe is underway. This is known as Mapping European Seabed Habitats or MESH (see Box 3D).

Benthos

3.73 The diversity of the animals and plants which live within or on our sea floor are ranked amongst the highest in Europe due to the very wide range of habitat types found in the UK. Benthos is important in its own right to provide food for humans but it is also a vital component of the marine food web providing habitat and food for other marine species, recycling nutrients and degrading our wastes.

Evidence and State

3.74 A description of benthos state is extremely difficult particularly over large areas, principally due to limited historical data with sufficient geographical or temporal coverage. Survey effort which helps to provide a baseline has declined in the past 10 years, particularly in offshore areas to the west of the UK. Only about 40% of groups have been recorded. The first quantitative survey of the macrobenthos of the North Sea was conducted as recently as 1986. Since then, monitoring effort in the UK has been undertaken largely within the NMMP, which has an estuarine and inshore coastal focus.

3.75 Combined with the lack of data there are no agreed tools (indices) to assess the state of benthic communities at a UK level. However, the WFD programme is developing a benthic invertebrate classification scheme to assess benthic quality in estuaries and coastal waters.

3.76 Benthic communities are generally naturally dynamic with community structures, which change as a result of many natural and anthropogenic influences. The health of benthic communities as assessed by the NMMP and various research projects show that they are impacted by a number of different activities and their response can be used as an indicator of change. Around the coasts there is good evidence of impacts at a local level according to activity and pressure, and some evidence of broad-scale impacts.

Hazardous Substances and nutrients

3.77 Most sources of hazardous substances are land-based and are substantially diluted in the offshore environment. Overall there is no evidence of broad-scale impacts of nutrients or hazardous substances on benthic communities but they do show signs of stress in local areas often close to the source of the contamination such as oil platforms where there are significant cutting piles, aggregate extraction areas and dredge disposal sites. For many transitional and coastal waters, benthic communities are likely to be at risk of failing to meet the good ecological status standard required under the WFD due to the historical legacy of contamination from industrialised estuaries. However, the NMMP data suggest that physical factors rather than contaminants exert the greatest influence on the macrofaunal communities present at the stations around the UK.

Fishing and other physical disturbances

3.78 Evidence shows that commercial fishing has affected benthic communities at the regional sea scale in three ways:

- firstly through physical damage to seafloor animals as a consequence of trawling and discarding of dead and dying animals caught in the trawl.
- secondly, through alteration of the marine food web by reducing the abundance of large predatory species enabling the smaller prey species to become abundant and feed intensively on the benthos.
- thirdly, by killing slow growing, larger and comparatively long-lived species that burrow into the sediment and recycle nutrients back into the food chain.

The impacts of fishing activity on the habitats and other components of the marine environment are described in Chapter 4.

3.79 Other physical disturbances arising from human activities in offshore areas, such as aggregate extraction, have only had an impact at a local scale; the comparative distribution, composition and abundance of species has been affected. This has become less of a problem in recent years, as better environmental practice has been developed by industry.

3.80 Shoreline modification and historical land claim have had the most significant impact on the coastal habitat distribution and abundance of benthos. The significance of some pressures and their effects and recovery time is dependent on the species present, type of seafloor geology and the nature of the activity such as dredging and dredged material placement.

Water Abstraction

3.81 There is no evidence of broad-scale impacts on benthic communities from water abstraction but there may be some impacts in estuaries such as broad-scale distributional changes of fauna.

Climate Change

3.82 Planktonic and rocky shore marine communities respond to climate change for example by changing where they live and their normal behaviour patterns. It is expected that subtidal benthos will respond to variations in climatic conditions (as it is known to fluctuate according to the NAO cycle) but little direct evidence of changes driven by anthropogenic climate change is available.

Non-Native Species

3.83 Non-native species have been found in UK waters both at regional and local scales. Under the WFD a presence of any non native species is classified as a change from the natural state. A nationally focused drive to improve bio-security (principally involving ballast water and aquaculture) is necessary to prevent further introductions of foreign species. However, it will be difficult to prevent the introduction of species not normally found around UK shores as a result of changes in water temperatures.

Figure 3.5: An example of impacts on benthic habitat*

* A: undisturbed *Modiolus* clump in an undisturbed *Modiolus/Chlamys* biogenic reef, Strangford Lough. B: heavily silted Modiolus shells in an area subject to trawling, Strangford Lough. (Source: EHS)

General status of benthos

3.84 In general terms the impacts on marine habitats and benthos depend on the type of anthropogenic activity, its frequency, duration and the spatial extent. On available evidence, there is no indication that significant structural or distributional changes to benthic communities have arisen from recent human activities on a regional or UK-wide sea scale. However, there is local evidence that benthic communities are heavily impacted by certain fishing activities, particularly those in more stable environments and many stretches of coastal waters and estuaries are significantly altered as a result of coastal developments and hydromorphological changes. On the basis of the widespread but patchy distribution of fishing in our seas it is likely that the benthos remains modified in areas where fishing intensity prevents recovery.

Future planned work

3.85 Studies at local scales highlight the benefits of using benthos as indicators of activity specific impacts since adult benthic species are relatively immobile and live longer than a year. Significant effort is presently underway by government agencies to meet the requirements of new environmental management systems of OSPAR, the EU and the WFD. However, there is an urgent need to establish a process to gather data together for the wider marine environment, both existing data and new data, to properly assess the status of benthic communities at a UK level. This requires the establishment of agreed quality assessment techniques and objectives or targets for benthic community quality for the area as a whole.

Plankton

3.86 The free-floating plant life of the sea (phytoplankton) at the base of the food web provides food for the animal plankton (zooplankton) which in turn is food for fish and their predators e.g. birds and marine mammals and the benthos. The carrying capacity of ecosystems in terms of the size of fish resources and recruitment to individual stocks is therefore highly dependent on variations in the abundance, timing, and composition of the plankton. Plankton can indicate both environmentally driven changes and man-made undesirable disturbances.

Implications of Change in the Marine Environment

3.87 Plankton types and populations are extremely sensitive to environmental conditions and play a crucial role in climate change in two ways. They export CO_2 to the deep ocean in what is known as the 'biological pump'. Without this process concentrations of CO_2 would be much higher in the atmosphere and the climate of the world would be much warmer. Plankton themselves also respond to climate changes such as increases in sea surface temperature. These changes in temperature may be more favourable to some species than others and the community composition may alter.

3.88 Both anthropogenic and natural nutrient inputs can lead to excessive growths, or planktonic 'blooms.' Temperature changes can also cause plankton to bloom earlier in the season. These blooms can negatively affect the balance of the ecosystem. Plankton levels do fluctuate naturally, but step changes in populations could result in permanent change of state of the marine environment.

3.89 Changes in plankton offshore may affect coastal areas. For instance, the changes in chlorophyll observed in regional areas of the northeast Atlantic may also have some impact in coastal areas around the British Isles and in the North Sea. However, offshore waters are not strongly influenced by land nutrients, therefore plankton in deeper seas are more likely to be affected by changes such as sea surface temperature.

Evidence and State

3.90 Studies of the variability of plankton began in Britain in the 1890s. ICES undertook studies of spatial seasonal and annual variability in 1902 and 1908. However, since then, with the exception of the CPR described below, studies have been in the form of time series at a single location (e.g. MBA station E1 and L4 in the English Channel and the Dove Laboratory time series off Northumberland in the North Sea) or covering local areas (e.g. Flamborough Line). Routine samples are also taken by government agencies for the purpose of assessing toxic algal blooms as and when these occur.

3.91 Supported by Government, the Continuous Plankton Recorder (CPR) survey has provided coverage of plankton variability in the offshore waters around the British Isles since 1931. This survey is one of the longest running marine biological monitoring programmes in the world and the only one that operates on an ocean basin scale. The long time series of data and wide coverage of the CPR survey makes it possible to determine baseline conditions for a range of planktonic species and indices in terms of abundance, biomass and biodiversity. There were also baseline surveys by ICES from 1902 to 1908.

3.92 The CPR survey indicates that major biological changes have taken place in the plankton in the seas around the British Isles over the last few decades, and these were greater than at any time over the last 100 years. Results show that there has been a northerly movement of warm water plankton and a parallel retreat of cold water plankton to the north and some plankton species are observed earlier in the season. There is clear evidence that these changes have been forced by global warming. The observed changes are likely to have a major impact on biogeochemical cycles and living marine resources.

3.93 There has been an increase in chlorophyll concentrations in the North Sea, which could be in part due to nutrient enrichment. Such changes in nutrient concentrations are important to the understanding and development of policy on eutrophication. However, the exact same pattern and increase was also seen in oceanic waters to the west of the British Isles. Therefore, it appears that a strong overriding climatic signal is apparent in the phytoplankton data. Whilst the evidence base is strongly based towards the CPR records offshore, the patterns of change are widespread and occur across the UK. It is likely therefore that the near shore areas will have been affected by the hydo-climatic signals detected by the survey.

3.94 Against the background of 'natural' variability, the plankton of the seas around the British Isles that are sampled by the CPR appear relatively pristine and apparently unaffected by anthropogenic inputs of contaminants or nutrient enrichment. However, the CPR survey monitors only in deeper water offshore. It is near shore regions that are more likely to be affected by pollution and where there is a priority to distinguish between natural forcing and human impacts.

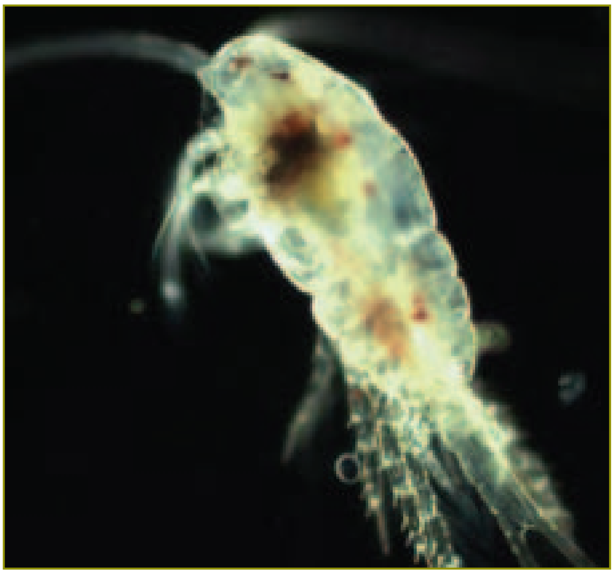
3.95 At present there is in general no systematic sampling of plankton in near shore waters although this will be required in the future to comply with the WFD and other international agreements. Defra are currently funding the development of a Phytoplankton Trophic Index (PTI) to be used for the WFD and in relation to other marine eutrophication objectives. This will draw on the more localised nutrient monitoring programmes in coastal and estuarine waters.

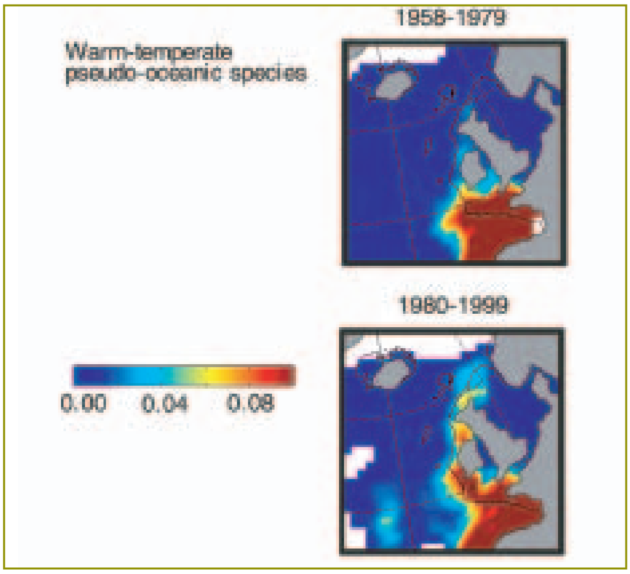
Indicators of State

3.96 Plankton could be used to indicate a number of changes in the marine environment. However, the only marine plankton indicators that have been developed so far relate to the total abundance of species. An index to describe long-term variability in phytoplankton biomass around the UK could be provided by the Phytoplankton Colour Index.

3.97 Assessing regional differences of species assemblage structure has also been recommended to monitor changes in the structure of the ecosystem in relation to climate change.

Figure 3.6: The dominant plankton species in the North-east Atlantic*





* Copepod are the dominant zooplankton in the North Atlantic (normal size 1–1.5mm). Change in distribution of one copepod species assemblage from 1958–1999. Measured by the Continuous Plankton Recorder (Source: SAHFOS).

Fish

3.98 This section describes the diversity and health of fish populations around the UK. The impacts of fishing on other aspects of the marine environment are dealt with in Chapter 4.

3.99 The North-east Atlantic and seas around the UK include some of the most productive fisheries in the world. More than 330 species of fish have been recorded from the continental shelf surrounding the British Isles, with many more species inhabiting the deep water habitats off the northern and western coasts of the Scotland and Ireland. Most species of fish occurring in UK waters are not targeted in commercial fisheries, although some are important in recreational angling (e.g. tope and smooth hound shark). Many species are important prey of other marine organisms and are therefore an integral part of the marine ecosystem.

3.100 Natural environmental factors such as temperature and depth influence fish distribution but human activities such as fishing can also influence fish populations and their health. Disentangling the effects of these human activities from the influence of habitat and broad scale climate variability is complex and requires further knowledge of fish ecology. Non-native fish species can be introduced from shipping or aquaculture and disperse in waters through migration.

Evidence and State

3.101 The fish fauna of our seas has been studied since at least the early 1900s. However, apart from commercially exploited fish stocks this has not been conducted in a systematic way. The results readily available are from the routine trawl surveys of the UK shelf seas, which generally do not sample fish communities on reefs, estuaries and in deep water beyond the shelf edge.

Offshore Distribution

3.102 The overall distribution of British fish is well documented and much summary information is also available on FishBase ***(http://www.fishbase.org/)***. The distribution and relative abundance of fish is affected by many factors, but the physical conditions (temperature and depth) and habitat type has the greatest influence on where fish species live during different life-cycle stages. The British Isles lie at a biogeographical boundary between colder, northern waters and more southerly warmer waters. Some species are restricted to either the more southerly or northerly latitudes of the British Isles. Natural changes in climatic conditions have led to fluctuations in the distribution and abundance of fish over recent decades, particularly of pelagic species.

Coastal and Estuarine Fish

3.103 Fish diversity is greatest in the south-west and along the western seaboard of the UK, with the central and southern North Seas the least diverse. There are distinct fish assemblages in coastal and estuarine waters but several offshore species use coastal habitats at various life history stages. Some migrate from the sea to rivers to spawn, for example salmon, sea trout, shad, sea lamprey, conversely, the European eel spawns at sea.

3.104 The species of fish that migrate between fresh water and the sea are exposed to a variety of human activities. Many have seen significant declines in distribution and/or abundance, often as a result of human impacts in estuaries and rivers such as water pollution, physical obstructions, and habitat modification.

Deep Water Fish

3.105 There are no systematic surveys of deep-sea fish, but there have been occasional studies particularly of the deep-sea fish communities in the Porcupine Seabight and Rockall Trough. The dominant fish species at 250m depth were silvery pout, blue-mouth redfish and blue whiting whereas in deeper waters, various species of morid cod, grenadier (rat-tails) and arrowtooth eels dominate.

3.106 Deep water environments beyond the shelf edge are increasingly important areas where, for example, the DTI have recently undertaken Strategic Environmental Assessments for the oil and gas industry. The SEA process has provided good data but there is little expertise in this area in government agencies. We must rely on the SEAs and NERC funded science to provide evidence to underpin policy development.

3.107 The life-history characteristics of deep-water fish make them susceptible to over exploitation and other impacts. In the colder waters, where food availability is variable, fish tend to grow and mature more slowly but can live for a long time. The geographical area over which the larvae are dispersed is relatively low for some deep-water species and adult fish may aggregate at certain sites, such as around sea-mounts. One deep-water fish, the orange roughy, is included in the OSPAR list of threatened and/or declining species and concern has been raised for other deep-water species, including deep-water sharks.

Figure 3.7: Orange Roughy and Cod *


* Orange Roughy (Source: FRS) and Cod (Source: National Marine Aquarium) – examples of stocks under threat in our seas.

3.108 Reefs also provide important habitats for many species of fish that prefer rough grounds, whether they are natural rocky or biogenic reefs, or artificial structures such as oil platforms and wrecks. Such environments are not included in the routine fisheries surveys of the UK shelf but research data suggests that they support a diverse fish community, including wrasse, clingfish, conger eel, topknots, and various species of goby and gadoid. Such communities tend to be most common along the western coast of the UK (Regions 4,6,7,8) where rocky coastlines predominate.

Fish Health

3.109 The disease status of fish has been used as a general indicator of environmental stress affecting fish populations since the mid-1980s. Measurement of visible internal and external disease conditions in individual fish provides an important tool when monitoring the overall health of fish populations (see 4.39). Target species (dab and flounder) have been selected mainly for their availability and their susceptibility to external and internal disease conditions. The health status of commercial species such as cod and plaice is also monitored but data on these species is less comprehensive. Offshore areas in the North Sea and Irish Sea have been monitored most consistently, with information also available on the health of fish in the English Channel and western approaches. The health status of flounder from estuarine locations has also been monitored since 2001.

3.110 Dab and flounder samples at some locations both exhibit health changes (as shown by patterns of liver pathology and DNA adducts) which indicate exposure to complex mixtures of organic compounds. For dab, however, migration patterns within and between regions make it possible that fish health at a particular location will be a consequence of previous exposure to contaminants elsewhere.

- Around the UK, some dab and flounder populations are being exposed to carcinogenic contaminants that are partly responsible for their observed pre-cancerous and cancerous lesions. Diseases in dab remain at generally low levels, and fish from Scottish waters have lower levels of disease than fish in the southern North Sea and Irish Sea. Overall, prevalence levels remain consistent in several areas. However, dab captured off Flamborough, on the Dogger Bank (Region 2) and in some areas of the Irish Sea (Region 5) continue to exhibit higher levels of disease than fish from a reference site in the eastern English Channel (Region 3).

3.111 External diseases in flounder from estuarine locations are present at low levels. Pathology of the liver and gonad associated with the presence of organic compounds and endocrine disrupting chemicals is present at several sites.

By-catch

3.112 Commercial fisheries catch non-target fish species as an incidental part of their catch, and although some fish by-catches are sold, much is discarded at sea. The UK is aiming to reduce the rates of fish by-catch and discarding to reduce undesirable impacts on the ecosystem, (see 3.131) although some seabird populations are increasingly reliant on such discards for food. Small and short-lived fish species such as dab and gurnard are generally unaffected by by-catch mortality, while long lived and slow-growing species such as spurdog and common skate are much reduced in abundance.

Genetics

3.113 Commercial fisheries target the larger and more valuable species. Many larger fish in the North and Irish Seas are now reduced to less than 10% of their expected abundance without fishing. This selective fishing on large individual or sub populations (see table 4.1) of a species can lead to reductions in the genetic variability. In extreme cases the populations may become locally extinct or are less able to adapt or show resistance to other pressures. Both plaice and cod have already shown these selective effects. In light of our concern and international commitments we are working through ICES to develop ways of managing fishing impacts on the genetic diversity of fish stocks.

Indicators of State

3.114 There is currently much international activity to develop indicators of change for fish communities including the OSPAR Ecological Quality Objectives (EcoQOs process). The existing monitoring data could be used to describe trends in fish community composition and indicators of ecosystem health.

3.115 Under the revised CFP there are plans to develop a series of indicators to monitor and evaluate the wider environmental performance of fisheries. A comprehensive assessment should include a) indicators which relate to fish stock status;

b) indicators which relate to non-target species; and c) indicators which measure broader impacts on the ecosystem but which may be difficult to separate from impacts caused by other activities. OSPAR is currently piloting examples of those that measure the direct impact of fishing on non-target species (e.g. by-catch of harbour porpoises), and those that measure the impact of fishing on the broader marine environment (e.g. density of sensitive and opportunistic species).

3.116 The only indicator currently in use relates to the percentage of fish stocks around the UK fished within safe biological limits. Progress has been made with developing a new indicator, EcoQO, which ensures that estimates of spawning stock biomass and fishing mortality comply with their respective reference points.

3.117 The development of indicators for fish communities has highlighted several difficulties including the fact that reference levels can only be identified when the relationship between fishing disturbance and the size composition of the fish community is fully understood. The use of a reference direction, for example to show an improvement in status without specifying a precise target, is a useful first step.

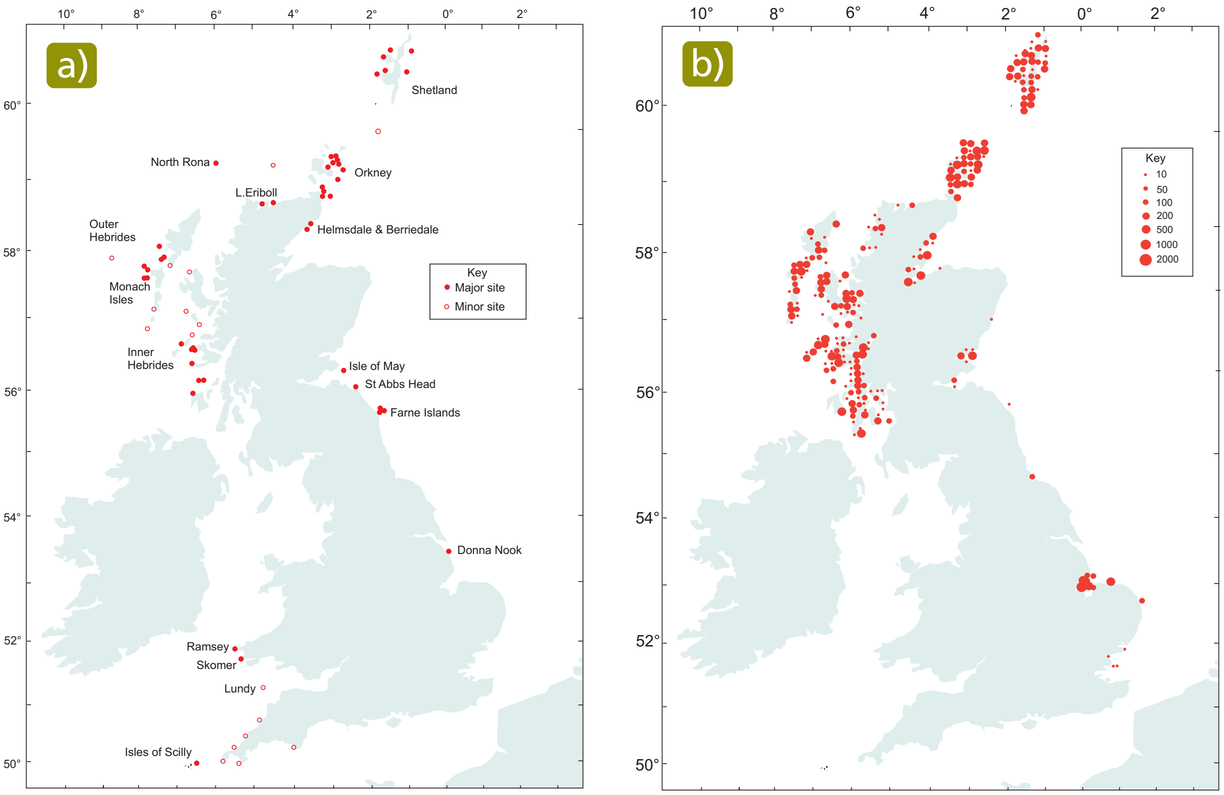
3.118 Measures of the ecological status of fish populations in estuaries are also being developed under the WFD. Fish populations, one of the five biological quality elements, are to be assessed by taking account of the species composition and abundance of the fish fauna. This will be monitored within an estuary using a number of different tools. It is expected that each measure would respond in a predictable way to environmental stress. Several approaches to establishing reference conditions for these measures are being considered, including the use of historical records, predictive models, expert opinion, or the selection of sites that are least impacted.

Seals

3.119 The two resident species of seals in the UK are the grey seal and harbour seal. The harbour seal is sometimes also known as the common seal. The UK holds in the order of 123,000 grey seals which is 39% of the world population and 90% of of these breed in Scotland. Approximately 50–60,000 harbour seals are found in the UK and this represents 40% of the world's population of the European subspecies and about 5% of the world population of all harbour seals. Grey seals are the larger of the two species. Adult males can weigh 350kg and be over 2.3m in length whereas harbour seals weigh up to 130kg and are up to 1.85m long.

3.120 Seal populations and structures are vulnerable to disease, hunting, by-catch in fishing gear, other marine obstacles and changes in food and habitat availability. Seals are predators on fish, including species of commercial importance.

Figure 3.8: Grey and Common Seal population distribution in UK waters*



* a) main breeding sites of grey seals around the UK. There are further, smaller dispersed breeding sites around the coasts of Cornwall and Wales
b) main haul out sites of harbour (or common) seals around Great Britain in August 1995–1997 by 10km squares (SMRU).

Evidence and State

3.121 Under the Conservation of Seals Act 1970, the Natural Environment Research Council (NERC) has a duty to provide scientific advice to government on matters related to the management of seal populations in the UK. The Special Committee on Seals (SCOS) formulates this advice annually based on the latest scientific information provided mainly by the Sea Mammal Research Unit (SMRU). This advice includes an assessment of seal populations, diet, behaviour, epidemiology and habitat use. The annual assessment of seal populations includes information from surveys conducted by SMRU that are concentrated mainly in Scotland, as well as counts from the Countryside Council for Wales and Dyfed Wildlife Trust in Wales, the National Trust at the Farne Islands and Lincolnshire Wildlife Trust at Donna Nook in Lincolnshire. These surveys are adequate for monitoring changes in seal populations over time, although they provide little information about the underlying reasons for that change.

- Grey seal populations have grown steadily since the 1960's when records began, to an estimated population of up to 123,000 in 2002. The number of Grey seal pups born increased steadily from 1984–1996, it has remained broadly static since 2000 and the populations are therefore thought to be stabilising in some regions.
- Seal populations were affected by the phocine distemper virus (PDV) in 1988 and 2002 but this mainly affected common seals and the epidemic has now run its course. However, it is likely that epidemics will recur in future.

3.122 The UK has selected 11 SACs for harbour seals and a further 11 SACs for grey seals under the EC Habitats Directive. Although these cover the entire UK a large proportion is in Scotland. They cover most to the main breeding sites across the range in the UK.

- The conservation agencies are currently undertaking monitoring of SACs to meet the EC Habitats Directive reporting deadline at the end of 2006.

3.123 There is currently one OSPAR Commission EcoQO being tested for seals, "seal population trends in the North Sea". The "Utilisation of seal breeding sites in the North Sea" has also been proposed for future development. It will be necessary to have more information about the underlying processes, which lead to variations in populations if this is to be used as a measure of status.

Cetaceans

3.124 At least 28 species of cetaceans (whales, dolphins and porpoise) occur around the UK continental shelf but only about 10 are commonly recorded. They are complex, charismatic and much loved animals, which inspire great interest in the marine environment, generate revenue for coastal communities through whale and dolphin watching and act as indicators for the health of our marine ecosystem.

3.125 There are a number of human activities, which threaten cetaceans including fishing, chemical pollution, noise and disturbance from shipping, recreational activities and oil and gas drilling.

Evidence and State

3.126 The nature of the marine environment and of cetaceans themselves makes the study of these animals in their natural habitat extremely difficult. The JNCC currently maintain a surveillance programme (but not systematic monitoring) on cetacean populations.

3.127 The UK's total species complement is comparable to that of other areas at the same latitude and represents a diverse assemblage of this order of mammals. There are resident populations of the bottlenose dolphin in the Moray Firth and Cardigan Bay SACs. A significant number also occur in the Lleyn Peninsula and the Sarnau SAC in Wales and can be found in a further 6 SACs which are identified primarily for other marine features. Although no sites have yet been proposed for harbour porpoise, the UK is actively considering doing so. Assessments to give an indication

Figure 3.9: Common dolphins*

* Photographs courtesy of the Countryside Council for Wales.

of status of SACs will be reported by 2006 using data and assessments collected in the next two years. Future monitoring programmes will provide important contextual information against which an overall assessment of the state of cetacean populations can be made. Data, currently available, suggests that in Moray Firth, the bottlenose dolphin has a population of approximately 130 animals; whilst in Cardigan Bay there are approximately 170 dolphins. However, there is not much reliable information for other species or populations on trends in population size, and there are no reliable methods of using sightings data to establish those trends.

3.128 The UK lacks adequate statistically robust methods to monitor cetacean density at appropriate geographical scales and reliable indicators of population status. Baseline data for future surveillance of cetacean populations will be collected through the broad scale survey SCANS II. The Joint Cetacean database project will also provide enhanced co-ordination of cetacean sightings programmes by making best use of environmental impact assessment data ahead of marine developments.

3.129 There are no systematic monitoring programmes for the impacts of disturbance and noise pollution on cetaceans. However, this is an issue which may need to be considered in the future.

3.130 Strandings of cetaceans around the coasts of Britain are recorded and summarised by the Institute of Zoology London (England and Wales) and the Scottish Agricultural Centre's Veterinary Investigation Centre (Scotland); see ***www.defra.gov.uk*** and ***www.nhm.ac.uk***. This scheme yields much valuable information on the basic biology and pathology of UK cetacean species. However, strandings data are imprecise and imperfect indicators of the population status or trends of cetaceans nor are they necessarily indicative of wider ecosystem health.

Ecological Quality Objective (EcoQO)

3.131 Marine mammals can be caught accidentally during fishing operations, and by-catches of common dolphins and harbour porpoises in the North Sea, the English Channel and Celtic sea fisheries have been identified as a concern. The UK is committed to reduce harbour porpoise by-catch to less than 1.7% of the best available estimate of abundance (population per year) for major fishing areas in the short-term. The UK Small Cetaceans By-catch Response Strategy works towards the reduction of by-catch; mainly of dolphins and porpoises, to the lowest possible level. An EU Council Regulation was agreed in April 2004 to reduce the incidental by-catch of cetaceans. The ASCOBANS limit was adopted by OSPAR as an EcoQO, and is currently being piloted. The lack of population abundance estimates and historic population trends need to be addressed before making the objective operational. It is necessary under the EC Habitats Directive to have a system to monitor the incidental capture and killing of all cetaceans. Future research into how by-catch numbers, including the regular surveying of cetacean populations and fishing gear is needed.

Breeding Seabirds

3.132 Britain and Ireland supports some of the world's most important populations of seabirds. The presence of approximately 8 million seabirds provides living proof of the richness of the seas. The bird species nesting around the coastline of the British Isles include more than two thirds of the world's northern gannets, 90% of the world's Manx shearwaters and 60% of the global population of the great skua. These figures do not include waders and wildfowl.

3.133 The EC Birds Directive covers the protection, management and control of all naturally occurring birds, their eggs, nests and habitats. A significant result of the Directive has been the creation of a network of Special Protection Areas (SPAs) that contain important habitat for breeding, wintering and migrating birds throughout the European Union. In the UK, a total of 243 such sites have been included in the SPA Network, 95 of which are for seabirds.

Causes of change in seabird populations

3.134 The causes of change in population numbers and breeding success are complex and varied between species and between geographic areas. Some causative factors are connected with the actual state of the seas (e.g. weather and climate patterns, sea surface temperature, plankton biomass and food supplies such as sand eel stocks) and other factors may arise from the land or be due to changes in the overseas areas where migratory species spend time. Local impacts can vary from constructions e.g. windfarms or loss of habitats from sea level rise or development and the impacts of oil spills.

Evidence and State

3.135 Currently 25 seabird species breed in the UK. Eight of these warrant special protection of their habitats. Population changes of breeding numbers and breeding success of seabirds are collected both regionally and nationally through the JNCC's Seabird Monitoring Programme (SMP) which began in 1986. Baseline data from which subsequent monitoring can be compared are available from complete censuses providing total population estimates of all seabirds in UK. These population numbers give an assessment of state for each species but not all species indicate marine environment state.

3.136 The total number of seabirds breeding along the UK coastline has increased from 4.4million in 1969–70 to 6.7million in 1998–2002. An additional 225,000 gulls, terns and great cormorants also breed at inland sites. The most recent census of UK breeding seabirds in 1998–2002 has shown that there have been significant increases in 12 species, significant decreases in 2 species and 6 populations which have not changed significantly since the 1969–70 census. The overall increase in bird numbers over the last century has been attributed to increased protection from hunting and persecution in the UK and overseas.

3.137 However, the comparison between the two censuses in 1969–70 and 1998–2002 can mask significant changes that have occurred in some species. For instance, numbers of Arctic skuas and northern fulmars increased substantially between 1969–70 and 1985-88 but have declined since. In contrast, Mediterranean Gulls have colonised the UK since the last census in 1985–1988. Also, herring gull numbers declined by a much greater extent between 1969–70 and 1985–88 than they did subsequently; whereas roseate tern numbers have declined much more consistently over the last 30 years as they have gradually moved to more preferable nesting sites in the Republic of Ireland. Other species to have shown consistent increases in numbers over the past 30 years since 1969–70 include northern gannet, great skua, common guillemot, razorbill and lesser black-backed gull.

3.138 Black-legged kittiwakes and other species that feed on sandeels just below the surface (rather than diving down to deeper water) have shown a decline in numbers since the 1985–88 census. The decline is mirrored in the sandeel populations to the east of Scotland and around Shetland and has been linked to the plankton regime shift measured in the North Sea since the 1980s that has resulted from a warming of sea-surface temperatures. If sandeel stocks are further depleted by the combination of rising sea temperatures and commercial fishing, then populations of seabirds such as kittiwakes that rely on them for food, would be severely at risk.

3.139 However, it is recognised that most of the sandeel fisheries in the North Sea are beyond the foraging range of sea birds in UK colonies. Indeed not all commercial fisheries compete with seabirds over fish. Discards from trawlers are an important food source for scavenging seabirds. Ironically as the fisheries have declined or changed methodologies in the last 30 years, this has led to a decline in the associated bird species. Further work is required to decipher the complicated relationships between fisheries and seabird populations in order to determine the true impact of future changes in fisheries practices.

3.140 Other human impacts on bird populations from fisheries by-catch, from oil spills and from pollution have been recorded in some regions. The effects these impacts have on the overall population numbers in the long-term is not easy to assess.

Indicators of state

3.141 Seabirds are sensitive to the ecosystem health in which they live (i.e. both physical climatic conditions and biological health) and therefore can be used as indicators of a number of human impacts. However, since trends in the population status of seabirds vary both positively and negatively between species and between geographic areas, it is inappropriate to merge data from different species to derive composite indices as indicators of the state of seabirds as a whole (equivalent to the terrestrial bird index). Nonetheless, the use of a provisional indicator of population status in the England Biodiversity Strategy based on time-series trends of nine seabird species, is currently under review to take account of new data from a more comprehensive survey published recently in 2004.

3.142 All seabirds breeding in the UK are relatively long-lived and late maturing species Hence it may take several years for environmental changes affecting their breeding performance to have a measurable effect on the size of their breeding population. Therefore an annual measure of breeding success would be an immediate indicator of the state of the sea and perhaps provide an early warning of likely future population changes.

3.143 Currently two seabird-related Ecological Quality Objectives (EcoQOs) are being tested relating to i) the proportion of oiled common guillemots among those found on North Sea beaches; this methodology is being refined and ii) the use of black-legged kittiwake breeding success as an indicator of sandeel availability near their colonies. Work so far has suggested that the relationship between fisheries and seabird populations is a complex one, but that refinement of current measures which link breeding success to management action show some promise.

3.144 OSPAR is also investigating other measures for development of EcoQOs, including the number of plastic particles in fulmar stomachs and trends in sea bird populations.

Biological components: Summary of Evidence

3.145 Described in this Chapter are brief summaries of the monitoring of the major elements of the marine ecosystem at all trophic levels from plankton to marine mammals. Table 3.2 summaries the main results which help us understand how healthy the ecosystem components are.

3.146 Table 3.2 shows that the population status is not uniform across the species monitored in the marine environment. In some cases there are real threats to the health of the population. For example, significant changes have taken place in the plankton communities as a result of climate changes and some seabirds have been particularly hard hit by changes in fish assemblages and distribution. The implications for the rest of the ecosystem have yet to be fully understood. However, many fish stocks are under threat from direct commercial exploitation or from by-catch with deep water species particularly vulnerable.

3.147 In contrast some fish species are thriving and seals have recovered from previous threats to health. There are, however, many other species which we do not monitor and where the status is unknown. As a general picture we know less about our marine environment than we do for example the terrestrial environment. It is also that we do not have a comprehensive set of indicators of state. Instead we concentrate on the broad messages and the overall picture. A significant gap is the complete understanding of the distribution and health of seabed habitats.

3.148 Human impacts on these biological components of the sea are described more fully in Chapter 4 and in the integrated assessment Table 6.1. We do not have sufficient knowledge of natural changes in the marine environment to clearly differentiate natural, man-made and cumulative impacts. Continued long time series data and a wide geographical coverage is needed to fill this gap.

Table 3.2: Summary of the key evidence for the state of UK marine biodiversity and habitats

Categories	Associated measurements and research findings	Results	Assessment Confidence*	Sector report Chapter ref
Specific habitat and biodiversity	Evaluation programmes to monitor favourable status of conservation sites	Sites of Special Scientific Interest, Marine Nature Reserves, Special Areas for Conservation, Special Protection Areas, Marine Habitat Classification and Marine Biodiversity Action Plans are monitored on an ad hoc basis. There is a mixed message, some areas have shown improved status, others are declining.	II	MHS Chapter 1
	Ad hoc observations of non-native species in UK waters	Over 50 species identified in UK waters in recent years which range from benthos to marine plants and plankton.	III	MEQ Chapter 10
Benthic communities and associated sea floor habitat	Commercial fishing impact studies	The large spatial extent of fishing affects benthos on a regional scale through direct effects (direct mortality) and indirect effects such as modifying the food web and predator/prey relationships.	II	MHS/ EQ Chapter 1
	Physical disturbance studies	Impacts of disturbance have be found at a local level near the activity. The status of benthos on a broad scale is unknown but the significance of the effects depends on the species present, the geological seafloor and the nature of the activity.	III	MEQ Chapter 3
	Contamination from monitoring hazardous substances in the NMMP and for FEPA	There is no evidence to suggest that contamination affects benthos on a regional scale, however, some bentic species are stressed in local areas. These are near sites of hydrocarbon exploration or where contaminated dredge spoil disposal was historically disposed. There is also evidence of hormone changes caused by TBT.	III	MEQ Chapter 3
	NMMP samples	There is no evidence of broad scale (regional sea) adverse impacts on benthos from elevated levels of nutrients and organic matter.	II	MEQ Chapter 3
Plankton	Continuous Plankton Recorder survey	Offshore plankton species composition have changed in the North Sea. The scale of the change has been termed an ecosystem regime shift. This is driven by changing climatic conditions. There is little evidence of effects from pollution.	III	MHS Chapter 2
Fish	Commercial fish stock assessments	Many species of commercial fish adversely affected with some stocks are outside safe biological limits in all regions. Some species of pelagic (shoaling) fish have recovered strongly and are inside safe biological limits.	III	MFF Chapter 4
	Population Studies	The mean size of fish is lower in heavily exploited populations. Climate change is affecting the abundance and range of some species. There is limited evidence that wild salmon and trout stocks are declining in West Scotland.	III	MFF Chapter 2
	Fish Health	Prevelance of disease in dab at some Irish Sea locations are probably increasing. Levels of most fish disease in the North Sea generally static. Evidence of feminisation has been found in some flounder in estuaries, but how this affects the population as a whole is unclear.	II	MEQ Chapter 3
Marine mammals	Annual population assessment and counts of seals, and limited surveillance programme for seals and cetaceans	Grey seal populations have grown steadily since the 1960s to an estimated population of up to 123,000 in 2002. At least 28 species of cetaceans (whales, dolphins and porpoise) occur around the UK continental shelf. There is a bottlenose dolphin population of approximately 130 animals in the Moray Firth and 170 animals in Cardigan Bay. However, there is not much reliable information for other species or populations on trends in population size.	III	MHS Chapter 4
	By-catch figures for dolphins and harbour porpoises	Accurate counts for the numbers of animals caught acidently by commercial fishing operations are not available, however, the levels are of concern and thought to be greater than the internationally agreed limits of 1.7% of the population.	II	MHS/ MFF Chapter 4
Seabirds	Surveys of breeding seabird species carried out regionally and nationally and trends assessed annually	Although sea bird populations numbers show an overall increase from 1970 to 2000 there is great variability of population health by both species and location. Much of the increase in numbers is due to a few species doing well. There is real concern at the continued rate of decline of other species, particularly those in the North Sea. There was a large decline in population numbers from 1985 to 1990 and since then breeding success has been variable due to a variety of factors.	III	MHS Chapter 6

*** Confidence in the statements we are making from the available evidence.**

Confidence assessment **III** High **II** Good/Satisfactory **I** Low **0** No assessment possible

Chapter 4: Human Impacts on Marine Environmental Quality

4.1 A wide range of different human activities impact the marine environment. These include fisheries, different types of marine pollution such as hazardous chemicals and waste, extractive uses such as aggregate dredging and oil and gas extraction. Shipping and the accidental introduction of non-native species also have an impact.

4.2 This chapter describes the effects of these activities by identifying their individual impacts on the marine environment, and summarises the evidence and indicators of state. It includes also the major regional differences. An integrated assessment is provided in Chapter 6.

Climate Change

4.3 The physical effects of a variable climate are described in Chapter 3 and whilst the causes of climate change are known to be enhanced by human activities, there is little understanding of how these activities contribute to the impacts of climate change on the marine environment. The impacts known to date are described in Box 3A.

Capture Fisheries

4.4 Some of the world's most productive fisheries are found around the UK and wider North-east Atlantic, the annual landings of fish from the North-east Atlantic contribute about 11 per cent of the total world production of fish. These include demersal and pelagic fisheries for human consumption, industrial fishing and shellfish fisheries. The annual harvest of fish and shellfish in the North-east Atlantic is about 10 million tonnes of which more than 3 million comes from the North Sea.

4.5 Fish are an important part of the marine ecosystem and a key part of the food chain for other forms of marine life as well as humans. Continuous increases in fishing efficiency have increased pressure on pelagic and demersal ecosystems during the 20th Century.

Impacts on the marine environment: the evidence and state

4.6 The wider environmental impacts of fisheries are summarised in Box 4A. These include the abundance, size and genetic diversity of the target fish species, the by-catch of non-target animals such as marine mammals, the fish and benthic fauna that are caught incidentally during fishing operations, physical disturbance of seabed habitats; the genetic, species and population diversity and the food web.

Box 4A Key Messages from Marine Environment Technical Paper for Net Benefits (Cabinet Office, 2004)

Fishing is not the only cause of degradation, but is the most significant human activity causing change in the UK's marine environment. Fishing may reduce the resilience of the marine environment to other pressures. Whilst the greatest risk beyond our control, is of large-scale climate change, the effect of climate on fish stocks is obscured by the effects of fishing.

There is still uncertainty about some ecosystem processes but,

- the size of most fish stocks or the fishing pressure exerted upon them is outside safe biological limits;
- the genetics of some fish stocks have changed;
- some non-target species have been fished out of some areas;
- and the by-catch of marine mammals is serious and a risk to the viability of some populations;
- food webs have been disrupted.

Damage to the seabed and to seabed communities is widespread which will adversely affect other species, including fish, dependent on these habitats and communities.

The full report can be found on: *http://www.number-10.gov.uk/su/fish/index.htm*

Fish stocks

4.7 The Government Agencies (CEFAS, FRS, DARDNI) undertake research into the status of commercial fish stocks, while the EA are concerned with salmon and sea trout fisheries (out to 6 nautical miles) and estuarine fish which live for either part or all their lives in estuaries. Efforts are coordinated on a European level by ICES which undertakes an annual assessment of most commercially exploited stocks, basing its conclusions on data from commercial landings, research cruise investigations and observations of commercial fishing practices, including discards. Annual scientific advice on fish stocks is given to national governments and the EU.

4.8 In most regions, the level of fishing of demersal stocks remains too high and if maintained, will continue to lead to unsustainable fisheries in the long-term. Over the past decade there has been an improvement in the status of some stocks. Of those assessed by ICES, 38% are at full reproductive capacity compared to 21% in 1999. Some stocks such as cod show a severe deterioration. Once stocks become depleted, then other sources of mortality such as predation and environmental factors including climate change exert a greater influence than they do when the stocks are healthy. Throughout the regions, valuable ***Nephrops*** (Norwegian Lobster) stocks continue to be exploited at sustainable levels.

4.9 Total Allowable Catches (TACs) alone have not been successful in regulating fishing mortality rate on several stocks, and so recovery plans increasingly include limiting the number of days at sea and technical measures. In some cases it may be necessary to reduce fishing mortality even more severely in order to ensure that stocks can rebuild to safe biological levels.

Table 4.1: Main fish stocks exploited in UK waters in 2004

ICES Areas/ Sub-areas	IV	VIId	VIIe-k	VIIa	VIa, b
State of the Seas Report Regions	**1, 2**	**3**	**4**	**5**	**6, 7 & 8**
Plaice	a	a	a / a	+	
Sole	h	+	a / h	a	
Cod	!	!	+	!	!
Haddock	+			h	+
Whiting			+		
Angler (piscatorius)			h		+
Angler (budegassa)			+		
Megrim			+		
Hake				a	
Herring	+	+			+
Sandeel	a				
Saithe	+				+
Norway Pout	a				
Mackerel	!			a	
Horse Mackerel					
Blue whiting			h		

Assessment	
!	Indicates stocks **which are suffering** reduced reproductive capacity
a	Indicates stocks **which are at risk** of suffering reduced reproductive capacity
h	Indicates stocks which are at full reproductive capacity but **are being harvested unsustainably**
+	Indicates stocks which are at full reproductive capacity and are being **harvested sustainably** (i.e. are within Safe Biological Limits)
	Indicates no assessment (either no data, not fished or species not present)

North Sea Regions 1, 2 and 3

4.10 During the past 10 years the state of the stock for most demersal species in the North Sea has deteriorated. Only three of the eight main commercial stocks are within safe biological limits (Table 4.1). The cod stock remains at historically low levels and is subject to emergency management measures and a recovery plan from 2004. However, herring stocks have increased substantially and ***Nephrops*** are exploited sustainably.

Region 4

4.11 Most demersal stocks in the South-west Approaches are harvested outside precautionary limits. The northern hake stock is at a low level and is the subject of a recovery plan introduced in 2004. Stocks of other demersal species, such as anglerfish, sole, megrim and whiting are considered to be at full reproductive capacity.

Region 5

4.12 Irish Sea cod and whiting stock status has deteriorated in the last decade and there is concern over stock collapse. Plaice stocks are harvested sustainably while sole stocks are harvested outside precautionary limits. The herring stock has increased in recent years from low levels in the early 1990s and ***Nephrops*** stocks are considered to be fully exploited but there is concern about the high level (60%) of whiting discarded by the trawlers.

Scottish Waters Region 6 and 7 and 8

4.13 Stocks of cod in the west of Scotland and haddock at Rockall are thought to be at or close to historically low levels in the period 2000–2003, and below the precautionary biomass limit point. Cod is subject to a recovery plan. Whiting stocks have declined steadily since 1981, and are considered to be close to historically low levels. The haddock stock in the west of Scotland has shown a temporary recovery following a successful recruitment year. Anglerfish and megrim were previously taken as a by-catch in the mixed demersal fisheries in the west of Scotland and were often heavily discarded. As fleets have moved offshore, these deepwater species have been increasingly targeted. The status of the west of Scotland sandeel stock is uncertain but the fishery is closed after 31 July each year to protect the sandeels as a food source for breeding seabirds. ***Nephrops*** are exploited at sustainable levels and landings have remained stable since the mid-1980s.

Fishing impacts on the food web

4.14 Capture fisheries modify the marine food web by removing both predator and prey species. As larger species and individuals are more vulnerable to fishing, many of the top fish predators have been lost from UK seas particularly in the North and Celtic Seas. This has led to a proliferation of smaller fish. The targeting of the larger and more valuable species by fisheries can result in undesirable genetic

Figure 4.1: The ratio of the number of over fished stocks in ICES regions*

* i.e. ratio of stocks outside safe biological limits to the number of commercial stocks (for which assessment of their status has been carried out) per fishing area in the North East Atlantic and Baltic (2002). European Environment Agency (2002). Indicator Factsheet.

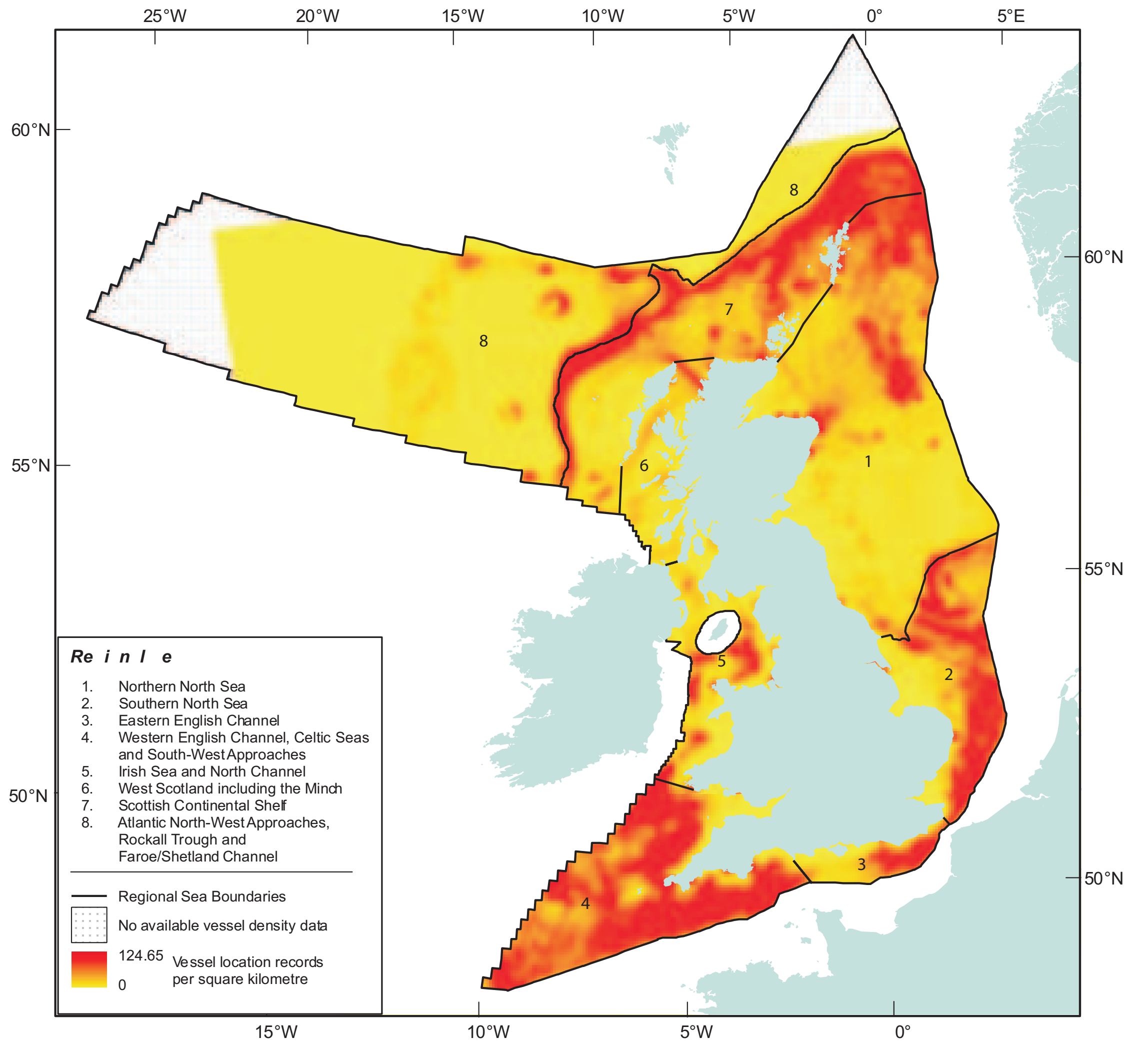
effects on fish populations (see Section 3.113). A community dominated by smaller fish has a faster turnover time, and this will lead to greater fluctuations in the abundance of fish as the environment changes. The small fish such as small cod and whiting feed on benthos so this comes under greater threat. These fishing effects take place against a background of climate change, and recent warming of the North Sea has led to a change in the composition of the fish community. In addition, fishing for small but important prey species, such as sandeels, can disrupt the local food supply for predatory fish and seabirds.

By-catch

4.15 Another impact of fisheries is the by-catch of non-target species, such as marine mammals (3.131), fish, seabirds and benthic animals. Some fish by-catches are retained to be sold, however, much more is discarded at sea and therefore, reducing the current rates of by-catch and discarding is desirable.

4.16 Monitoring programmes to determine the quantity and composition of discarded catches are now in place in many of the UK fisheries, and England and Wales have used observers on most types of fishing vessels to provide annual estimates of discarding by weight and length for the main commercial species. Scotland has been monitoring discards since the 1970s, and Northern Ireland has conducted extensive short-term discard studies through EU funded research projects.

Figure 4.2: The distribution of fishing effort in UK waters during 2002*



* Data shows the density (observations per km²) of all UK and European fishing vessels >24m length in 2002 using Vessel Monitoring System (VMS) satellite data. No speed filter has been applied so data reflects both fishing activity and steaming.

4.17 Marine mammals caught accidentally during fishing operations include by-catches of common dolphins in the pelagic bass pair trawl fishery and harbour porpoises in the North Sea gill and tangle net fisheries. There is concern over the extent of this by-catch since mortality rates are thought to exceed the ASCOBANS limit of 1.7% of the population per year (See section 3.131)

Impacts on the sea floor

4.18 Continental shelf ecosystems of north-west Europe are some of the most disturbed habitats within European waters. The areas traditionally exploited by the fishing industry are generally less than 150m deep. The use of heavy trawl gear and dredgers can lead to loss or modification of sensitive seafloor habitats and fragile species, the disturbance of sediments and the release of nutrients. The fishing gears can also leave a trail of dead and dying animals on the seafloor that is eaten by scavenging species. Bottom trawling disturbance reduces the production and diversity of larger bottom dwelling invertebrates, but has a smaller effect on many of the smaller bottom dwelling animals that provide food for flatfish. Burrowing seabed animals play an important role in controlling sediment structure and biochemical processes. Trawling disturbance rapidly depletes populations of the most active bioturbators, and thus the mechanical effects of trawling may replace animals that undertake this role. Trawling also suspends seabed sediments. The effects of these changes are not well understood and the subject of research.

4.19 Fishing with towed gears takes place in all sea areas, but when viewed on a local scale the distribution of fishing effort around the UK is remarkably patchy (Figure 4.2). For example, in the case of the North Sea beam trawl fishery, much of the North Sea is fished less than once in 7 years while smaller areas may be fished repeatedly, up to 10 times each year or more. The effects of beam trawling on the seabed would be much greater if trawling effort were more evenly distributed. Of course, the areas not impacted by the beam trawl fishery may be fished in other ways. However, when the aggregated effort of all North Sea bottom trawl fisheries is considered; much of the North Sea is impacted only infrequently by bottom trawl gears.

4.20 Infrequent impacts can be significant as the first impact of trawling on a previously untrawled area has the greatest effect on the benthic community. Some infrequently impacted areas may have slow recovery times and thus will be particularly vulnerable to impacts.

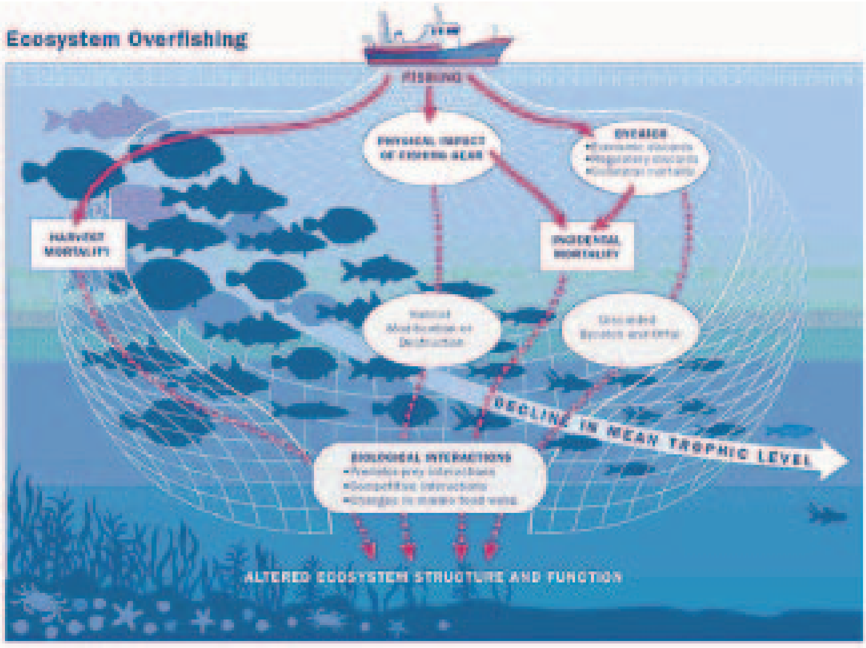
4.21 At a local scale fishing has a permanent or long-term destructive effect on delicate biogenic structures. Cold-water coral reefs are slow growing fragile habitats that are easily damaged by towed fishing gears. In response to this threat, an area of $1380km^2$ around the Darwin Mounds coral reef off north-west Scotland was closed to towed gears, and this site will now be designated as an SAC. Such closures are the only effective way to protect the most sensitive habitats from bottom fishing impacts. See also Box 3C.

4.22 In unfished areas with low levels of natural disturbance, such as wave or tidal action, benthic communities are often dominated by large slow-growing and habitat forming species that are more vulnerable to fishing disturbance than the smaller fast-growing species that dominate biomass in fished areas. For benthic animals, the densities of sensitive (e.g. fragile) species and opportunistic species have been proposed as EcoQO elements and are now being assessed by ICES.

Fishing Impacts in the deep sea

4.23 The fishing industry has increasingly been directing attention to deeper waters well offshore in the Western Approaches (outer area of Region 4) and in Regions 7 and 8. The species, known to be found on sea mounts and other seabed features in these deep waters, are considered to be particularly vulnerable to damage by bottom trawls. Many target and non-target species are vulnerable to any form of fishing as they are long lived and slow growing, reach a relatively old age before reproducing and reproduce at a very low rate.

Figure 4.3: Wider ecosystem impacts of fishing*



* Fishing activity has a wide range of effects, including direct impacts on the target fish populations, and indirect impacts on species caught as by-catch, benthic habitats and the food web. In some areas a reduction in the mean trophic level of fish communities has been recorded.

Aquaculture and Shellfish Harvesting

4.24 Over the last 20 years there has been a massive expansion in the number of fish farms. The main finfish species produced in this way are salmon and rainbow trout but halibut, cod and haddock production are expected to increase. Most of the fish and shellfish farms in the UK are situated in Scotland Region 6; although there are important sites also in Regions 1, 7 and 5. Scotland contributes approximately 90% of all UK aquaculture production. Around England and Wales aquaculture is dominated by shellfish harvesting, namely mussels, oysters, clams and cockles.

4.25 Fish farming involves provision of food usually in the form of pellets whereas shellfish culture relies on the phytoplankton food present in the sea. The pressures of aquaculture on the environment include particulate organic waste, nutrient excretion and medicinal chemicals. Fish and shellfish farms are regulated to minimise adverse impacts on the environment. In particular, a discharge consent must be obtained that will specify the production tonnage and quantities of medicines that can be deployed.

Impacts on the marine environment

4.26 The key impacts from aquaculture mainly arise from waste materials. These include particulate organic matter, nutrients and medicinal chemicals, although the use of the latter has been reduced. Sea lice have been a major problem in salmon farms and there is concern that the numbers of larval lice in the environment may be one reason for the decline in wild sea trout and salmon stocks on the west coast of Scotland. There is a risk that escaped farmed fish will breed with the natural (wild) population and affect the gene pool.

4.27 Around the coastline of England and Wales, shellfish harvesting can cause morphological change or reduce the food supply for over-wintering birds such as oystercatchers and knots. Mussel cultivation in new areas will change the existing marine communities and naturally occurring habitats. When mussel seed is transported to an area non-native species may be introduced. There is increasing interest in commercial hand gathering of shellfish and this may lead to disturbance of local bird populations and damage to sensitive intertidal habitats such as saltmarsh by vehicles. (These issues are highlighted in the WFD Characterisation Report rather than the sector report).

The evidence and state

4.28 Fish health and the wider ecosystem: Environmental monitoring is required by the industry as a condition of the discharge consent. SEPA and the EA also undertake additional work to ensure compliance with international and national regulations while other organisations undertake research to provide an improved understanding of the impacts. The evidence suggests that:

- The amount of particulate organic matter and nitrogen discharges from fish farms has increased as the industry has expanded. This is despite outputs from each farm being reduced as a result of improvements in technology. However, monitoring in Scotland has shown that the impacts on the sea bed by organic waste are small and localised (rarely extending beyond 50m from the cages).
- The discharge of nutrients has been a concern and therefore the nitrogen, phosphorous, silicate and chlorophyl ratios are measured. In recent surveys OSPAR eutrophication assessment criteria were not exceeded at any site but the nitrogen/silicon ratio was thought to be able to cause plankton composition changes in one site in Western Scotland and at all sites in Shetland. Concentrations of nuisance algae were insufficient to cause adverse effects on the wider marine environment.
- The source of fish food could also be at unsustainable levels. For example pelagic blue whiting is often used in fish food pellets but is considered to be exploited unsustainably in some areas.
- Better management and treatment of sea lice is reducing the sea lice load on fish farms. As well as their use in medicines, chemicals are used as antifouling agents on cages. Whilst concerns exist over possible adverse effects on biota living near the mariculture sites, to date no problems have been identified. The position is similar for medicines.

4.29 The evidence base for assessing the effects on wild fish populations is poor. These effects could be sea lice infections in wild populations of trout and salmon, or the potential for genetic interaction between escaped farmed fish with their wild counterparts. Consequently there is a risk of a decline in the genetic diversity of wild fish; the scale and significance of this risk is unknown and the subject of ongoing studies.

Box 4B National Monitoring for Environmental Quality

Quality status monitoring is also undertaken in the UK, through the **National Marine Monitoring Programme (NMMP)**. The NMMP undertakes an assessment of the chemical, biological and physical characteristics of the environment at approximately 80 sites around the UK. This provides data for a direct assessment of the status of depositional soft sediment at 47 coastal stations and 31 estuarine stations. The results are submitted annually to ICES and the EEA as the UK commitment to the assessment programmes under the OSPAR Convention.

The quality of water entering our seas from riverine basins is measured by the **Riverine Inputs and Discharges (RID)** programme. The results are sent annually to OSPAR for each water basin.

The disposal of dredged material or construction at sea requires a licence. Regular compliance monitoring of the impacts is targeted on key sites receiving large quantities of material or those which are adjacent to sensitive or conservation areas. This FEPA monitoring, conducted by CEFAS, FRS and EHS, concentrates on the physical distribution/transport, contaminant concentrations and fauna in the sediments. Data from these activities are held by the regulatory agencies and private organisations that hold licenses, and the findings are published at periodic intervals in journal articles and reports.

These multi dimensional programmes therefore provide evidence for a number of ecosystem components and activities described in this report.

Location of NNMP monitoring sites in the UK (NMMP 2nd Report – MEMG 2004).

Hazardous substances

4.30 There are thought to be some 100,000 chemicals currently on the market and some 30,000 are produced in quantities greater than 1 tonne in the EU. As well as their many advantages, there is concern that a significant minority may be harming the environment now or may do so in the future if they continue to be released and their levels accumulate in the environment.

4.31 Until the mid 1990s, chemicals were regulated mainly because they had been found by experience to cause health problems to humans and biota. Examples of these are the heavy metals lead, cadmium and mercury, polychlorinated biphenols (PCBs) and pesticides such as lindane. However, in recent years a more systematic approach has been developed internationally to focus work on those chemicals of most concern, and all chemicals which are produced and used in significant tonnages have been screened to see if they possess inherent hazardous properties which might cause health risks if they reach the environment in significant amounts.

4.32 There are currently around 50 "priority hazardous substances or group of substances" which have been identified internationally which include many of the "traditional" chemicals of concern and a number of new ones[1]. They can be naturally occurring, produced directly for use or produced as by-products of other processes. Sources include industry and household use and offshore industries and shipping. Goals have been agreed for these substances such as the OSPAR cessation target of "making every endeavour to move towards the target of cessation of discharges, emissions and losses of hazardous substances by the year 2020" with the ultimate aim of achieving concentrations in the marine environment which are near background values for naturally occurring substances and close to zero for man-made synthetic substances.

Impacts on the marine environment

4.33 The term "hazardous substance" has been coined to cover those chemicals which possess the hazardous properties of **toxicity** to organisms, **persistency** (i.e. the ability to remain unchanged in the environment long enough to get taken up by biota) and **bio-accumulation** (i.e. the ability to be taken up and stored in the tissues of biota with the potential to pass up the food chain and become concentrated in the top predators such as marine mammals).

4.34 In addition to persistency, toxicity and bio-accumulation, some chemicals known as endocrine disruptors can adversely affect the hormone systems of organisms, and there is also concern that mixtures of chemicals acting in combination can also have toxic effects in marine ecosystems. The effects of mixtures still needs to be better understood and quantified and is being evaluated in Defra research programmes.

1 The OSPAR List of Chemicals for Priority Action can be found at http://www.ospar.org/eng/html/welcome.html and the EC Water Framework Directive list of priority substances can be found at http://europa.eu.int/comm/environment).

The evidence and state

4.35 Identification of the significant sources of these priority hazardous substances and the associated monitoring programmes needed to demonstrate compliance with the goals, are currently being elaborated at European level.

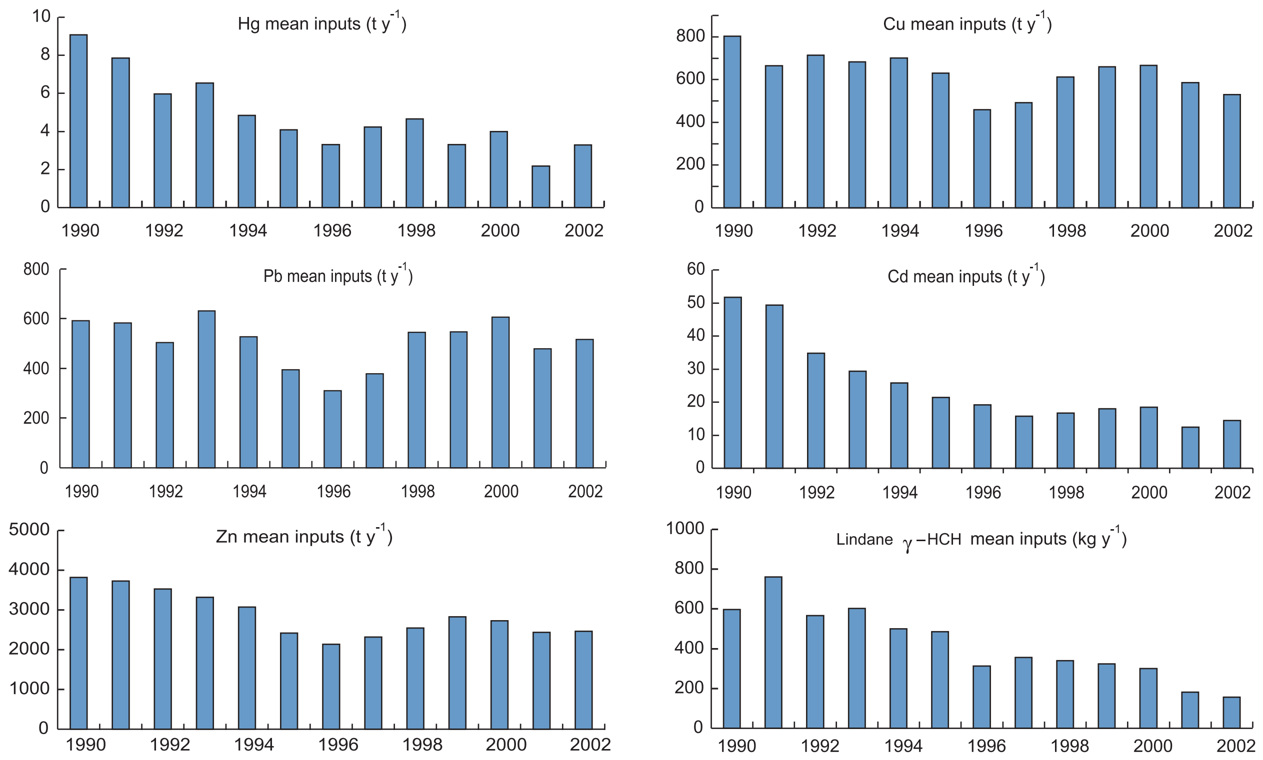
4.36 The evidence used in this report focuses mainly on the "traditional" hazardous substances for which monitoring programmes have been agreed at European level, most of which are carried out under the OSPAR Joint Assessment and Monitoring Programme (JAMP). Evidence on some of the more recently identified substances will not be available until new monitoring programmes have been developed and agreed.

4.37 The monitoring for the JAMP substances (heavy metals, natural and synthetic organic compounds and nutrients) in the UK is coordinated through the NMMP and includes monitoring of substances in the water column, sediments, the tissue of biota, and of the effects of substances on biota (see Box 4B). For some JAMP substances both direct and riverine inputs and the environmental concentrations in water, sediment and biota are monitored.

4.38 Historically, only a limited range of heavy metals have been monitored such as mercury, cadmium, copper, zinc and lead. The NMMP also monitors a range of organic compounds such as polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides such as γ-HCH (lindane) and polychlorinated biphenyls (PCBs or CBs). Early work for the WFD has also assessed inputs from land to coastal and transitional waters. There is evidence that:

- Overall UK inputs into the marine environment of heavy metals have been sharply reduced over the last 25 years. Direct and riverine inputs have fallen by between 20 and 70 per cent since 1990 (as shown in Figure 4.4) and atmospheric emissions have been reduced by between 50 and 95 per cent.
- Concentrations of contaminants in marine waters are compared to the Environmental Quality Standard EQS set in response to the EC Dangerous Substances Directive. The waters at 18 of 401 sampling points failed to meet the List II metal standards for copper. The majority of these were in the Thames. The most common failure for organic compounds was TBT (29 failures at a variety of sampling points around the English Coast) with 16 failures for other organics in 2003.
- Evidence suggests that concentrations of mercury, copper, lead, PAHs and CBs in sediments in a number of UK estuaries exceed the OSPAR 2003 ecotoxicological assessment criteria (EAC) levels which indicate that harm to biota may occur. However, concentrations of cadmium and zinc only exceed EACs levels in a few estuaries in Regions 1 and 2 (North Sea). The highest levels of contamination and/or effects of these historically monitored contaminants are essentially restricted to some inshore and estuarine areas (notably Liverpool Bay, Morecambe Bay and the Thames estuary). Regions 6, 7 and 8 and the offshore areas of Region 4 have concentrations close to background and are not of concern.

Figure 4.4: Hazardous substances input to the marine environment



- However, although some clear patterns are emerging, there still remains insufficient long-term data to enable a rigorous assessment of trends in concentrations of hazardous substances in biota to be made on either a regional or national level. There is also very little data in the offshore areas.

Concentrations in marine organisms

4.39 Fish and shellfish and benthos absorb contaminants from their surroundings. Marine organisms have developed a range of strategies to cope with different concentrations of essential or toxic metals and organic compounds. In general, detoxification depends on the conversion of toxic forms into less toxic bound forms. The bound forms may be stored and subsequently excreted (see 3.113). Contaminants that are persistent and cannot be excreted are accumulated over time.

4.40 Monitoring for hazardous substance in marine mammals is carried out as part of the UK Marine Mammals Strandings Programme as part of the UK's commitments under the ASCOBANS. There is evidence to suggest that PCBs accumulate in the blubber and mercury in the liver and reduce the ability of marine mammals to fight disease.

4.41 An assessment of temporal trends of contaminants in biota was undertaken by the OSPAR Commission for the whole North-east Atlantic area in 1998, covering data collected between 1976 and 1996. UK fish data from the Southern Bight of the North Sea (Region 2) and Liverpool Bay (Region 5) showed a significant downward trend in the concentrations of mercury HCB, DDT dieldrin and PCB. A reassessment of all available data is due in 2005. The concentration of metals in fish were greater than background mercury concentrations in Region 5; the Mersey Estuary, Liverpool Bay and Morecambe Bay probably as a result of discharges of mercury from the chlor-alkali industry. Cadmium and lead concentrations were generally low, with higher concentrations, typically in industrialised estuaries. Relatively high concentrations of cadmium were also measured at the Dogger Bank in Region 2.

Biological effects monitoring

4.42 The NMMP programme (Box 4B) samples benthos from some 60 stations around UK estuarine and coastal waters. The data (collected in 2000) shows clearly the differences between estuarine and coastal sites. Estuarine sites had larger populations but lower diversity. Many of the techniques used to monitor the health of seabed communities are presently subject to ongoing research effort aimed at improving their sensitivity. There are many other impacts on benthos (see also 3.58).

4.43 The NNMP results for determinands monitored during the 1999–2002 period in – the flatfish dab, flounder or plaice and for shellfish, the blue mussel show that concentrations of several metals were elevated in mussels, mainly in industrialised estuaries and CB levels were above background for many bilological samples. Concentrations were above the upper level EAC in about 30% of samples. There are currently no background reference concentrations or EACs for CBs in fish liver. Concentrations were highest in the Thames estuary (Region 2) and in Liverpool Bay (Region 5).

4.44 Formation of Metallothionein (MT) is a natural response to exposure to certain metals, particularly mercury, copper, cadmium and zinc. The presence of MT is an indication of exposure to these metals, rather than a measure of subsequent health. MT is usually measured in the liver of fish or in mussels as these normally contain the highest concentrations of inducing metals.

4.45 In a UK survey in 2002 concentrations of MT in male flounder were only elevated in the Mersey. Concentrations in mussels do not correlate with those for flounder livers. These findings may reflect different feeding behaviours (benthic invertebrates vs. filter feeding) and therefore availability to different compartments of the ecosystem. further investigations are required to enable the data to be fully interpreted.

4.46 The oyster embryo bioassay has been used for over ten years as one biological technique to assess general water quality in UK waters. Embryos are exposed to discrete water samples for 24 hours and their success to develop normally into larvae is a measure of biological water quality. Monitoring at the 17 sites in England and Wales showed that generally, toxicity was not detected and oyster embryo larval development was good. However, a small number of samples at each site did show toxicity on an occasional basis and no trend. It is notable from comparisons with similar surveys 10 years ago that a reduction of toxicity has occurred.

4.47 Surveys on the Clyde highlight the variability of biological water quality with location, time and depth, and the need for detailed spatial surveys of each estuary prior to developing a longer-term temporal trend, monitoring programme.

Sediment bioassays

4.48 Sediment bioassays measure the acute toxicity of pore water or contaminants bound to sediment or to sediment dwelling organisms. Localised sediment toxicity was recorded in all 4 estuaries surveyed (Mersey, Southampton Water, Tyne and Tees). This is a baseline for further monitoring in these estuaries which must now be linked to the chemical contaminants which cause the toxicity.

Endocrine disruption

4.49 In the 1990s a number of organic substances were found to be capable of causing feminisation or masculinisation (endocrine disruption) of fish. The key substances implicated as causing the observed effects were substances such as the human female sex hormone 17ß-oestradiol and synthetic chemicals such as nonylphenol. Oestrogenic chemicals originate from domestic sewage and industrial discharges.

4.50 The Endocrine Disruption in the Marine Environment (EDMAR) programme was the first large scale, and most detailed, research to establish whether such changes were occurring in marine life, where they were occurring, what was causing them, and what the consequences were. Some feminisation has been found in flounder from estuaries such as the Tyne, Tees, Mersey, Clyde and Forth. Migratory salmon and trout do not appear to have been affected nor do crabs or shrimps.

4.51 The main inputs of TBT compounds to the sea arise from the use of biocides in antifouling paints on the hulls of vessels, from which TBT slowly leaches into the surrounding water. This has been banned on vessels less than 25m and will apply to all vessels from 2008. Inputs of TBT to offshore areas may come from dumping of harbour dredge spoil materials, anchorages and shipping lanes.

4.52 Common dogwhelks are sensitive to TBT exposure and females develop male sexual characteristics. In severe cases, this condition (imposex) can lead to sterility and death of the females, and subsequently to declines in dogwhelk populations. OSPAR has developed detailed guidelines for the use of imposex in monitoring programmes along with assessment criteria and ecological quality objectives based on the level of this response.

4.53 Surveys of TBT effects on dogwhelks carried out between 1992 and 1998 showed effects of exposure all around the UK. However, the effects were generally low at sites more than a few hundred metres from the point sources and there are no effects at the population level. The level of imposex response decreased over a 5 year time period and this trend is expected to continue following the proposed ban of organo-tin based antifoulants on all vessels in 2008.

Future work

4.54 In order to address the combined effects of chemicals in the environment, we are developing new biological monitoring techniques such as whole effluent assessment. These tools which, when combined with traditional analysis of single substances, will give a much broader perspective on water quality and the impacts of contaminants. Furthermore, research has confirmed the need for international initiatives to phase out the use of such chemicals. Also, the picture for contaminants will not be complete until monitoring programmes for the persistent, bioaccumulating and toxic (PBT) chemicals recently identified a European level have been agreed and implemented.

Nutrients

4.55 Human activities such as the manufacture and use of fertilisers, human and animal wastes and the burning of fossil fuels result in nutrient releases to the atmosphere or aquatic environment. Nutrients may enter the sea directly or via rivers from a variety of land based sources including sewage, industrial processes, run-off from agricultural land or by more diffuse drainage, shipping, aquaculture and congregations of wild-life such as seals, wild fowl and seabirds are sea based sources which may be significant in local areas. Some atmospheric emissions of nitrogen are deposited onto marine waters.

Impacts on the marine environment

4.56 Nutrients are essential for the growth of the plants on which the marine food web is based. However, an excess of nitrogen and phosphorus can lead to excessive growth of phytoplankton or fixed algae, which can cause a variety of problems. The over-abundance of nutrients leading to problems associated with excessive algal growth is known as eutrophication.

4.57 Various measures have been taken by OSPAR and the EU to limit or reduce nutrient inputs; especially where problems exist or there are signs of potential problems arising. Assessment criteria were developed by OSPAR (they are currently under review) to guide decisions on what symptoms are to be regarded as indicative of eutrophication problems. The key indicators – ecological quality objectives – are still being developed but under the WFD we have used the existing OSPAR indicators of excessive growth such as algal mats, Chlorophyll a levels, shellfish poisoning and nuisance blooms as an indicator of risk of failing the ecological objectives still under development.

The evidence and state

4.58 Nutrients in the marine environment are monitored at various times for fulfiling a number of EC Directives (Nitrates, Urban Wastewater) and the OSPAR strategy to combat eutrophication. Nitrogen and phosphorus inputs (waterborne loads from land based sources) are monitored nationally under the RID Riverine Inputs and Direct Discharges programme and reported annually to OSPAR. Factors pertaining to the status are:

- Since 1990 there has been a 35–50% reduction in direct inputs of nitrogen and phosphorus but the riverine inputs, which vary according to river flow rate have not shown any significant change.
- UK marine waters with significant freshwater influence tend to have elevated levels of nutrients. However, such areas, which were confined to estuaries and coastal waters close to large rivers, tend to be turbid and less susceptible to the risk of excessive growth of phytoplankton. Waters beyond these limited areas of freshwater influence are dominated by the movement of Atlantic waters and nutrient levels and the effects are generally unaffected by anthropogenic nutrient inputs.
- The extent to which, anthropogenic input of nutrients present a risk to the ecological status of the eight regional areas around the UK, differs markedly. There are no problems in Regions 6, 7 or 8 and low concentrations in Regions 1 and 4. Parts of Region 3 and 5 are subject to anthropogenic influence. The highest concentrations of nutrients occur in coastal areas off the south-east coast of England in Region 2 but the indicative effects are generally below OSPAR assessment criteria. This is probably because wave and tidal energy combined with the relatively shallow depth to naturally enhance turbidity and rapid dispersion thus restricting light penetration and algal growth. In Region 1 inputs of nitrogen have been reduced by about 60%, but only marginal reductions have been achieved in Region 2. Region 2 riverine inputs account for about 40% of total UK inputs and riverine flow variability has a major influence on the pattern of inputs in this Region and in Region 4. There is, however, generally only a weak correlation between nutrient input and the concentrations observed in waters around England and Wales.
- There are various parameters of the natural environment, which can be measured to show what effects there are. At least so far as plankton are concerned, the records of the Continuous Plankton Recorder (CPR) suggest that generally the offshore waters around the UK are not affected by nutrient inputs from land based sources. These effects are limited to localised inshore areas. Some localised problems with anthropogenic nutrient related change has occurred in enclosed estuarine environments and harbours such as the Ythan Estuary, Chichester, Langstone and Portsmouth Harbours and inner Belfast Lough. Reviews of eutrophication status are made periodically under the Urban Waste Water Treatment and Nitrates Directive and under OSPAR. The results of these assessment processes will become available over the period 2005–2007.

- In terms of effects, the highest concentrations of chlorophyll occur in the north eastern Irish Sea (Region 5) where concentrations do occasionally exceed the relevant assessment criteria. The full implications for the local ecosystems are not yet fully understood.

4.59 Chapter 3 explained that there has been a major change in the plankton, both in species and abundance terms. This affects a large area of the North Atlantic and appears to be linked to changes in climate. This makes the task of identifying changes at a more local level and disentangling them from the broader scale changes more difficult. A priority for science, is development of a better understanding of the ecosystem consequences of nutrient input.

Sewage treatment discharges: Microbiological quality of the coastal environment

4.60 Microbiological contaminants (bacteria and viruses) are introduced to the marine environment primarily from land-based sources and essentially affect only the coastal zone. They arise from human and animal (including birds) sources. Three EU Directives require microbiological monitoring: the Bathing Waters Directive (which sets mandatory water quality standards as well as more stringent guideline levels), the Shellfish Hygiene Directive (which sets standards for the microbiological quality of bivalve shellfish flesh and intravalvular liquid) and the Shellfish Waters Directive (which seeks to protect or improve the quality of waters where shellfish grow). All set standards for numbers of indicators of faecal bacteria in seawater and/or shellfish as well as other parameters.

Impacts on the marine environment

4.61 Discharges of sewage, including those from storm overflows or treatment failure, contain faecal contaminants. Microbes from farm livestock and other animals are also washed into rivers and can reach coastal waters. These can harm marine organisms and also be concentrated in shellfish (which are filter feeders) and passed on to humans. Tourist beaches also rely on low microbiological levels to demonstrate that the bathing water is suitable for swimming. Some shellfish are used as an indicator for microbiological contamination.

The evidence and state

4.62 A clear measure of the microbiological quality of coastal waters is available through three national microbiological monitoring programmes covering the degree of compliance with the standards set by the EC Directives. The responsibility for reporting the results varies across the UK.

Bathing waters

4.63 Almost 98% of the 567 UK bathing waters identified under the EC bathing waters Directive now meet the mandatory microbiological standards with over two thirds of these bathing waters also complying with the more stringent 'guideline' microbiological standards. The improvement in bathing water quality since 1990 (when mandatory compliance was only 77% and guideline compliance a mere 33% reflects the substantial investment in sewage treatment and infrastructure over the last 15 years. Although very few beaches continue to fail a significant number are at risk from agricultural and urban diffuse microbial pollution. Action is required to tackle this diffuse pollution if compliance with the more stringent microbiological standards proposed in the revised Bathing Water Directive is to be achieved.

Shellfish harvesting areas

4.64 Harvesting areas under the Shellfish Hygiene Directive are categorised according to the level of processing (cleaning) required before shellfish can go onto the market for human consumption. In England and Wales in 2003, 249 harvesting beds were classified in 79 harvesting areas. 4% were graded class A (i.e. shellfish may be sold directly for human consumption) and 81% class B (i.e. after passage through an approved purification) compared to 5% and 69% respectively in 1999. Some further improvement is anticipated when the current schemes of sewage treatment upgrades are completed. In Scotland in 2003 157 harvesting beds were classified. Sixty-eight percent were graded class B and 29% class A. In Northern Ireland of the 29 classified harvesting areas 17% were graded class A and 83% class B. In England and Wales the majority of the class C (i.e. must be relayed for at least two months then heat-treated) beds occur in Regions 4 and 5 whereas in Scotland they are in Regions 1 and 5, (Firth of Forth and Inverclyde areas respectively), where the population is mainly centred and sewage inputs are greatest.

Shellfish waters

4.65 Most of the standards under the EC Shellfish Waters Directive relate to chemical quality but it includes a guideline standard for the numbers of faecal coliforms in shellfish flesh. This standard is broadly equivalent to the standard for class A under the Shellfish Hygiene Directive and as a minimum requirement for England and Wales. The English and Welsh Governments have set an aim of achieving at least class B for all waters designated under the Shellfish Waters Directive. In order to link this target to sewage design criteria, a secondary standard has been defined in terms of the numbers of faecal coliforms in sea water. Compliance with the Shellfish Waters Directive has improved in recent years with 91% of UK designations complying with the mandatory standards in 2001. Data for compliance 2002–2004 will be available later in 2005.

Radioactive discharges

4.66 Exposure to radionuclides arises from numerous sources including weapons testing, nuclear accidents and nuclear fuel production and reprocessing, oil and gas production, steel processing and the processing of phosphate ores. The levels of exposure to artificial radionuclides and the effects of such exposure must be looked at in the context of exposure to all other forms of nuclear radiation including purely natural sources in the earth's crust.

4.67 Radioactive substances are closely regulated to protect the natural environment and to safeguard human health. In 1998 the UK Government signed the Sintra Statement which included a commitment that discharges, emissions and losses of radioactive substances are reduced by 2020 to levels where the additional concentrations in the marine environment above historic levels resulting from such discharges are close to zero. There are also internationally agreed limits of exposure exist against which UK exposures can be assessed. They are continuously reviewed as new information on the possible effects of environmental levels on humans and marine organisms is gathered. In all cases individual doses experienced by the public are well within the internationally agreed dose limits.

Impacts on the marine environment

4.68 The largest single input of artificial radionuclides to the UK marine environment arises from Sellafield on the Cumbrian coast (Region 5). Other sources arise from various nuclear powered electricity generating plants, naval operations, hospitals and radiochemical production at the GE Healthcare plant in Cardiff. Concern regarding radionuclides has focused on the potential impacts on human heath and uptake. Impacts on marine organisms have not been detected at population level even during times of maximum discharge.

The evidence and state

4.69 All authorised releases of radioactive materials are subject to regular monitoring and assessment of exposure. Measurements are also made of concentrations in sediment, water and biota around the UK as indicators of distribution of radiation in the environment and to estimate the exposure to other pathways such as use of seaweed as a soil conditioner. Discharge monitoring data are reported to the annual Radioactivity in Food and the Environment report the following:

- Discharges of radionuclides from Sellafield have been greatly reduced since the 1970s as a result of various measures and in most cases are now at least 100 times lower than peak discharge levels. An exception is ^{99}Tc (Technetcium) discharges which rose in 1994 following commissioning of the Enhanced Actinide Removal Plant (EARP). The increase in 1994 to a peak in 1995 was predicted and, like all other discharges of radioactive materials, had been granted an authorisation that took account of the low radio-toxicity of ^{99}Tc. ^{99}Tc has subsequently been detected in seawater and in lobsters, seaweeds and other marine biota, over a wide area of the northern Irish Sea, around Scotland (Region 6) and in the northern North Sea (Region1). Authorised annual discharge limits were reduced by slightly more than half from 200 to 90TBq in January 2000 and the intention is to reduce the authorisation limit to 10TBq by 2006.

- Concentrations of ^{137}Cs in sea water are now only a small percentage of those prevailing in the 1970s and concentrations in the North Sea are significantly lower than those observed in the Irish Sea. The highest concentrations of radionuclides occur in sediments in the eastern Irish Sea close to the Sellafield outfall. Remobilisation from these sediments contaminated by historical discharges is now the predominant source of caesium and plutonium in the water column. Despite this as with radionuclide concentrations in water, concentrations in biota have fallen in response to reductions in discharges and except for ^{99}Tc are now much lower than the peak concentrations observed in the 1970s and 1980s.
- In England and Wales the issue of licences to operators for the disposal of dredged material is only granted when the radioactivity associated with the disposal is below 0.01mSv or less (***de minimus*** levels) which implies radiological exposure levels are below those of concern.
- The OSPAR Quality Status Report 2000 did not identify radioactivity in the marine environment as an environmental problem.

Oil impacts

4.70 Oil and oil-based contaminants reach the marine environment via a number of routes including rivers and run off from land, atmospheric fall out and the offshore oil and gas industry (including oil discharged in produced water). Oil pollution can also result from deliberate or accidental discharges from ships.

Impacts on the marine environment

4.71 The implications depend on the type of oil, the magnitude of the discharge or spill and the local sensitive species. The implications also depend on the management response. The oil can be rapidly dispersed or linger in the environment. All levels of the food chain might be affected.

The evidence and state

4.72 Data on oil-based hydrocarbons entering the marine environment is collected in different ways and direct comparisons of quantities reaching the marine environment by different routes are not possible. There is no comprehensive monitoring of inputs of oil or oil based contaminants although PAHs are monitored annually in sediments at some NMMP sites and other data sources such as shellfish monitoring by the Food Standards Agency are discussed in the sector report. Oil spills from ships and offshore installations have to be reported. However, many illegal discharges by ships may be unreported.

Oil pollution from land-based sources

4.73 The largest inputs are still thought to come from land based and atmospheric sources. This is despite large reductions of inputs from refineries to rivers (approximately 20-fold since 1981) and volatile emissions of PAHs to the atmosphere (approximately a factor of 4 since 1990). With the exception of PAHs, the content is not particularly toxic, and since it is mostly in dispersed form, does not give rise to visible surface films and is relatively easily degraded.

4.74 Inputs to the different regions around the UK vary. Due to prevailing winds, inputs from the atmosphere mainly affect Regions 1 and 2 the North Sea. Inputs from refineries obviously occur only where these facilities are situated (Regions 1, 2, 3, 4 and 5).

Offshore oil and gas industry

4.75 A smaller input of oil is made by the offshore oil and gas industry via three principal sources a) oil spills which release free crude oil or heavily contaminated oily water onto the sea surface, b) oil in produced water discharges. (This is the residual oil that is discharged along with the water at production sites) and c) discharges from oil based production fluids (now banned) which were in the form of fine granular solids coated with oily mud. These oily solids formed aggregates which created accumulations known as cuttings piles beneath a number of the larger installations.

4.76 In recent years although the volume of produced water has increased the treatment efficiency has improved. The overall effect is that the quantity of oil entering the sea from this source has remained fairly constant at 5,000 tonnes per year. The industry operates mainly in Regions 1 and 2 and hence it is in the North Sea that the largest inputs have historically occurred. Region 5 is also affected (oil and gas extraction form Liverpool and Morecambe Bays) and Region 7 (oil production on the Atlantic Margin). Despite concerns about the risk of major oil spills occurring at an offshore oil production site no such incidents have so far occurred. Small scale spillages (300–400 per annum) do occur and there are mandatory reporting procedures. Most spills typically involve the loss of less than one tonne of oil and the environmental damage they cause is insignificant.

4.77 Drill cuttings contaminated by oil based drill muds are no longer permitted to be discharged to the sea. However, previous practises left piles of oil contaminated cuttings around many installations in Region 1 and surveys show that contamination and biological effects are decreasing.

Shipping

4.78 There are mandatory reporting procedures for oil spills from ships. Spills may arise from accidents involving tankers and other ships and slicks or more extensive surface oil/tar may be encountered as a result of deliberate discharges of oil or oily water from vessels.

4.79 There have been no major oil spills in UK waters since the Sea Empress accident off Milford Haven in 1996. The UK has a well established contingency plan to deal with such incidents, but the short-term consequences for the local environment and economy can be considerable. Seabirds in particular are likely to be badly affected, but the scale of impact is rarely as bad or as long lasting as predicted. Recovery from the most recent oil spills (The Braer and the Sea Empress) which both occurred in winter months was essentially complete within two years.

Overall environmental effects of oil

4.80 Sediment contamination by oil inputs is highest in estuarine and nearshore environments. The PAH levels in shellfish and sediments give some indication of the level of hydrocarbon contamination in the wider marine environment but we do not have a clear picture across the regions. Wider area survey protocols to determine sediment contamination levels are under development. One EcoQO under development in OSPAR is that of the proportion of oiled guillemots found on beaches. This is described in the seabird section 3.54.

Construction in the sea and coastal zone

4.81 There is considerable development along much of the UK's coastal zone including port development, coastal protection and construction for tourism and recreation purposes. The historical establishment of communities and infrastructure along the coast has been driven by the need to access the water for economic livelihood. There is growing pressure for renewable energy to be located in the offshore areas and offshore windfarms are already under construction. There are also natural processes occurring which modify the coastal zone and this section should be read in connection with the natural coast changes section in Chapter 3.34.

Impacts on the marine environment

4.82 There are various measures in place to safeguard the environment from the impacts of developments. These include measures to protect the physical environment from habitat degradation, fisheries resources, nature conservation sites, maritime culture (shipwrecks, prehistoric landscapes), and potential contamination of water biota or sediment. This can be done by adopting appropriate construction methodology, materials and timing of construction. Due to the limited space in the marine and coastal environment the cumulative effects of these developments need to be considered as a whole so that natural resources are adequately protected.

The evidence and state

4.83 Construction activities in the coastal and marine area need to obtain a licence. Part of the licence agreement is to monitor the impacts. The data from before construction can sometimes be found in the Environmental Impact Assessment EIA but there is no central coordination of the post construction monitoring, which is undertaken by various agencies and researchers; this means that the data sets on the impacts of coastal developments is dispersed. This will have to be addressed together with the growing demand to underpin decision making for each sectoral activity with a central (spatial) plan, a habitat map and the collection of nationally consistent data on impacts. Evidence of the state is that:

- The coastline around much of the UK has been modified to some extent to create ports, harbours, villages, towns and cities. Furthermore, in many areas coastal defence works have been erected either to prevent flooding of low-lying land or to reduce long-shore transport, beach loss and coastal erosion more generally. These various constructions have undoubtedly altered the shape of the coastline and the diversity of habitats available for wildlife. The exceptions are Regions 7 and 8 in western Scotland, which has suffered only limited construction from oil developments offshore and agricultural activity on the coast.
- A few major construction projects are currently planned or in progress. There are port developments in the Firth of Forth and in Region 2 at Immingham and Felixstowe/ Harwich and the Thames gateway development. Elsewhere the main activities are construction of new sewer outfalls associated with improvement of the quality of bathing waters and shellfish harvesting areas. Whilst we cannot turn back the clock we have to decide what 'state' of the coastline is acceptable (see also Chapter 3 coastal processes).
- Offshore Windfarm development is proceeding mainly in the southern North Sea (Region 2) and in the Irish Sea (Region 5). Some construction is also planned off the coast of South Wales in Region 4. To date, windfarms have been constructed, at North Hoyle off the North Wales coast and at Scroby Sands off Great Yarmouth. The first round of wind farm licences consented eleven further sites, each with up to 30 turbines. There are proposals for at least 15 more sites in the second round of consenting. Continued collaborative research into the potential impacts of offshore wind development, particularly into the present distribution of seabirds and mammals and the likely effects on them, is proposed as is post construction monitoring.

Aggregate extraction and sea bed disturbance

4.84 Much of the seabed surface around UK is comprised of sand and gravel in various proportions (see Figure 3.2). This can be dredged for use in the construction industry as well as in coastal and beach recharge schemes. Marine aggregate extraction is currently carried out at licensed sites in English, Welsh and Northern Irish waters. There are no active aggregate licensed sites in Scottish waters.

Impacts on the marine environment

4.85 Local benthic community structures and habitats are either removed or destroyed by aggregate extraction. Turbidity (the amount of solids in the water) also increases due to the sediment plume created during operations. Aggregate extraction can also interfere with traditional fishing grounds, by processes such as the removal of gravel deposits used by over-wintering crabs and the effect of fine outwash material on shrimps or fish. Timing and location of extraction is restricted via licence conditions to minimise such impacts and concerns.

The evidence and state

4.86 Government policy is to encourage exploitation of deposits offshore, provided this can be done with the minimum of effect on other interests – particularly fisheries and biological diversity. Licences for aggregate extraction have strong environmental controls and a commitment to monitor the marine environment.

- Most of the exploitable deposits are located around England and Wales in Regions 2, 3, 4 and 5. There is no active aggregate extraction off the coasts of Scotland. However, small quantities of maerl (calcareous algae) are extracted from a site off Shetland for use as a soil conditioner. The dredging of maerl is also still licensed in the Fal Estuary..
- To ensure conformity with the licence conditions the location of dredging activities is monitored by means of an electronic monitoring system (EMS) fitted on board the ship. The total areas involved in aggregate extraction are relatively small. In 2003, the total area licenced was 1245 km^2 of which 890km^2 was dredged, but in practice 90% of the activity took place in just 45.7 km^2.
- The quantities of marine aggregates extracted peaked in 1989 and have remained fairly static at around 23 million tonnes annually since that date. The bulk of this quantity was recovered from Regions 2 and 3 with only small quantities taken from off the North Wales coast (Region 5) and the Bristol Channel (Region 4). The relative proportions taken from Regions 2 and 3 may change following discovery of large resources in the eastern English Channel. If this were to be fully exploited it would account for more than 50% of the total extracted in future years. Aggregate extraction takes place in few areas around the coast of England and Wales, and despite concerns over the effect on local coastal morphology no direct relationships have been found. The monitoring suggest that the extraction has a low impact on the marine environment beyond the local impact area.

- Research projects have shown that samples of sediment and animals collected from areas of low dredging intensity were indistinguishable from surrounding areas after 6–7 years, but in areas where dredging intensity was high, effects can be seen on the sea floor more than ten years after the dredging has stopped.
- The Aggregates Levy Sustainability Fund (ALSF) was introduced in April 2002 to provide funds to help address the environmental costs of aggregate extraction. This allows further research on the environmental impacts and possible mitigation measures.

Box 4C Marine Aggregates and the Historic Environment

(Survey of Designated Historic Wreck Site HMS Colossus – courtesy of Kevin Camidge).

There is a good record of partnership between the historic environment sector and the marine aggregates industry. For example, English Heritage has worked with the British Marine Aggregates Producers Association (BMAPA) to publish a guidance note on the effects of marine aggregate dredging on marine archaeology. ***Marine Aggregate Dredging and the Historic Environment: Guidance Note (BMAPA & English Heritage, 2003)*** contains a comprehensive review of the issues relating to aggregate extraction and provides advice and procedural information relating to the offshore development process. This helps to preserve features in our sea such as that shown in the photograph above. For further information on the ALSF and Maritime Archaeology, visit ***www.english-heritage.org.uk/maritime.***

Dredging of harbours and navigation channels and disposal

4.87 There are roughly 150 ports in the UK of which 100 are commercially active. Seabed material has to be removed in the course of construction and maintenance of new port facilities and from navigation channels or marinas where they are subject to siltation. Between 25 and 40 million wet tonnes of material are dredged and deposited at about 150 licensed disposal sites annually. Whilst this is across all regions, over 60%, takes place in Regions 2 Southern North Sea and 5 Irish Sea.

Impacts on the marine environment

4.88 Dredging changes the morphology of the seabed and may change sediment transport patterns and can cause turbidity. The material removed must be placed somewhere and the logical place is elsewhere on the seabed. This may also cause morphological or chemical change at the disposal site, and may cause the benthos to become smothered. The operation may also directly impact other users of the sea such as navigation, fishing and conservation.

4.89 Dredged material may contain harmful contaminants such as TBT, PCBs and metals and there is potential for contaminant redistribution and release from the sediment to the water column where it is more available for uptake by living organisms. A licence is only given for dredging when a suitable disposal method and a site is found. This is taken account of in the licensing process. Licensing authorities control the number of disposal sites in order to minimise the extent of impacts on the seabed.

The evidence and state

4.90 Regular compliance monitoring of the impacts is targeted on key sites receiving large quantities of material or those which are adjacent to sensitive or conservation areas. This FEPA monitoring, conducted by CEFAS/FRS/EHS, concentrates on the physical distribution/transport, contaminant concentrations and fauna in the sediments. Samples of dredged material proposed for disposal are routinely screened to assess the extent of contamination by metals, TBT, PAH, PCBs etc in order to ensure the quantities of these substances do not exceed those which might adversely affect marine organisms in the deposition area.

4.91 Monitoring has demonstrated that impacts are mostly confined within the boundaries of the disposal sites and indicate that sea disposal is an acceptable option subject to continued oversight of the activity. Quantities have increased since 1992.

- Research has recently indicated that the short-term (i.e, 18 months) ecological impacts associated with the intertidal placement of fine-grained dredged material (beneficial use) for flood defence/habitat creation are comparable to those associated with sub-tidal placements. However, the potential long-term benefits of beneficial use schemes (e.g., keeping the sediment within the system) must be appreciated as part of the management process. As the ecological impacts of the coastal disposal of dredged material are primarily affected by variations in the characteristics of the dredged material, amount and frequency of placement and the nature of the receiving environment, each situation must be assessed on a case-by-case basis.

Litter and waste

4.92 Although the dumping of waste at sea is prohibited under the OSPAR convention and the dumping of waste and litter from ships in the North Sea is prohibited under MARPOL, and the London Convention, marine litter remains a problem for coastal communities and the marine environment. Tourism and river-borne litter are also important sources. The problem is preventable.

Impacts on the marine environment

4.93 Marine litter can pose a hazard to beach users and recreational water users. Fish, seals, cetaceans and seabirds can become trapped (e.g. in sections of discarded fishing nets and plastic or rubber rings). They can also ingest plastic particles and objects which can be fatal. It can also degrade the aesthetic quality of the environment, particularly in tourist areas.

The evidence and state

4.94 A number of surveys are undertaken primarily by NGOs and volunteers.

- The Marine Conservation Society annual ***Beachwatch survey*** is conducted by volunteers. It provides the only long-term dataset and measures the number of items per km of beach. The current levels of beach litter are high and have increased by 50% over 1994 levels.
- The aesthetic quality of beaches is surveyed annually by the National Aquatic Litter Group (NALG) in designated bathing beaches across the UK. A grade of A to D (good to bad) is assigned for a combination of sewage related debris, gross and general litter, potentially harmful debris, oil, dog faeces and large accumulations of litter. The number of bathing beaches graded A or B rose from 77% in 2000 to 82% in 2002.

Introduction of non-native species

4.95 Non-native species can be introduced in a number of ways. Shipping activity can result in the introduction of non-native species through the exchange of ballast water between global ports or via fouling of ship's hulls. Aquaculture operations may also be responsible for introduction of non-native species. Other less obvious routes are via the public and climate change impacts in the marine environment may mean there are large bio-geographic shifts in species. Therefore the definition of 'native' species may not be static.

Impacts on the marine environment

4.96 Once introduced, non-native species can be virtually impossible to eliminate and can disrupt the ecosystem balance. They can then migrate and spread around the UK particularly if ship antifouling paints are not as effective as the now banned TBT. Each new species may result in different problems for that specific ecosystem. The IMO produced an Non-native Invaders fact sheet 2004.

The evidence and state

4.97 There is little information available to assess the impacts or state of non-native species. At least 50 species have so far been identified as non-native in British waters. The range of species involved includes five species of diatom, one species of flowering plant, at least 15 species of seaweed and 30 of invertebrate animals. Two examples are shown in Figure 4.5. Early detection of new species is a challenge for any marine monitoring programme and one to address to prevent or mitigate the threat. The state is that:

- more than 50% of non-native species found in British waters are estimated to have been introduced by shipping. The International Maritime Organisation adopted a Ballast Water Convention in February 2004 and has drawn up guidelines for the control and management of ballast water aimed at minimising the transfer of harmful aquatic organisms.
- a few species have been introduced deliberately in connection with mariculture projects, for example the pacific oyster and soft shell clam, or by accident with transfers of cultivated shellfish species from outside UK waters. ICES has developed a code of practice to cover this.

Figure 4.5: Examples of non-native species*

* a) Mitten Crab *(Eriocheir sinensis)*, whose use of soft embankments can cause costly damage (Civil Service Canoe Club)
b) Japanese weed *(Sargassum muticum)*, as first discovered at Bembridge, Isle of Wight (Dr Gerald Boalch, Marine Biological Association of the United Kingdom, Plymouth).

Summary of the evidence of Human Impacts in the Marine Environment

4.98 Humans make use of marine resources directly in a number of ways. They also have indirect effects on marine waters arising from actions on land such as discharges of hazardous substances and nutrients to estuaries. A more tenuous link is with the actions giving rise to the anthropogenic induced aspect of climate change. Table 4.2 summarises the evidence presented for human impacts in UK Seas.

4.99 The impact of fishing on fish stocks, by-catch species and the wider marine environment remains the largest impact in UK waters. The activities are largely unregulated for their environmental impacts and we have no strategic monitoring of these impacts other than monitoring of commercial stocks.

4.100 However, the evidence also shows that there has been a marked decline in measured contaminants reaching sea. This is a result of the steps taken to reduce inputs of substances that are recognised as harmful or potentially harmful e.g. nutrients, toxic chemicals, persistent and bioaccumulative chemicals and discharges of oil and undesirable chemicals by the offshore oil and gas industry.

4.101 In addition, the implications are that many of the known pressures are on a local scale. Further projects such as navigation dredging, aggregate extraction and any form of construction whether it be a new groyne, beach replenishment, stretch of seawall, pipeline, harbour or windfarm, requires a licence. The licensing process usually involves an environmental impact assessment and negative potential impacts on the environment are therefore mitigated where possible.

4.102 The lack of a full seabed habitat map makes assessing the significance of the foot print of these activities difficult. The cumulative impacts of all these activities occurring simultaneously are not understood. This report does not cover the social and economic issues that need to be taken into account in ensuring that marine resources are managed in a sustainable way.

Table 4.2: Summary of human impacts in our seas via pollution and physical disturbance

Categories	Associated measurements and research findings	Results	Assessment Confidence*	Sector report Chapter rem
Hazardous substances	Inputs of monitored heavy metals, lindane and PAH via rivers	Inputs are decreasing over time due to various regulatory controls and are moving towards the OSPAR 2020 cessation target.	III	MEQ Chapter 3
	Atmospheric emissions of heavy metals from point sources	Emissions have generally decreased significantly in recent years due to regulatory controls, particularly the application of best available technology. Emissions are moving towards the OSPAR 2020 cessation target.	III	MEQ Chapter 3
	Inputs from aquaculture	The leakage of medicine and chemicals from fish farms were a concern but have now been controlled.	II	MHS/EQ Chapter 1
	Concentrations of contaminants in water	Levels are not harmful to biota, except possibly at a small number of sites in some industrial estuaries.	II	MEQ Chapter 3
	Concentrations of contaminants in sediments	Levels are above those considered potentially harmful to biota in some industrial estuaries. However, these are mainly from historical activities.	III	MEQ Chapter 3
	Concentrations in biota (various)	Generally low, but some localised areas of high concentrations found in industrialised estuaries. There is evidence to suggest that PCBs accumulate in the blubber and mercury in the liver and reduce the ability of marine mammals to fight disease.	II	MEQ Chapter 3
Oil	Inputs of oil from refineries and the offshore industry	Inputs from Industrial offshore oil and gas refineries have reduced substantially. Oil from cuttings discharges has been eliminated but produced water contributions have risen as volumes increase; overall, oil inputs have decreased.	III	MHS Chapter 5
	Inputs of oil from shipping	No significant/major spills in UK waters since 1996, but some illegal discharges.	III	MFF Chapter 5
Radioactive substances	Radionuclides in discharges and water, sediment and biota	Inputs to sea and levels of radioactive substances in marine biota significantly reduced in recent years. The highest concentrations of radionuclides occur in sediments in the eastern Irish Seas close to the Sellafield outfall.	III	MFF Chapter 6
Nutrients	Inputs of nitrogen and phosphorus via rivers	Direct inputs have reduced by 35% since 1990 but the river flow volumes are critical. Offshore waters are not affected by the land based input (except perhaps in the Irish Sea).	III	MEQ Chapter 2
	Observations of eutrophication and chlorophyll concentrations	Concentrations high enough to cause ecological disturbance have been observed in only a few estuarine environments and harbours.	III	MHS Chapter 2
Microbiological inputs	Measurements of sewage bacteria in bathing waters, shellfish waters and shellfish	Bathing water quality has improved: only a handful of beaches fail European mandatory standards and three quarters meet guideline standards. Shellfish hygiene standards are improving but shellfish water quality is variable.	III	MHS/ MFF Chapter 4
Physical seafloor disturbance	Scale of human activities and information from licence conditions	Fishing, aggregate extraction, dredging disposal and construction all impact the sea floor. Monitoring and licensing of most of these activities aims to minimise the impacts but it is likely that benthos communities are impacted by commercial fishing in areas where the intensity of trawling prevents recovery.	II	MHS Chapter 3
Litter	Annual Beachwatch Surveys of beach litter	Beach litter levels are high and despite some improvements in recent years, leading to improved general beach quality (estimated by the National Aquatic Litter Group), litter levels have increased since 1994.	III	MHS Chapter 8

*** Confidence in the statements we are making from the available evidence.**

Confidence assessment **III** High **II** Good/Satisfactory **I** Low **0** No assessment possible

Chapter 5: Regional Assessments

5.1 The Integrated Regional Assessment, which is included in the CD attached to this report or can be seen on the Defra website, sets out the evidence provided in the sector reports for each of eight regional areas into which the UK seas have been divided – see Figure 5.1. This chapter summarises that evidence, and sets out the major issues arising in each of the regions.

5.2 It should be noted that an issue highlighted as of importance for a particular region does not necessarily mean that it relates to a current significant impact or problem. Rather it indicates that the issue is either of high public concern or an ongoing activity which could, if unmanaged lead to significant impacts in the regional ecosystem. Consideration of these issues at the regional level will help the development of an effective framework for marine stewardship in which issues are tackled on the most appropriate and effective scale. There may be additional issues of high local concern which are not in the generalised regional summary.

How the regional areas have been defined

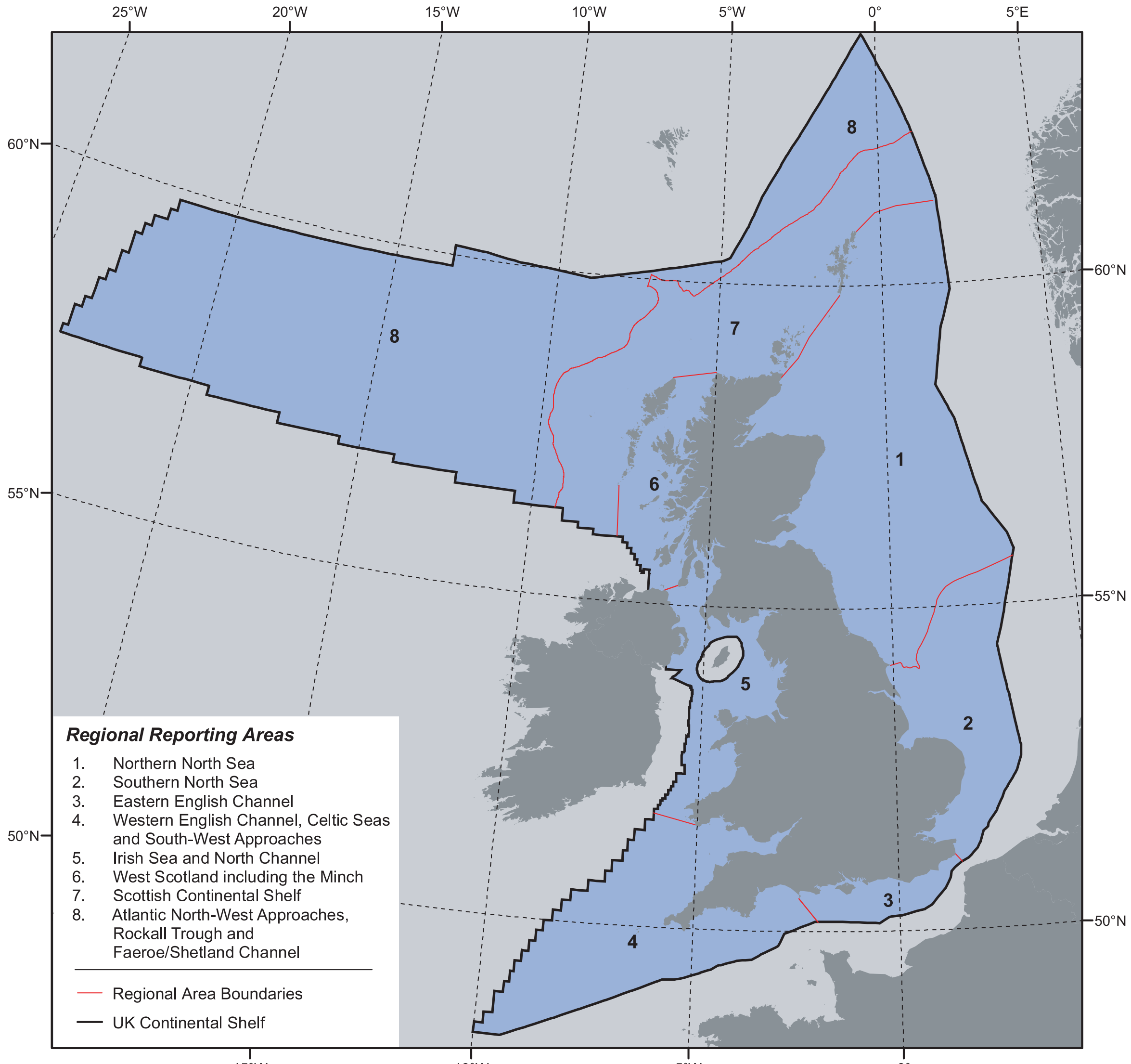
5.3 The aim has been to define regional sea areas which reflect, as far as possible:

- Subdivisions of the sea which are ecosystem-based and make sense ecologically.
- The distribution of natural resources.
- The socio-economic uses made of the area.

5.4 UK waters have previously been split into regions for a number of purposes including fishstock assesssment and conservation. The 8 regional areas used for this state of the seas report (Figure 5.1) are based on the 11 biogeographic regions identified as part of the Review of Marine Nature Conservation RMNC (Defra, 2004b). The areas are defined principally by reference to physical and biological features such as tidal fronts and seabed flora and fauna.

5.5 This report concerns waters within UK jurisdiction. However, the evidence reported may well be relevant to the quality of international waters and waters under the jurisdiction of other countries since natural and anthropogenic influences can move freely across the boundaries in either direction.

Figure 5.1: Regional Reporting Areas in UK waters*



Note: The exact limits of the UK Continental Shelf are set out in orders made in Section 1(7) of the Continental Shelf Act 1994.

* Areas based on RMNC. Note that because marine waters, sediment and biota are highly mobile it is not possible to draw sharp boundaries; therefore, the divisions on the map are only a representation of a transition from an area of one character to another. We have not considered in this report the extension of boundaries beyond UK waters.

What the regional assessment shows

5.6 Table 5.1 and Figure 5.2 illustrate how the nature and the magnitude of the threats vary across the regions. A few general conclusions can be made:

- Climate change and the impact of commercial fishing (both on stocks of the targeted species and on other marine life including the benthos) are issues for all the regions. They are also the issues on which there is the greatest need for more understanding of the extent and nature of these impacts.
- None of the regional areas are unaffected by human activity but some such as the Southern North Sea (Region 2) and the Irish Sea (Region 5) have more issues of concern than any of the other regions. These are also the regions with the largest and most industrialised coastal communities.
- Coastal areas are under the greatest pressure from the inputs of contaminants and nutrients although these are rarely a regional problem. Coastal habitats are also under pressure from rising sea levels, development and hard flood defences.
- There is a real need to understand the in-combination effects of many activities in order to assess the overall impacts on the marine ecosystem as a whole.

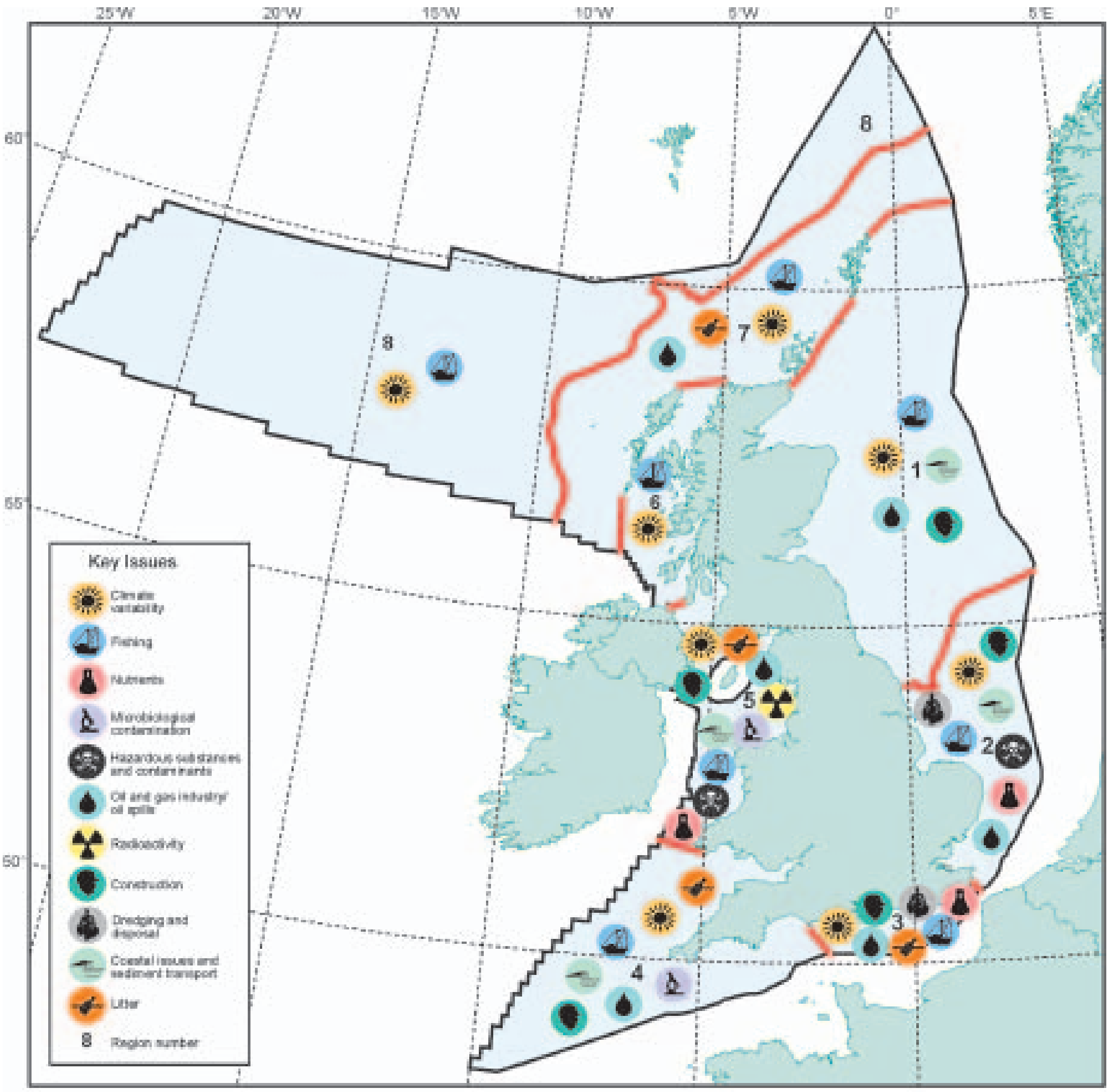
Table 5.1: Main Issues for each region*

Region	1. North Sea	2. Southern North Sea	3. Eastern English Channel	4. Channel and Approaches	5. Irish Sea	6. Western Scotland	7. Scottish Continental	8. Scottish Offshore
Climate Impacts	■	■	■	■	■	■	■	■
Fisheries	■	■	■	■	■	■	■	■
Nutrients		■ Coastal	■		■			
Microbiological Contaminants				■	■			
Hazardous Substances		■			■			
All oil Industry	■	■	■	■	■			
Radioactivity					■			
Construction	■	■	■	■	■			
Dredging		■	■					
Sedimentary and Coastal Erosion	■	■		■	■			
Litter			■	■	■		■	

■ Considered important issue per region

* See also Map (Figure 5.2).

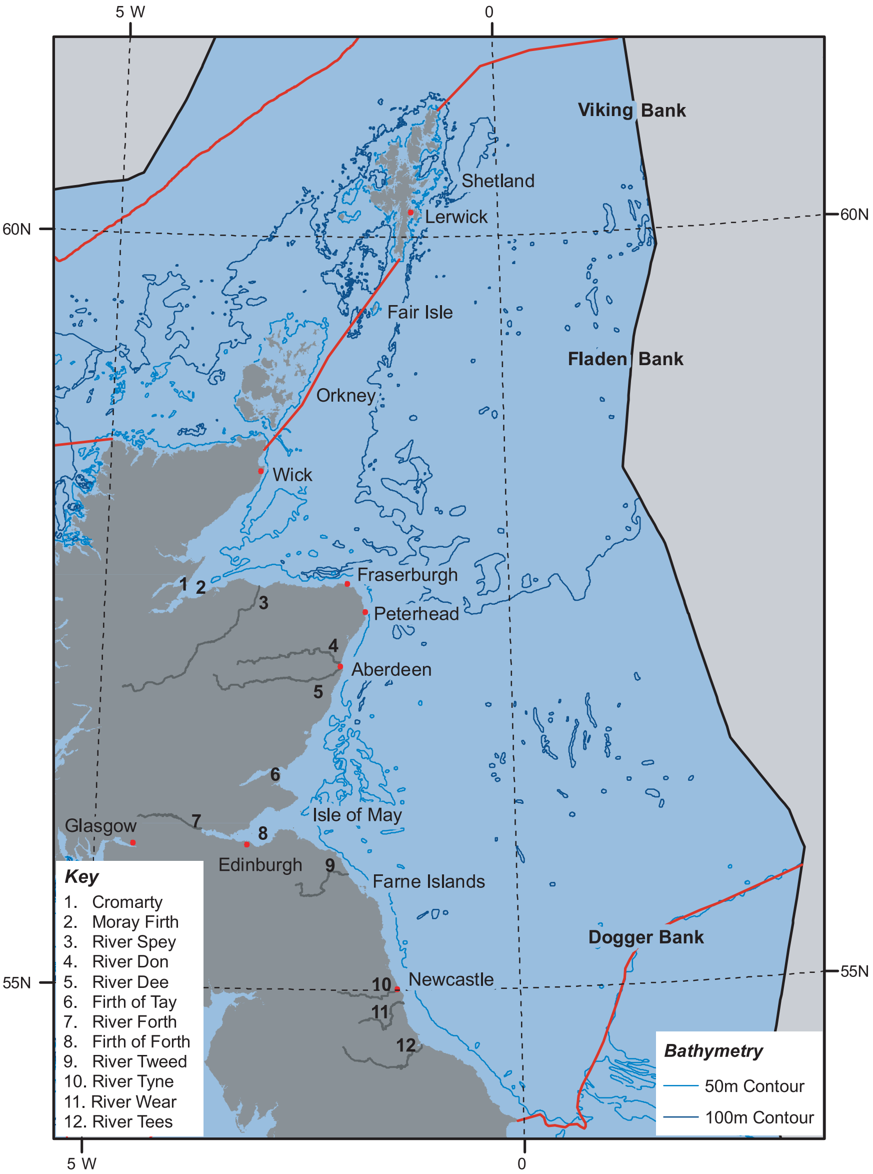
Figure 5.2: Main Issues for each region*



* See also Table 5.1.

Region 1 – Northern North Sea

Figure 5.3: Map of North Sea Region 1



Note: bathymetric contour data copyright UKHO.

5.7 Region 1 the North Sea north of the Dogger Bank includes the Scottish and English coasts as far south as Flamborough Head (Figure 5.3). The region supports a substantial proportion of the UK's globally important seal and seabird populations. The sea area is used for commercial fisheries, oil and gas industry, windfarm construction and is subject to coastal erosion.

5.8 *Climatic variability.* Records of sea surface temperatures indicate a rising trend since the 1970s while sea surface salinity has been decreasing over the same period. Plankton show an increase in the proportion of warm water species and a complementary reduction in cold water species. This is consistent with the evidence from the whole North-east Atlantic area and a sign of climate change (nutrient inputs, which could also affect plankton, are not a main issue in Region 1). There is also evidence that the collapse of the sandeel population around Shetland in the late 1980s, which seriously affected the breeding success of some seabirds, was attributable to climate change.

5.9 *Fisheries.* Region 1 continues to be one of the most productive fisheries in the UK accounting for the greater part of the North Sea's fish production. However, in the last 10 years the stocks have been reduced. Cod is particularly at risk of collapse and a recovery plan is in place. Only 4 of the nine main commercial species, including haddock, herring, saithe and sole are being fished at levels which are within safe biological limits. Landings of ***Nephrops*** (Norwegian Lobster) are also currently at rates considered to be sustainable. The wider ecosystem effects of fishing are shown by the fact that heavy trawling gear has permanently damaged the diversity and abundance of benthos populations in areas that are frequently trawled. Also the by-catch of harbour porpoises and other species remains a concern.

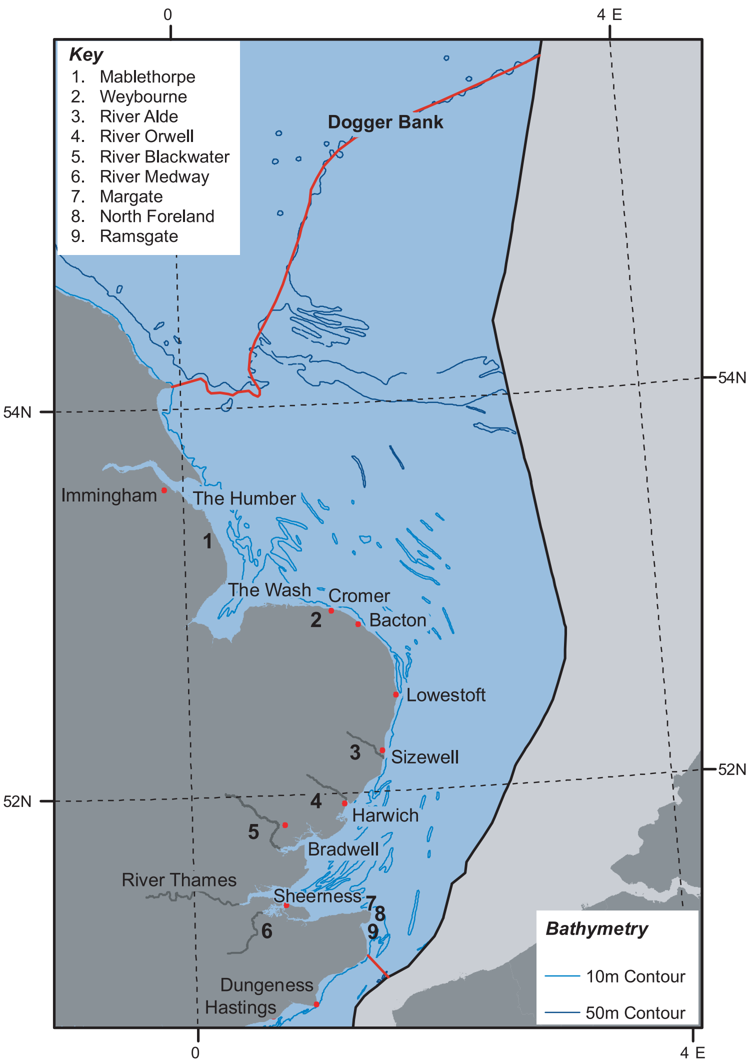
5.10 *Oil.* Much of the UK's current oil production takes place in Region 1. However, measurable environmental effects from current production activities are limited and produced water discharges do not give rise to visible oil slicks. There remains concern about the local effects of accumulated piles of contaminated cuttings from past activities. These effects will remain both localised and will continue to decline provided that the cuttings remain undisturbed.

5.11 *Coastal issues.* Natural coastal erosion occurs in many places and there are a number of developments on the coast but in general the sedimentary system works in equilibrium with erosion of material in one area providing material for beach and flood protection. Two bathing beaches failed the mandatory bacteriological standards on the Yorkshire coast and in Moray Firth, shellfish waters were classified as Class C meaning that improvements are desirable.

5.12 *Construction.* In addition to oil and gas platforms the area will be used for a significant number of offshore renewal energy projects such as wind farms. Such projects may only be approved after assessment of their significant environmental effects, and it will be important to ensure that the location of each development is decided with full regard to the environmental implications.

Region 2 – Southern North Sea

Figure 5.4: Map of Region 2



Note: bathymetric contour data copyright UKHO.

5.13 Region 2, the Southern North Sea, extends from Flamborough Head in the North to the Dover Straits in the south (see Figure 5.4). The region is subject to many anthropogenic pressures including fisheries, inputs of nutrients and hazardous substances, the oil and gas industry, construction, dredging and coastal erosion. In addition much of the heavily populated coast is low-lying and at risk of flooding. The input of contaminants and nutrients from land have been reduced and the region has populations of both common and grey seals noticeably in the Wash and the Humber Estuary. There are number of major seabird colonies and protected sites.

5.14 *Climatic variability.* Records of sea temperatures indicate a rising trend around 0.5°C/decade although in certain weather conditions there are intrusions of cold water through the Dover Strait. Winter sea bottom water has also increased since the 1970s in all of the North Sea fishing grounds (0.3–0.6°C/decade). There has been an increase in the frequency of storms recently while salinity values have not changed significantly. Plankton populations show an increase in the proportion of warm water species and a complementary reduction in cold water species. This is consistent with the evidence from the whole North-east Atlantic area and a sign of climate change. The change in the plankton species and timing of blooms are less favourable to the young stages of cod. Therefore this plankton shift could slow the recovery of cod stocks. Overall productivity of plankton has increased with major increases being noted since 1998.

5.15 *Fisheries.* The Region supports a large and varied fishing industry, although it is less important in catch terms than that of the northern North Sea Region 1. Only herring stock is being exploited at a safe level. The main commercial species of plaice and sole are both outside of precautionary limits. The use of bottom trawls in certain heavily fished areas has seriously affected the benthos, reducing species abundance generally and numbers of the larger more fragile species while increasing the numbers of opportunistic and smaller species. However, in general the benthic structure within the southern North Sea is dominated by the nature of the seabed, latitudinal influence and temperature. The scale of fishing mortality of harbour porpoises and other species remains an issue of concern in the central North Sea. Seabirds may also be affected. There are as yet no reliable targets or indices against which to judge either the acceptability of change or normality of the species diversity for the Region as a whole.

5.16 *Nutrients and hazardous substances.* The input of both organic and inorganic contaminants especially via the Humber and Thames, is substantially less now than in it was in the past. Much of the region is unaffected by contamination. However, a few estuaries still contain concentrations of some contaminants in the environment that are undesirably high. In only a few instances are they likely to cause biological effects and there is no suggestion that fish stocks have been affected by chemical contaminants. Similarly, inputs of nutrients from land have reduced and there is little evidence of eutrophication or of elevated chlorophyll levels in the offshore region. Suspended sediment loads in the southern North Sea tend to be high; this restricts light penetration and has consequences for the growth of phytoplankton and the marine food web generally. There have been changes in plankton composition but these are attributable to changes in physical environmental conditions, particularly temperature, affecting the whole north-eastern Atlantic. However, there is a need to keep such areas which may be affected under review and to work towards evaluating the possible impact of UK nutrients in remote areas.

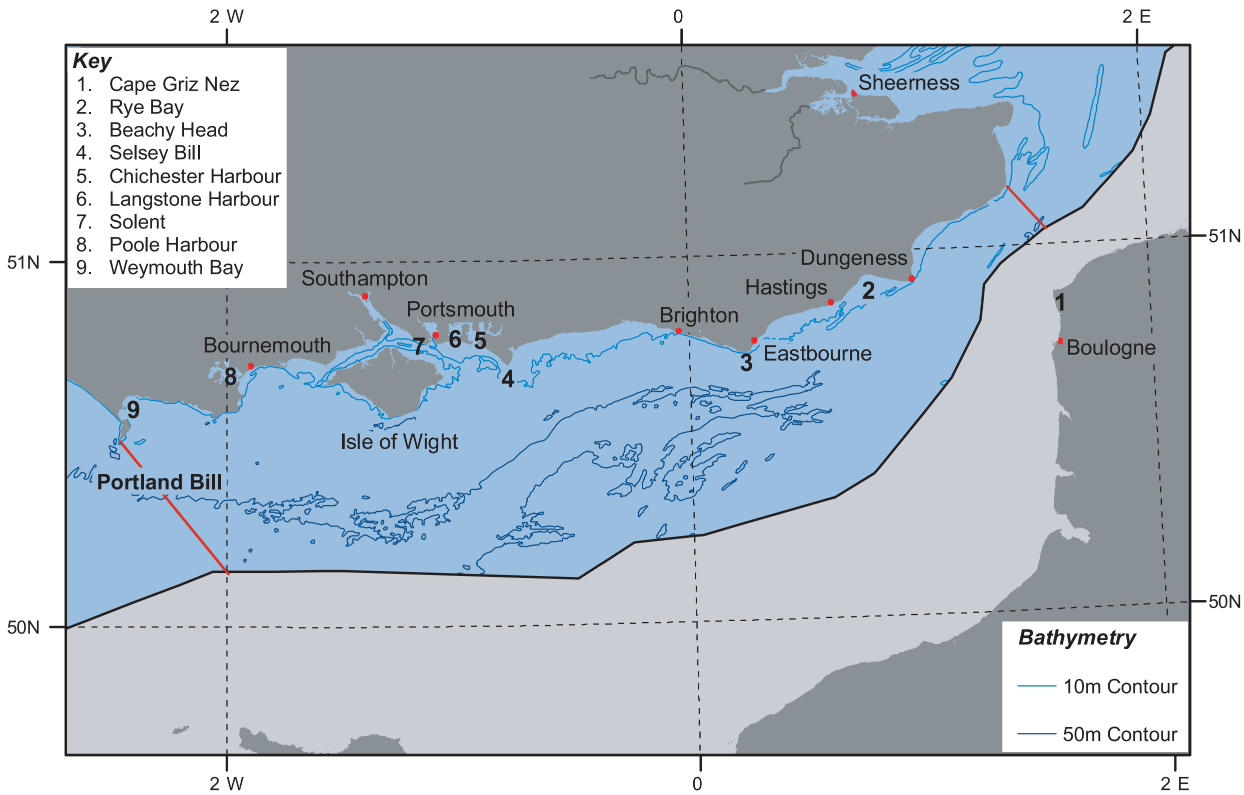
5.17 *Oil.* Exploitation of gas reserves is a major activity, but seabed disturbance as a consequence of drilling activity and pipeline construction is no longer a significant issue. Oil pollution as a consequence of illegal discharges from ships still occurs but causes little lasting damage to marine life or beaches.

5.18 *Construction and dredging.* About 5 million tonnes/year of aggregates are extracted from the region's seabed for use by the construction industry or beach recharge. In addition, about 6 million tonnes/year of dredged material from maintenance or harbour dredging continue to be disposed of at sea. Both activities are regulated to minimise the impacts on the sea floor and surrounding environment. Much of the development of wind powered electricity generation is taking place, or is scheduled to take place, in the Region.

5.19 *Coastal Issues.* Due to the risk of flooding as a result of coastal erosion of soft cliffs, storms and overall sea level rise, much of the coastline has been modified by sea defence works. There is also extensive modification to the coastline around urban areas and port complexes where population densities are high. Ongoing developments in the coastal zone puts pressure and on shallow water areas such as sandbanks, saltmarshes, mudflats and seagrass beds.

Region 3 – Eastern English Channel

Figure 5.5: Map of Region 3



Note: bathymetric contour data copyright UKHO.

5.20 Region 3 comprises the English Channel east of Portland Bill and includes some of the busiest shipping lanes in the world. The region is strongly influenced by inflow of water from the Atlantic. The coast is well developed and there is a high population density but major industry only on Southampton Water. All beaches reached the EU bathing water standards and the region has a number of representative and threatened habitats such as mudflats, littoral and sub-littoral chalk, sub-littoral sands and gravels and seagrass beds. Five sites have been designated for seabird protection in the Region and there is no particular cause for concern over man's adverse impact on seabirds. Mediterranean gulls have started to breed in the area in the last 20 years.

5.21 *Climatic variability.* Records of sea temperature indicate a rising trend in line with trends throughout the North-east Atlantic area. Plankton populations show an increase in the proportion of warm water species and a complementary reduction in cold water species which is consistent with the evidence from the whole North-east Atlantic area.

5.22 *Fisheries.* Inshore fishing fleets have declined in recent years and fishing effort is now dominated by larger vessels. Fishing productivity has fallen and most of the main commercially exploited stocks such as cod, whiting and plaice are outside safe biological limits except sole and shellfish which are being exploited within sustainable limits. The information available about the wider ecosystem effects of fishing in Region 3 such as seabed disturbance and by-catch is limited but sufficient to suggest that the effects are similar to those in other regions. In particular fish assemblages broadly reflect the nature of the benthos but the common skate and angel sharks are no longer seen in the Channel.

5.23 *Nutrients and contaminants.* In a number of enclosed sea areas including Chichester, Langstone and Portsmouth Harbours there is excessive growth of *Enteromorpha* (a seaweed), which is thought to be due to nutrient inputs from sewage and/or agricultural run-off. These areas have been identified as eutrophication problem areas. The problem is being tackled by remedial measures required under EU legislation and the region does not generally display the negative effects of enhanced algal blooms. Concentrations of monitored contaminants are generally low in the region.

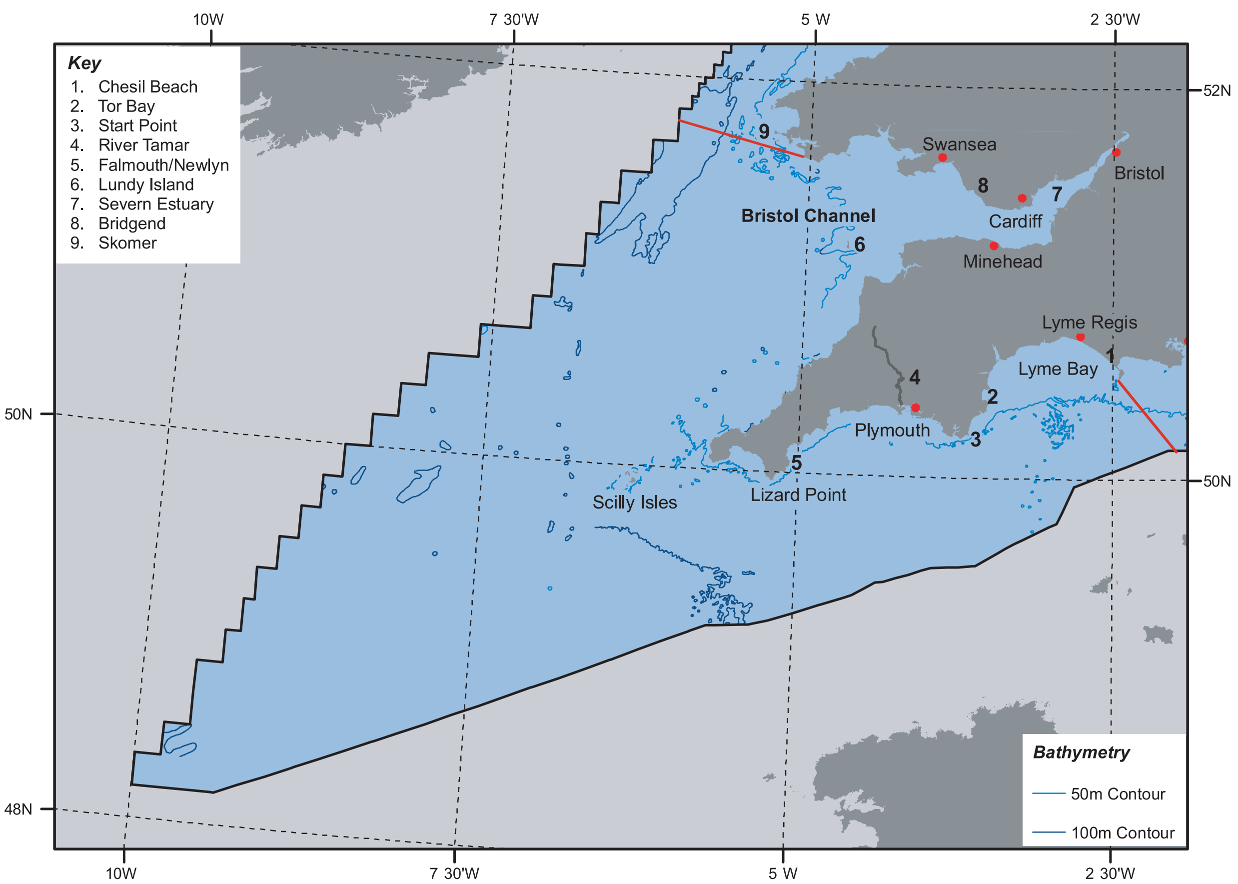
5.24 *Oil.* Oil production continues on a small scale around Poole Harbour and at Kimmeridge on the Dorset coast. There are a number of natural oil seeps around the base of the cliffs in this area and as in other regions there continue to be reports of oil slicks which are believed to be discharges from ships. These are mostly around the Isle of Wight and in Weymouth Bay, but they cause no serious ecological damage or beach pollution.

5.25 *Construction and dredging.* Large sections of the coast have been modified by urban and port developments with some coastal defence works, particularly in the east of the Region, designed to minimise beach erosion and/or to reduce the risk of coastal flooding. Dredging continues to take place in most port areas to maintain navigation channels and harbour depths. Disposal of the dredged material is only permitted in designated disposal areas all of which have been selected so as to minimise effects on the environment and other user interests. There are substantial deposits of sand and gravel offshore e.g. on Hastings Bank, which are actively exploited. Additional reserves have been identified in recent years in deeper waters and applications for licences to extract sand and gravel have been submitted to Government. If any of these applications are found to be environmentally acceptable any resulting licences might contribute significantly to the level of supply of aggregates from the eastern English Channel. However, the total area involved is small relative to the area of the whole of the Region and extraction would be subject to controls intended to minimise impact on the environment and other user interests.

5.26 *Coastal issues.* The rising sea levels combined with sinking of the land mass is enhancing the risk of coastal flooding and erosion of beach areas. Litter, particularly on beaches, gives rise to aesthetic concern; its impact on biota has not been quantified but can be a hazard to marine life.

Region 4 – Western English Channel, Celtic Seas and South-west Approaches

Figure 5.6: Map of Region 4



Note: bathymetric contour data copyright UKHO.

5.27 Region 4 covers all the south western approaches west of Portland Bill and south of Milford Haven, and the waters of the region extend out to the shelf break in the Atlantic Ocean where water depths reach 1000m. The area is exposed to the prevailing westerly winds and waves and subject to some of the strongest tidal currents in the world, especially in the Bristol Channel. Along the south coast of England suspended solids concentrations are generally low although in the inner reaches of the Bristol Channel and in the Severn estuary, suspended solids loads are considerably higher as a consequence of the strong tidal currents and waves. A greater variety of fish species is found than in any other region, including native species that have become rare in other regions and and increasing number of previously uncommon visitors from warmer waters to the south. The region also includes some important seabird and seal habitats, including at Lundy Island one of the UK's three designated Marine Nature Reserves.

5.28 *Climate variability.* The rise in sea water temperature has is less notable in this region with the increase at the shelf edge being between 0.12 and 0.29ºC. There have been marked variations in salinity since the start of the twentieth century but no overall trend. The intensity of storms has increased as have average wave heights. These changes are likely to have as much to do with mid-Atlantic weather and ocean variability as with local conditions. The changes to plankton populations, which show an increase in warm water species, are consistent with those found throughout the North-east Atlantic area because waves reaching this area may have been generated well outside the Region. The region's benthos shows changes attributable to immigrant species and increases in water temperature.

5.29 *Fisheries.* Most of the commercially exploited fish stocks are considered to be fished at outside biologically sustainable levels and reduced effort/recovery plans have been proposed. Exploitation of most shellfish stocks appears to be at an acceptable level but with over 2000 licences for mussel cultivation and cockle hand gathering this is a significant pressure in the region. There is evidence of seabed disturbance and damage to benthos from the use of heavy trawl gear. By-catch mortality of common dolphins causes particular concern.

5.30 *Microbiological contaminants.* There have been improvements in sewage treatment works but microbiological contamination of coastal waters remains a recognised issue for Region 4. The region contains 2 of the 5 UK beaches which in 2003 failed to meet the mandatory standard prescribed by the EU Bathing Waters Directive. Monitoring of microbiological contamination of shellfish indicates that a significant proportion of the shellfisheries in the region fail to meet the standards and guidelines. Most of the UK shellfisheries which fail to meet those targets are located in Regions 4 and 5.

5.31 *Oil.* As in other regions with substantial shipping traffic, discharges of oil from ships remain a concern. However, recovery is now complete from the region's two major oil spills:

Name of tanker	Date	Recovery time
Torrey Canyon	1967	15 years
Sea Empress	1996	2 years

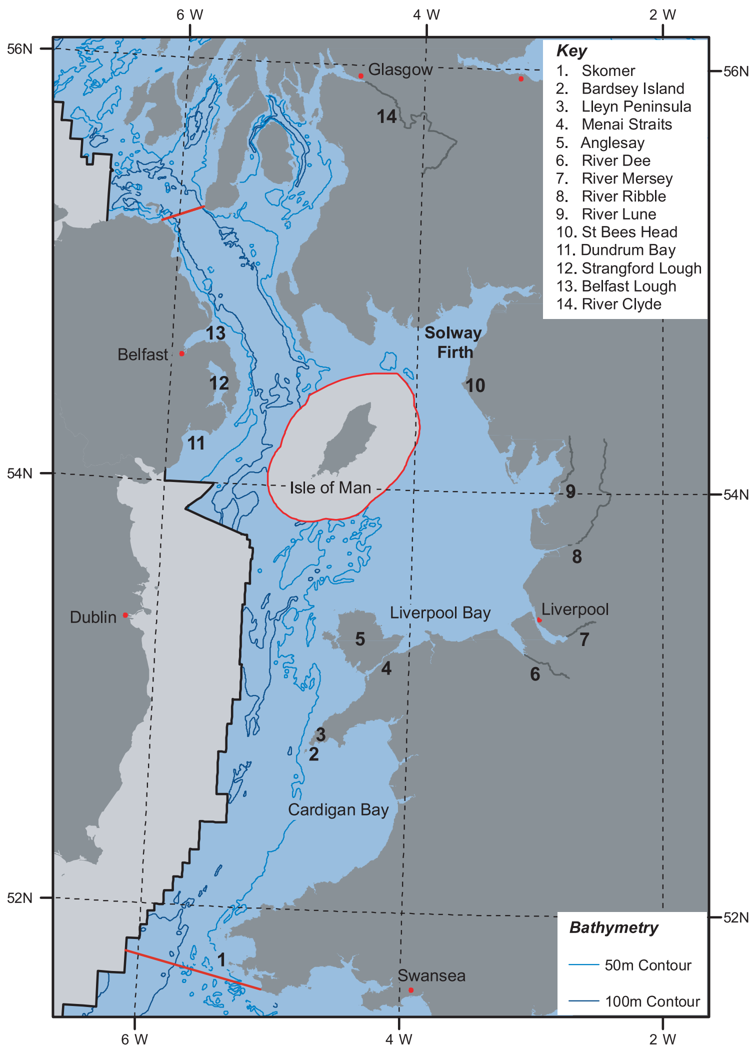
In the Sea Empress case the use of lower toxicity dispersants helped to speed recovery.

5.32 *Construction.* The proposed installation of up to 30 wind turbines on Scarweather Sands in Swansea Bay is a major project. The potential use of other renewable energies such as tides and waves are being explored in the area. The consent processes will aim to ensure that the development causes the minimum of adverse effects on other uses of the marine environment. Only about 4% of the UK total marine aggregates are dredged from the Bristol Channel (this was 8 million tonnes between 1992 and 2002).

5.33 *Coastal issues.* The sea level rise noted as part of climate change is compounded in the region by the land mass subsidence due to post glacial adjustment. A national survey in 2003 suggested that the density of beach litter in Region 4 was about twice the average for the UK as a whole.

Region 5 – Irish Sea

Figure 5.7: Map of Region 5



Note: bathymetric contour data copyright UKHO.

5.34 The Irish Sea region, is bounded to the north by a line from Mull of Kintyre (Scotland) to Fair Head (Northern Ireland) encompassing the North Channel within the region (Figure 5.4). For practical reasons both the northern and southern boundary has been aligned to those used in the Irish Sea Pilot Project.

5.35 Region 5 is the most enclosed of all the marine regions and has the major UK conurbations of Merseyside/Greater Manchester, Strathclyde and Belfast on its shores. The water is strongly influenced by coastal processes, turbid, stratified and has a slow circulation. Hence, it is not surprising that it is one of the two UK regions which is most affected by anthropogenic pressures especially in its northern half. Nevertheless the region contains a wide variety of habitats worthy of protection including two of the UK's three Marine Nature Reserves at Skomer and Strangford Loch, 45% of the worlds population of Manx shearwaters and the resident populations of dolphins and seals.

5.36 ***Climate variability***. Sea temperatures have risen, salinity has decreased (though not statistically significantly) and wave heights increased between 1960 and 1990. As in other regions there is clear evidence of changes in phytoplankton and zooplankton since the late 1980s; the timings of blooms indicate that these changes are not attributable to changes in nutrient inputs, but are associated with similar changes over a wide area of the north-east Atlantic that are probably induced by climate change.

5.37 ***Fisheries.*** Commercial landings of fish are substantially below the levels achieved in the past and the stocks of most commercially exploited species apart from plaice, sole and ***Nephrops*** are considered to be outside precautionary limits. Herring have shown signs of recovery in recent years but as a result of commercial fishing pressure, species such as the common skate and white skate are now rare or totally absent from the region. In addition, there is evidence of the adverse effects of by-catch which diminishes the food available for seabirds, and of damage to the seabed and to benthic species from the use of heavy trawling gear. The Strathclyde region is an important area for mariculture, particularly for shellfish. Over half of the entire UK mussel production arises from the Menai Straits, North Wales.

5.38 ***Microbiological contaminants.*** The microbiological quality of bathing waters has improved substantially since 1990 but is still below satisfactory levels. In 2003 five beaches in the Region failed the EU bathing waters standards. This is the highest failure rate of any region but does nevertheless indicate the effectiveness of the several sewage treatment and disposal schemes commissioned since 1999. In 2002 five of the seven Shellfish designated waters that failed to meet the desired standard in 2002 are located in the Region. Some improvements in the microbiological quality of shellfish harvesting waters have also been achieved through better sewage treatment although several to be graded as class C thus precluding practical harvesting for human consumption. The effects of organic enrichment in Belfast Lough has been reduced in recent years following reductions in the input of organic matter with the cessation of disposal of sewage sludge.

5.39 *Nutrients.* Offshore concentrations of winter dissolved inorganic nitrogen are above the normal range, but have stabilised or begun to fall since input reduction measures were introduced in 1990. Chlorophyll exceeds background levels at a number of locations but the concentrations are high enough for eutrophication to occur only in Belfast and Strangford Loughs. Elsewhere there is no evidence of algal blooms that might be attributable to eutrophication and off the Isle of Man there is evidence of a decrease in primary productivity in recent years.

5.40 *Hazardous substances.* Contaminant concentrations and the biological effects associated with contamination are low in the Irish Sea south of Anglesey. However, in the northern part of the region outputs from the major centres of population and industry become trapped in the re-circulating waters. Concentrations of measured metals in water, sediments and biota tend to be above background levels in areas like the Mersey, Clyde Estuary and Belfast Lough. Concentrations of organic contaminants such as chlorinated pesticides, CBs and PAHs have decreased in environmental samples in response to controls on inputs. Many of the currently observable effects of contamination are due to past inputs but a variety of studies confirm that controls over inputs continue to be necessary. The impacts of TBT contamination is still widespread but unlikely to be great enough to effect the reproduction of the dog whelk population.

5.41 *Oil.* As in other regions with substantial shipping traffic, discharges of oil from ships remain a concern. There are important gas reserves off the north Wales coast and in outer Morecambe Bay, but disturbance due to these activities is not an issue that currently raises marine environmental concerns.

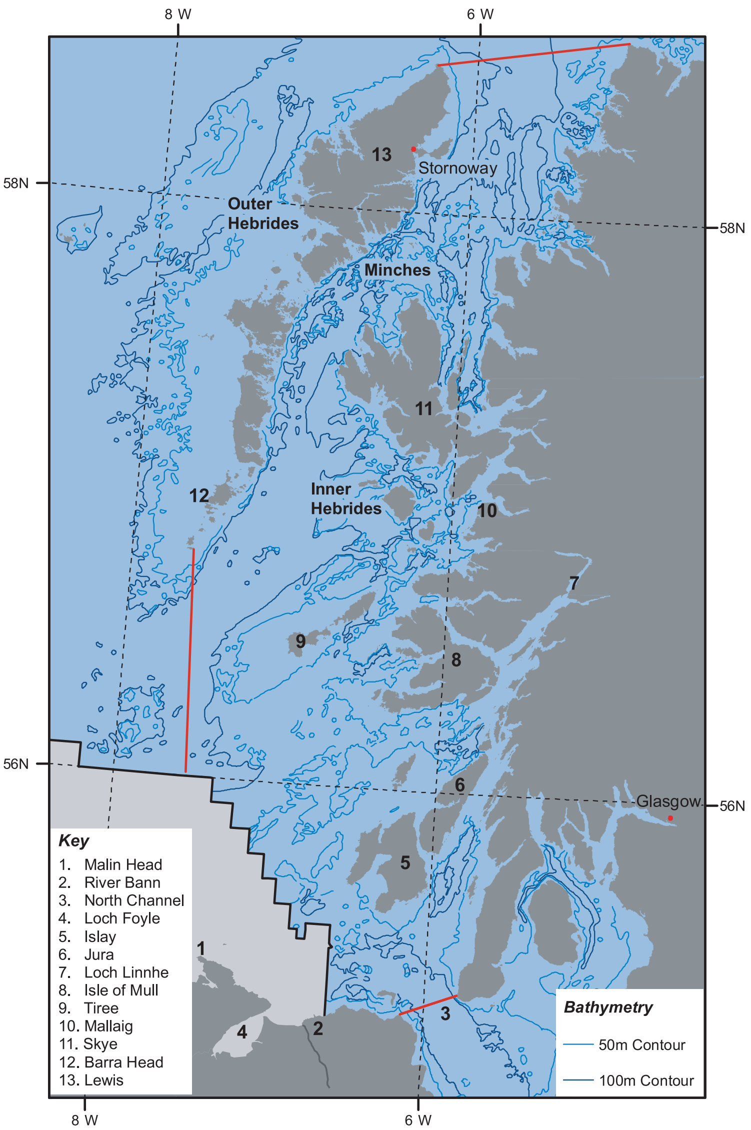
5.42 *Radioactivity.* Sellafield nuclear fuel reprocessing plant on the Cumbria coast has been a cause for concern over the discharge of radioactive materials and their possible effects on people and the environment. However, inputs of radionuclides have been reduced and are scheduled to fall further in 2006. Levels of ^{137}Cs in water are now only a small percentage of those prevailing in the 1970s and the main source of release of radionuclides is now from sediments in the mud patch close to Sellafield. Exposure levels to the most exposed members of the public are well within present internationally agreed acceptable dose limits and exposure levels to the most exposed biota are considered to be below those that might cause effects at population level.

5.43 *Construction and dredging.* Over 500 offshore wind turbines are proposed to be installed between the Welsh coast and the Solway Firth. Minimising the impact these will have on other marine interests will present a major challenge. In addition, there are five major port developments in progress. In total almost 7.8 million tonnes of material were disposed of in ten licensed disposal sites, each of which has been selected so as to minimise impact on other user interests. There is a limited amount of aggregate extraction off the north Wales coast. This is forecast to double between 2002 and 2016 but will still only represent about 2% of the total extracted from UK waters.

5.44 *Coastal issues*. Strong tidal currents and the generally soft sandy or muddy seabed, particularly in the northern half of the Region contribute to the tendency of estuaries on the west coast of Great Britain to infill. Recently coastal flooding has been a serious problem in north Wales where coastal defences have been strengthened. A national survey in 2003 suggested that the density of beach litter in Region 5 was about 50% above the average for the UK as a whole.

Region 6 – Minches and West Scotland

Figure 5.8: Map of Region 6



Note: bathymetric contour data copyright UKHO.

5.45 Region 6 essentially comprises the waters north of Northern Ireland and between the Scottish mainland and the Outer Hebrides. They consist largely of North Atlantic water brought by the continental shelf current and then modified by coastal influences. The economy of the small coastal communities depends on tourism, fishing and increasingly fish farming. Chemical environmental quality is generally good since there is little industry or major populations to contribute to contaminates inputs from land. Both grey and common seals are encountered in large numbers particularly around the Outer Hebrides and west coast of Scotland and there are many types of seabird. The cetaceans species diversity is typical of that encountered in other similar latitudes.

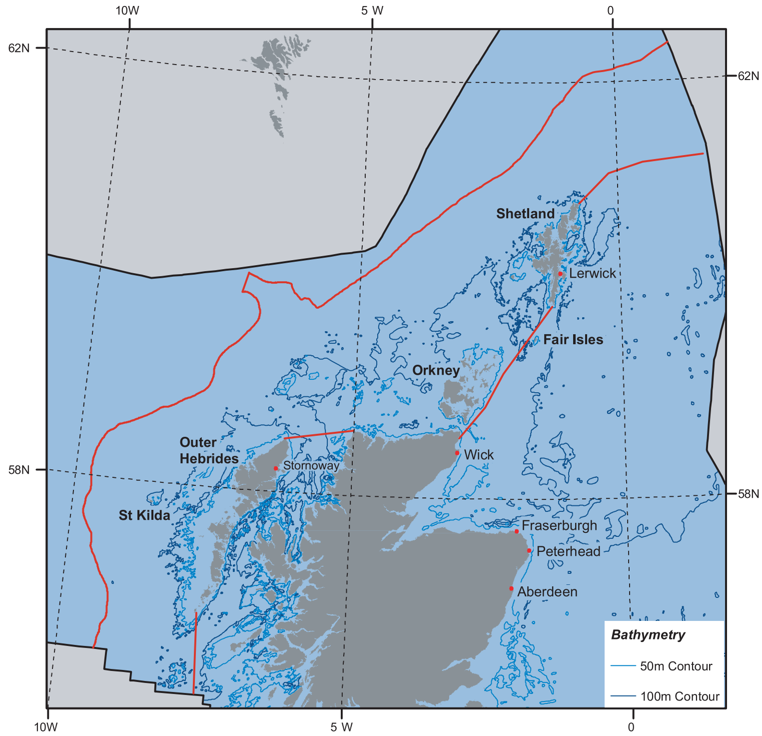
5.46 ***Climate variability.*** As in other regions, sea temperatures have risen by about between 0.11 and 0.39ºC in the last 100 years and wave heights have increased by about 0.03m/yr since at least the 1960s when reliable records began. Sea level rise is offset by the fact the land is also subject to uplift so that the risk of coastal flooding is less than in other regions. There is a trend towards drier summers and wetter winters particularly in Northern Ireland. Plankton records are more sparse than in other regions but measurements taken just outside the region indicate that changes in plankton are likely to be consistent with those in other regions and related to climate change.

5.47 ***Fisheries.*** Both fish farming and capture fishing are major activities in Region 6. Most of the fish species that are currently exploited commercially are fished too heavily and in many cases stock sizes are outside safe biological levels. However, ***Nephrops*** is harvested at a sustainable level. The state of the sandeel stock in 2004 is unknown but was previously assessed to be within safe biological limits. The fishery is closed on 31 July each year to ensure that sufficient food is available for seabirds. Effects such as by-catch mortality and seabed disturbance must arise but apparently not on a scale to give rise to particular concerns. However, the impacts are not uniform and some species, such as the common skate and basking shark, that have become very rare or have disappeared from other regions, are still locally abundant.

5.48 The economy of the Region depends increasingly on mariculture; which initially centred on salmon but now includes other fish species and bivalve shellfish such as mussels, oysters and scallops. Fears have been expressed over a variety of possible adverse effects as described in section 4.25. Whilst some effects may have occurred in isolated instances, improvements in fish farming practices and better regulation have largely eliminated these problems.

Region 7 – Scottish Continental Shelf

Figure 5.9: Map of Region 7



Note: bathymetric contour data copyright UKHO.

5.53 Region 7 comprises the Scottish Continental Shelf, north and west of the Outer Hebrides. The Wyville-Thomson Ridge almost splits Region 8 into two parts and effectively blocks the flow of cold deep water from the Nordic Seas into the North Atlantic. The Region runs along the continental shelf to the north of the UK, bounded to the west, south of the Wyville Thomson Ridge, by the 1000m contour. The boundary to the west, north of the Wyville Thomson Ridge is placed along the 600m contour where the influence of cold Norwegian Sea commences (Figure 5.9). The region is entirely exposed to the influence of the Atlantic and to winds from all directions. The entire continental shelf is dominated by the warm (>8°C) waters to the Shetland Isles, has low turbidity is subject to seasonal stratification.

5.54 The economy of the sparse population depends on tourism, fishing and increasingly fish farming. The Region is the main breeding area of some seabirds and home to the largest numbers of the UK's two native species of seal. The main division between the fauna occurs in the channel between the Orkney and Shetland Islands

5.55 *Climate variability.* The Region shows some differences in the way the physical environment has changed relative to other regions. The Scottish Islands Temperature Index shows a warming that is entirely consistent with that experienced over land elsewhere in the British Isles. Sea water temperatures have shown an increase of about 0.4°C between 1981 and 2000 over the whole of the Region but along the western shelf break boundary the long-term temperature records suggest a somewhat smaller increase of between 0.12 and 0.29°C during the last century. Sea level rise due to ocean warming and ice melt is largely offset by land uplift. The biggest wave heights experienced in Region 7, on the Outer Hebrides, where the long-term mean significant wave height is about 3m. These wave heights have risen at a rate of 0.03m/decade. There is clear evidence of changes in both phyto- and zooplankton abundance and species diversity and dominance. As elsewhere these are associated with changes in physical environmental conditions and involve a northward shift in species previously considered to be typical of warmer waters to the south.

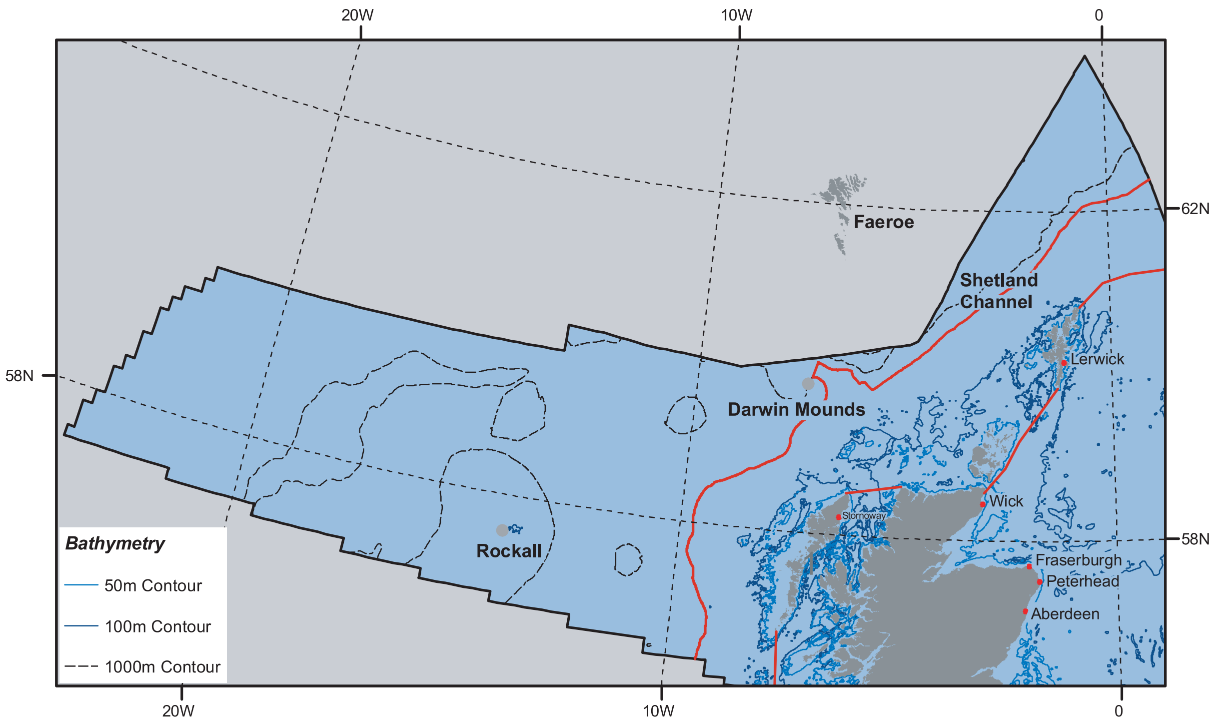
5.56 ***Fisheries***. Current levels of fishing effort are regarded as unsustainable in the longer term. Stocks of some commercially exploited species, notably cod, are considered to be outside safe biological levels. In response to falling catches, fisheries are increasingly moving offshore to target anglerfish. The species of fish found in the Region reflect the conditions afforded by deeper colder waters and their slow growth and reproduction rate makes it more difficult for them to recover when they have been disturbed. In addition there is concern over the impact of heavy trawling gear on the seabed and the benthic animals living there. There are also concerns about the damage to shallow water habitats such as mearl and horse mussel. The economy is largely based on fishing, farming and, especially in Orkney and Shetland, mariculture particularly of salmon although other species such as cod, halibut, scallops, mussels and oysters are becoming increasingly important.

5.57 ***Oil.*** The oil industry has important shore facilities in Orkney and Shetland as well as some oil fields in deep water to the west of Shetland. Oil pollution was the most significant concern of the island communities when the development was planned but is not currently an issue in the Region. Few instances of oil slicks attributable to discharges from ships are reported and the effects of the Braer spillages in Shetland in 1993 are no longer apparent.

5.58 ***Coastal Issues.*** A national survey of litter in 2003 included one beach in the Region 7 where fishing debris was the main source of litter. Unlike other regions, beach visitor debris was low.

Region 8 – Atlantic North-West Approaches

Figure 5.10: Map of Region 8



Note: bathymetric contour data copyright UKHO and BODC.

5.59 Region 8 includes all the UK's waters of the North-east Atlantic north west of Scotland not included in the other regions. It is separated from Region 7 by the continental shelf slope. The entire Region is more than 1000m deep and the only land mass is the uninhabited rocky outcrop of Rockall. The seabed is largely composed of fine clay and mud but it includes numerous outcrops and troughs, where unusual types of fauna including the deepwater corals of the Darwin Mounds and the marine life associated with them are to be found. The Wyville-Thomson Ridge almost splits Region 8 into two. Water over the Ridge is relatively warm but overlies two different deep water masses. To the west of the Ridge the deep water is typically 4°C and the benthic community in that area is richer and more diverse than to the east of the Ridge where the bottom water is typically -1°C.

5.60 As an essentially oceanic region with no direct land based inputs many of the routine measurements of physical, chemical and biological environmental quality have not been made here. The detection of oil slicks that can be attributed to discharges from ships is rare and oil pollution does not feature as a concern. As a deep water area, construction and dredging impacts do not occur although there is interest in oil and exploitation in the eastern (Atlantic Frontier) part of the Region. Fisheries and its impact on the very vulnerable habitats and species such as the slow growing cold water corals. is the most significant human pressure. Their rates of recovery following damage or mortality are likely to be slow. In response to these concerns the EU declared a protected area around the Darwin Mounds in 2003. Fishing in this area is now prohibited

5.61 ***Climate variability.*** Between 1981 and 2000 temperature in the wider eastern North Atlantic rose by about 0.4ºC and in the Faroe-Shetland Channel of about 0.3ºC/decade in the last 40 years. Salinity fluctuates markedly, but the Faroe-Shetland Channel records suggest higher salinity since the 1970s. Wave heights increased between the 1960s and 1980s and into the 1990s with a maximum wave height of 11.8m being recorded in that period. The limited evidence for plankton suggests that changes in Region 8 are likely to be consistent with those found to be associated with climate change in all other regions.

5.62 ***Fisheries.*** The fisheries industry is increasing in this region. Around Rockall large vessels fish for anglerfish, haddock, orange roughy, grenadier and other deep water species. Some of these species are know to be slow growing. Local depletion of a population around a seamount is likely if fishing effort around that site is intense. The stocks of northern hake and anglefish are regarded as being outside safe biological limits while the orange roughy has already been listed by OSPAR as a threatened species. Concerns exist over the damage that trawl gear can cause to the seabed and the marine species that live there such as deepwater corals and the animals associated with them.

Chapter 6: Integrated Assessment – the Status of the Seas

Rationale and approach for the Integrated Assessment

6.1 The traditional approach to protecting the marine environment has been to focus on the impacts of individual activities. But it is essential to understand how all the various natural and anthropogenic pressures on the seas act together in order to be able to assess how clean, safe, healthy, productive and biologically diverse the marine ecosystem really is. The main purpose of preparing the Charting Progress report has therefore been to get beyond the traditional piecemeal approach and make a first integrated assessment of the environmental status of the UK seas.

6.2 This chapter offers such an assessment. The Government has applied its expert judgement to the totality of the available evidence to gauge the status of water quality, and selected marine biota, seabirds, and habitats and to assess progress towards achieving the vision set out in Safeguarding our Seas. Table 6.1 brings together the key findings including a 'traffic light' indication of whether the current status is acceptable, unacceptable or there is room for improvement.

6.3 Judgements of this kind are inevitably subjective. Some of the evidence is capable of differing interpretations. The judgements expressed here represent our best estimate based on the evidence summarised in the preceding chapters and set out in detail in the reports included on the attached CD. They have been reached in consultation with the experts from the bodies listed in Annex 1.

6.4 Table 6.1 includes an indication of our level of confidence in the assessments. It has been clear from the outset that the evidence available for this report is incomplete. There are other data sets, particularly from research findings, which it has not been possible to include in the process of preparing this report, but we believe these would not change the overall conclusions. More importantly, however, there are some aspects of the state of the seas on which the evidence on which to base a judgement is either very limited or non-existent.

Table 6.1: Summary Assessment for UK Seas

	Key factors and pressures	What the evidence shows	Trend	Status (now)	Confidence in Assessment *	Reason for overall status
Water Quality	Riverine inputs and direct discharges of specified metals, lindane and PAH from point and diffuse sources	Reduction in inputs of metals and other contaminants since 1990 moving towards the OSPAR 2020 cessation target for OSPAR priority substances.	✓		III	On the basis of monitored substances water quality status is improving due to inputs falling. The open seas are generally not affected by pollution. The main contamination problems which are identified are in part due to the legacy of the past and are generally observed at higher levels in industrialised estuaries or areas local to the activity. However, some persistent chemicals are not routinely monitored and mixtures of chemical substances and diffuse inputs may pose a problem.
	Radionuclides	New anthropogenic emissions to marine environment highly controlled and meet internationally accepted exposure levels.	✓		III	
	Inputs from point and diffuse sources	Some persistent chemicals are not routinely monitored and mixtures of chemical substances and diffuse inputs may pose a problem.	?		0	
	Oil from accidental spills	No major spills in recent times.	✓		II	
	Oil from refineries and offshore oil and gas	Controls on deliberate inputs show that oil pollution only affects localised areas.	↔		II	
	Sewage discharges and microbiological	Improvements in sewage treatment infrastructure have given greater compliance with EU standards for bathing waters and shellfish waters, but some shellfish quality still fail the standards due to diffuse pollution.	✓		III	
	Discharges and emissions of nutrients from human activities	Direct inputs of nutrients from point sources discharging directly to the sea and atmospheric emissions of nitrogen have reduced by 35% since 1990. (NB direct inputs only account for roughly 25% of all nutrients inputs). Overall inputs of diffuse sources to the sea are unquantified.	✓		II	
Coastal habitats	Coastal development, erosion, sea level rise and climate change	A number of areas around our coast are vulnerable to erosion. This may be increased by rising sea levels and development on the coast. A number of key coastal habitats are under threat.	✗		III	Increasing development and sea level rise around our coastline leads to a narrowing of the coastal zone where natural processes may occur.
	Beach litter and human debris	Litter on beaches is totally preventable and yet quantities of debris are not falling.	↔		II	
Benthic communi-ties and associated sea floor habitat	Human activities causing physical disturbance	Benthic communities are adversely affected by human activities which have a physical impact on the sea floor such as fishing and dredging. Bottom trawling activity is the greatest impact since it results in direct mortality, can be over large areas of the sea bed and repeated frequently.	?		I	We have a very diverse range of benthic habitats and species but there are many threats which cause localised damage.
	Chemical contamination	Overall there is no evidence of broad scale impacts of nutrients or hazardous substances on benthic communities. However, some species do show signs of contamination in local areas, often close to the source of the pollution. Endocrine disruption (hormone change) has been detected in dogwelks.	?		II	
Fish	Commercial fishing	Many species of commercial fish adversely affected by exploitation with many stocks outside safe biological limits in particular regions.	↔		III	Our seas are some of the most productive in the world but many fish stocks are threatened by over exploitation.
	Industrial activities and contamination	Although the levels of disease in fish are higher than naturally expected in some UK waters it is unclear if human activities such as pollution are causing this.	↔		II	

*** The confidence is in the quality and amount of data used to underpin the statements made.**

Table 6.1: Summary Assessment for UK Seas

	Key factors and pressures	What the evidence shows	Trend	Status (now)	Confidence in Assessment *	Reason for overall status
Fish	Aquaculture and ecosystem variability	Limited evidence that sea lice leaked to the environment from salmon farms may be contributing to the decline of wild stocks of salmon and trout in West Scotland, but other factors also cause mortality.	?	Room for improvement (yellow)	I	Our seas are some of the most productive in the world but some fish stocks are threatened by over exploitation.
Plankton	Climate change	There has been a significant change in plankton communities populations across the UK sea. This has been shown to be linked to changes in the overall climate.	✗	Unacceptable (red)	II	Primary productivity in UK waters is naturally high and generally not affected by land based nutrient inputs. Plankton community interdependence with climatic change and its key role in the marine ecosystems function means the entire ecosystem may be affected by a sharp change in the plankton community.
	Nutrients Inputs	The offshore areas are naturally nutrient rich and do not appear to be affected by land based nutrients. Inputs of nutrients from the land are falling and affect only a small number of localised near shore waters and the Irish Sea.	✓	Room for improvement (yellow)	III	
Marine mammals	Commercial fishing	By-catch of dolphins and harbour porpoises are a significant pressure from some types of fishing methods. Since most cetacean population levels are unknown the overall effects on the sustainability of the system is unclear.	?	Unacceptable (red)	I	We have a large range marine mammals in our waters and have protected breeding and haul out sites for their use. Populations of marine mammals are poorly understood but accidental by-catch from fisheries threatens population stability.
	Other (apart from commercial fishing) anthropogenic activities and climate change	Some seal populations are increasing otherwise mainly stable populations which have recovered from virus epidemics. Areas for seal breeding and haul out designated as SACs.	↔	Acceptable (green)	II	
Seabirds	Climate change and food sources	Although sea bird populations numbers show an overall increase from 1970 to 2000 there is great variability of population health by both species and location. Much of the increase in numbers is due to a few species doing well. There is real concern at the continued rate of decline of other species, particularly those in the North Sea. There was a large decline in population numbers from 1985 to 1990 and since then breeding success has been variable due to a variety of factors. The availability of their food source, sand eels is a major reason which in turn is impacted by both climate change and commercial fishing.	↔	Unacceptable (red)	III	The UK holds a significant number of the worlds breeding seabirds and whilst protection of their breeding sites has been achieved there are many other factors such as commercial fishing practises and climate change which probably affect population numbers.
	Commercial fishing, pollution and oil spills	By-catch as a result of commercial fishing, pollution and oil spills continue to affect seabirds. Fisheries conservation practises which result in less discards and offal thrown overboard may reduce the food source for some species.	↔	Room for improvement (yellow)	I	
Marine Species (Bio-diversity)	Introduction of species from shipping and climate change	More than 50 non-native species have been identified in UK waters in recent years.	?	Unacceptable (red)	I	Overall our seas contain a rich mixture of animals and plants but too little is known to give an idea of the overall status. Climate change impacts represent one of the biggest unknown threats.
	General climate change	Clear evidence that the distribution and abundance of plankton, fish and benthos have been altered by change in the climate regime. Some benefits may be derived from this but the significance of the impact on the overall ecosystem is not yet clear.	?	Unacceptable (red)	II	

Assessment

- Red: Unacceptable
- Yellow: Room for improvement
- Green: Acceptable

Confidence assessment

- III High
- II Good/Satisfactory
- I Low
- 0 No assessment possible

Trends

- ✓ Measurement shows improvement
- ✗ Deterioration
- ↔ No change or variable trend shown
- ? No trend available or implications not understood

Overview of the significant impacts and pressures affecting status

Influence of Physical processes and climate

6.5 Water depth, ocean currents and weather and climate are the dominant factors that control the marine environment. Weather and climate are highly variable over both space and time, but trends in the longer term datasets show that sea temperature and sea levels appear to be rising.

6.6 The links between climate change and human activities such as the release of carbon dioxide are clear. Climate change can, in general, be managed effectively only at the international level. However, it is crucial to ensure that the effects of climate change on the marine environment continue to be monitored and further investigated at the local level so that information can be integrated into national and international actions. A discussion of climate change effects is in Box 3A.

6.7 There is at present no general agreement about the degree of physical change that might be acceptable in the marine environment. Table 6.1 shows that climate change affects coastal habitats, plankton species, marine mammals, seabirds and the presence of non-native species. Hence it is reasonable to conclude that, together with the natural atmospheric and hydrographical variability of the oceans, climate change is a major contributor to ecosystem change in the shelf seas of north-west Europe

Anthropogenic impacts on the seafloor and coastline

6.8 The physical habitats on the sea floor and in coastal environments are under pressure from activities such as oil and gas exploration, construction, aggregate extraction, navigation dredging, fishing, mariculture and litter. Any changes these activities cause to the physical environment are likely to affect the biological communities living in those areas.

6.9 Fishing is probably the activity which has the greatest impact on the sea floor; as shown by Figure 4.2, its impact is widespread but patchy in nature. Most at risk are the areas which are frequently subjected to bottom trawling where there are species that are unable to recover before the next disturbance. In contrast other activities (such as aggregate extraction) tend to have impacts which affect only a small area of the sea floor. Therefore on available evidence, there is no indication of significant structural or distributional changes to benthic communities arising from recent human activities on a regional or UK-wide sea scale. The impacts of new constructions, such as the proposed offshore windfarms, which will have a more permanent presence in the sea, will need to be studied carefully.

6.10 Development of the coast in combination with sea level rise and natural coastal erosion means that many coastal habitats are under threat especially in the eastern and southern parts of the UK. This is known as coastal squeeze. Continual dredging and maintenance of harbours and shipping channels creates hydromorphological changes in the areas of extraction and dumping of the material.

Impacts on the Status of Water Quality

6.11 There are a number of contaminants which influence the chemical status, water quality and cleanliness of the marine environment. These include radionuclides, nutrients, hazardous substances, oil, micro-organisms and litter. Table 6.1 shows the main pressures associated with the contaminants and what our monitoring programmes show about their inputs and effects such as;

- **Radioactivity.** All authorised releases of radioactive materials to air and water are subject to regular monitoring and assessment of exposure. In all cases doses are well within the internationally agreed dose limits for humans. The radiation exposure to marine organisms is highest in the in the north-eastern Irish Sea but even here is unlikely to be great enough to cause adverse effects at the population level. There is also no evidence that population levels were affected when discharges were at least ten times greater than they are today.
- **Hazardous substances.** The industrial, agricultural and general activities of humans result in the release to the environment of a wide range of substances. Some of these are toxic, persistent and bioaccumulative and can, if they reach the marine environment pose a threat to marine organisms. The substances which have been monitored in the marine environment are those for which monitoring programmes have been agreed at European level. In recent years there have been significant reductions in inputs, and concentrations of those substances which are routinely monitored are in all regions are generally below concentrations which may harm marine organisms. Nevertheless, some localised elevated concentrations of contaminants still occur mainly in industrialised estuaries.
- **Oil and hydrocarbon inputs.** Inputs to the different regions around the UK vary. Point source inputs from refineries have been significantly reduced but land-based run-off, from diffuse source inputs have not been quantified. Due to the prevailing wind direction oil inputs from the atmosphere mainly affect the North Sea.
- **Oil from oil spills.** Oil spills by their nature are a risk to the status of the seas. However, management systems are in place to ensure that the effects of any spill is minimised and the evidence shows that impacts do not last much longer than two years.
- **Nutrients.** Direct inputs of nutrients from point sources discharging directly to the sea and atmospheric emissions of nitrogen have reduced by 35% since 1990. However, these direct inputs only account for roughly 25% of all nutrients inputs. Overall inputs from diffuse sources to the sea are unquantified; they present a risk but only in small inshore areas. Offshore waters are generally not adversely affected by land based nutrient inputs.

- **Litter.** Litter on beaches can be a hazard to marine life as well as an eyesore. It is preventable and yet quantities of debris on our coastline are not falling. Types and sources of debris vary across the regions, but 37% is attributable to tourism or beach visitors.
- **Microbiological contaminants.** These are introduced to the marine environment primarily from land-based sources and affect only the coastal zone. Various legislation seeks to protect or improve the quality of bathing waters and areas where shellfish are harvested. We have reduced the number of waters failing the EU Bathing water mandatory standards by improving sewage treatment and infrastructure. These measures have also helped to increase the number of shellfish harvesting beds achieving Class B status or above (the Governments aim). The introduction of microbiological contaminants from ballast water is not quantified in current monitoring programmes.

6.12 The evidence indicates that many of the negative pressures on the marine ecosystem caused by contaminants on the seas around the UK have been significantly reduced in recent years. These include significant reductions in the amounts of hazardous substances, nutrients, oil, faecal bacteria and radioactivity being released into the sea. This has been achieved largely by regulatory pressure to apply better abatement technology and management practices. Furthermore, most uses of the sea are now controlled by licenses underpinned by impact assessments designed to prevent contamination and deterioration of the marine environment.

6.13 This report shows that the state of the sea has responded to these reductions. The open seas are generally not affected by pollution and there are general improvements in chemical and biological water and sediment quality, bathing water cleanliness, and evidence that the undesirable effects of nutrient enrichment are limited to a few small, enclosed areas. However, water quality is still poor and biota are adversely affected in some industrialised estuaries which for decades have acted as entry points for industrial, agricultural and diffuse contaminants. There are also still concerns about the effects of endocrine disruptors, mixtures of chemicals and those chemicals are not routinely monitored.

6.14 In order to address these combined effects we are developing new biological monitoring techniques such as whole effluent assessment, which, when used alongside traditional analysis of single substances, give a much broader perspective on water quality and the impacts of contaminants. But the picture for contaminants will not be complete until monitoring programmes for the persistent, bioaccumulating and toxic (PBT) chemicals recently identified at European level have been agreed and implemented.

The status of marine species and habitats

6.15 The generally positive assessment of water quality status of the UK seas is not matched by the assessment of the status of marine species and habitats. Our seas are still among the most productive fisheries in the world and are able to maintain a wide variety of all kinds of marine life, including fish, a range of marine mammals and a significant number of the world's seabirds. Land-based nutrients do not generally affect primary productivity, and although biological effects of pollution are locally detectable where there is a known history of contamination, there is no significant evidence to suggest that any contaminants have a serious impact on populations of marine organisms, including fish, in any region around the UK.

6.16 However, table 6.1 sets out some clear and well-documented threats to the delicate balance of the marine ecosystem.

- the sustainability of some fish stocks, especially commercial species such as cod, is gravely threatened by over-exploitation.
- commercial fishing practices also seriously threaten other parts of the ecosystem, particularly through the by-catch of marine mammals and birds and the physical disturbance of benthic communities in heavily trawled areas.
- there has already been a major change in the plankton, both in species and abundance terms since the early 1980s. This affects a large area of the North Atlantic and appears to be linked to changes in the NAO and climate. Plankton play a key role in marine ecosystem functioning and therefore the sharp change in the plankton community is likely to have implications for all elements of the marine ecosystem especially fish stocks;
- we have changed the diversity, dynamics and composition of marine life by the introduction of non-native species and by changes in the relative abundance of species from fisheries;

6.17 The overall effect humans are exerting on the biological environment status or marine biodiversity is still poorly understood and quantified. Moreover, the individual threats posed by each of these factors may be multiplied where they operate in combination and indicators of whole ecosystem change are needed before an accurate status can be given.

6.18 However, our knowledge of the variety and extent of human activities suggests there are likely to be few areas of marine habitats in the UK, which remain unchanged by human activities. Commercial fishing and climate change represent the major threats to marine life. Positive measures are now being taken to manage fish stocks, however, the wider ecosystem effects of fisheries have yet to be mitigated. Minimising the effects of by-catch is also a priority; it remains to be seen if existing measures will be effective.

Emerging and Potential Factors of Concern

6.19 The evidence on which the assessments are based does not cover a number of additional potential pressures and factors which might adversely affect the status of the marine ecosystem. These are not covered in current monitoring programmes and will need to be investigated or kept under observation so that they can be included in appropriate management plans or research programs. Examples are:

- The effects of endocrine disruptors, of new and unmonitored chemicals and of toxic contaminant mixtures on the viability of populations of estuarine and marine species
- The possible impacts of new offshore constructions such as windfarms on local biodiversity
- The possible impacts resulting from climate change which are not currently monitored, including acidification of the seas.
- The impacts of major new accidents such as large oil spills or radioactive discharges

6.20 It will also be essential to remain vigilant against the risks of unpredictable "wild cards" such as:

- Ecosystem regime shift, in which a key component of the ecosystem changes irreversibly, with significant knock-on effects on other ecosystem processes
- Fisheries collapse, involving loss of major stocks and ramifications for the food chain
- Tsunamis and other low frequency, high impact natural events.

General Conclusion on the Status of the Seas

6.21 The general picture that emerges from the evidence (Table 6.1) is that the UK seas are productive and support a wide range of fish, mammals, seabirds and other marine life. The open seas are generally not affected by pollution and the levels of monitored contaminants have decreased significantly. The main contamination problems which are identified are in part due to the legacy of the past and are generally observed at higher levels in industrialised estuaries or areas local to the activity.

6.22 However, human activity has already resulted in adverse changes to marine life and continues to do so. For example, widespread commercial fishing practices threaten many fish stocks by over- exploitation and damage sea floor areas. There is also evidence that the marine ecosystem is being altered by climate change: for example sea temperatures are rising and the distribution of plankton species is changing. These changes pose a real threat to the balance and integrity of the marine ecosystem.

6.23 Generally the evidence summarised in this report, which mainly derives from existing monitoring programmes covers only some of the physical processes, human activities and marine life which contribute to the status of our seas. These are insufficient to enable the status of many elements of the marine ecosystem to be assessed. This is why a number of the status boxes in Table 6.1 are coloured orange. There remains a general lack of knowledge about the status of offshore areas, which have been infrequently sampled due to the cost of ship-based monitoring.

6.24 Consequently, given the limitations in available information our overall assessment should be regarded as provisional. Nevertheless, we are confident that the major threats and issues have been identified and that this integrated assessment has given us a basis from which to assess data gaps, deliver improvements and detect adverse changes. But it is only the beginning of a long process which will develop further as our overall understanding and monitoring of the marine environment increases.

Lessons learnt and forward look

6.25 The preparation of this first integrated report represents the start of the much longer process of developing our overall understanding of the marine environment and formulating policies to respond to identified problems. A number of lessons can be learnt from the process of gathering the evidence and compiling the report itself and the following actions are suggested to address the issues. Although they overlap, they can broadly be divided into two main categories:

Knowledge of the marine ecosystem

A number of gaps in knowledge have been highlighted earlier in this chapter. These gaps are evident both in the basic data and in the tools available for assessing the data. There is a need to develop benchmarks against which progress towards the vision of clean, safe, healthy, productive and biologically diverse seas can be monitored. **Action 1** would involve the development of marine ecosystem indicators for this purpose. **Action 2** would be to use the Marine Monitoring Coordination Group to coordinate the current marine monitoring activities, to identify gaps and to develop a more comprehensive approach to UK Marine Monitoring. **Action 3** would be to promote marine research into the more fundamental gaps in basic knowledge that the process has revealed.

Institutional issues

Those of a more institutional nature dealing with how we can better optimise the considerable efforts and resources needed to assess the state of the seas thoroughly and make best use of scientific evidence to underpin policy and marine management decisions required to reach the overall aim of safeguarding our ecosystem. **Action 4** would involve the pooling of scientific expertise and ensuring that the relationship of work on specific issues to the broader marine environment is properly understood. **Action 5** involves working in partnership to establish a national framework for managing marine data and information based on the principle of ''capture once and use many times. **Action 6** would be the development of a better understanding of how climate change affects the marine environment. Finally **Action 7** would be steps such as the Government's proposed Marine Bill to facilitate the application of ecosystem approach to sustainable development.

6.26 Box 6A sets out these lessons and suggested actions in greater detail with the aim of achieving a fuller and more comprehensive understanding of the state of the seas and so of improving the quality of marine stewardship. The Government will be considering over the coming months how to take forward these suggested actions. All actions will require a coordinated, multi-sector approach to fulfil the vision we have for the marine ecosystem.

Box 6A Specific Actions

The following specific though overlapping and interrelated suggested actions arise from the lessons learnt whilst compiling this report.

Action 1: Development of marine ecosystem indicators to enable the state of the seas to be more precisely measured and progress towards the vision to be monitored

Making an assessment of the state of the marine environment raises the question of what constitutes a healthy or productive sea. The vision set out in Safeguarding our Seas gives a clear indication of our aspirations, but it needs to be expressed in more precise scientific terms in order to judge accurately how close we are to achieving the vision and to measure progress towards it over time. We need clear agreed benchmarks for assessing what "state of the seas" we are aiming for and what "clean", "safe", "healthy" ,"productive" and "biologically diverse" seas really means. This is a huge challenge, given the range of aspects of the marine environment, which must be covered, and the lack of scientific understanding of some of the interactions. While there has been considerable work both within the United Kingdom and within Europe to address these issues, much remains to be done. Chapter 2 describes the state of progress on the development of ecosystem indicators, which might provide the best means of assessing the state of our seas.

We will be taking this forward both through our research programmes and through participation in the development and application of the European Marine Strategy which is undertaking a similar exercise at European level. It will be essential that scientists and policy makers work closely together in this process.

Action 2: Evaluating and revising our current Marine Monitoring programmes

Current marine monitoring programmes, which are designed to demonstrate compliance with the requirements of current national and international regulations, are sector-based. As this report has shown, they do not provide sufficient evidence to provide a robust assessment of the overall state of the marine ecosystem.

A Defra led Marine Monitoring Coordination Group is taking forward work to redesign the collection, co-ordination and reporting of marine data. The Group is drafting an action plan with proposals for monitoring how the ecosystem is changing in response to both long-term and immediate human induced disturbances. The Government departments and agencies concerned are committed to working closely with this process to ensure that the various marine monitoring activities undertaken in UK waters are coordinated and fit for purpose. The Group will assess the gaps and explore how to move towards a more pragmatic risk-based approach to monitoring. It will need to consider the resource implications of its proposals and will aim to work internationally (for example in the context of the WFD, which sets ecological quality targets) to ensure that scarce resources are targeted efficiently.

Action 3: Marine Research

Attempting to apply the ecosystem approach has shown that there is a rather limited understanding of the marine ecosystem and its various components, how it can be defined, how it functions and what indicators are needed to see whether it is in good shape. The following is an initial list of science evidence gaps identified from this report.

- a set of tools to help demonstrate whether, taken together, the various human uses of the sea are having adverse effects on the marine ecosystem.
- the effects of contaminant mixtures on marine species and whether such mixtures affect the long-term viability of populations.
- impacts arising from changing uses of the sea such as new offshore developments of windfarms, extracting aggregates from new areas and new fishing regimes and practices.
- the degree of human impact that the marine environment can safely tolerate. This is essential in the light of the Government's policy to allow sustainable exploitation of marine resources. This is a significant challenge which will need better evidence and a better understanding of ecosystem health. These questions could be partially addressed by the development of ecosystem models.
- the lack of a basic habitat map of UK waters hinders the assessment of the current ecosystem 'state' and the effects of impacts on a wider scale. Such a map would provide a fundamental spatial planning tool.
- cumulative impacts on marine ecosystems and the links between cause and effect which hinders the development of appropriate management actions.

- natural variability of ecosystems and distinguishing this from anthropogenic pressures.
- longer term changes to ecosystems associated with pressures such climate change and what can be done to adapt to such changes
- the impacts which over-fishing has on the food web and overall ecosystem stability.

These need to be addressed by coordinated work through marine institutes and various marine research programmes

Action 4: Capturing 'knowledge'

The evidence for this report was gathered from a wide variety of sources (see Annex 1) but gaining access to knowledge and 'information' is sometimes more difficult than generating the raw data. Better use needs to be made of the expertise and information available in all of the relevant UK institutions which deal with the marine environment, so that it can be more effectively integrated into policy making. This was also recognised in the recent "Net Benefits" report on the future for UK fishing from the Prime Minister's Strategy Unit. This called for research councils, universities and government agencies to pool their expertise to deliver the knowledge and understanding needed to progress ecosystem management, particularly for fisheries.

There is a need to look at ecosystem processes at all levels and over pertinent time scales in order to optimise the gathering and dissemination of information and to build more transparent routes for transferring expertise and knowledge of marine science to policy and decision makers. There is also a need to share ideas of best environmental practice. To facilitate this, a national framework is needed to bring together the various pieces of science to complete the ecosystem jigsaw and thus best help advise on policy for marine stewardship. This requires close co-operation between the Government, the marine agencies and advisors and the research councils as well as with the wider marine science community. The Government will encourage and facilitate such joined up working so that the capacity of the various organisations concerned to deliver data and knowledge required for the assessment of the state of the seas is maximised. What is needed is not only better data management but also more consistent and coherent ways of interpreting data that address the state of the ecosystem rather than just the impacts of individual activities.

Action 5: Data and Information Stewardship

Fundamental to Action 4 is the way marine data are managed. A lot of marine environmental data held by different organisations could be used much more effectively if the information were more easily available. To enable the transformation of marine data and information into evidence and knowledge the Government is supporting the development of the Marine Data and Information Partnership (MDIP). MDIP comprises organisations working in partnership across Government, non-departmental public bodies, research institutes and the private sector to:

- Establish an enabling framework for managing marine data and information: 'capture once and use many times'
- Establish Data Archiving Centres
- Provide guidance on managing marine data and information including the development of standard protocols and procedures.

Action 6: Marine Climate Change Impacts

A detailed evaluation of the effects of climate change on marine ecosystems, which is a new and a developing area of study, has not been carried out in this report. However, the threat of climate change is becoming more certain. Ecosystem effects occur as a result of both natural and anthropogenic climate variations. Partly because of a lack of baseline monitoring data, it is difficult to separate out the effects of these two influences. It is likely that the state of the seas will be significantly affected by increases in sea temperature and sea levels and changes in the North Atlantic Oscillation (NAO). Significant impacts are predicted both on species and habitats and the way ecosystems function. It is therefore necessary to develop a better understanding of how climate change affects the marine environment, and ensure that this is integrated with the broader work and research. The Government intends to work in partnership with research and monitoring organisations to understand the cross cutting impacts of climate change in the marine environment. The formation of a Marine Climate Change Impact Partnership (MCCIP) also goes some way towards Action 4.

Action 7: Marine Stewardship in Action

Safeguarding our Seas (2002) adopted an ecosystem approach to the management of known activities in the marine ecosystem. Charting Progress considers in an integrated manner all the overall anthropogenic impacts on the marine ecosystems. The management of our seas must also recognise and adapt to longer term trends and variables which cannot necessarily be controlled. There is a need to address existing local problems which are caused by known human impacts such as polluting discharges or physical disturbance arising from dredging/disposal and fisheries, and to consider further how best to address the wider ecosystem damage caused by fishing. We need to bring the arrangements for managing marine activities more into line with the ecosystem approach.

To meet some of these policy challenges, the Government will bring forward a Marine Bill. One area, which can be improved, is our system of consenting marine developments that can have major impacts on ecosystems. This has grown in a piecemeal fashion over many years and is in need of modification. A pilot is underway in the Irish Sea to test the feasibility of marine spatial planning. We will work closely with the National Assembly for Wales, the Scottish Executive, and the devolved administration in Northern Ireland to consider what approaches may be suitable in each of their countries. Where they have responsibility for the management of their territorial waters it will be for the devolved administrations to determine the need to bring forward any new legislation.

Glossary

ASCOBANS – Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
Biodiversity – all aspects of biological diversity, including species richness, ecosystem complexity and genetic variation.
CEFAS – Centre for Environment, Fisheries and Aquaculture Science
CPR – Continuous Plankton Recorder
DARD – Department of Agriculture and Rural Development (Northern Ireland)
Defra – Department for Environment, Food and Rural Affairs
Demersal fish species – Fish living in waters close to the sea floor
DTI – Department of Trade and Industry
EA – Environment Agency
EAC – Ecotoxicological Assessment Criteria (concentrations of substances above which there may be impacts on biota)
Ecosystem approach – this entails taking into consideration all elements that make up the ecosystem (physical, chemical and biological variables) as well as activities taking place there in order to ensure that the biodiversity, health and integrity of the marine environment is maintained in the longer term.
EcoQOs – Ecological Quality Objectives
EHS – Environment and Heritage Service (Northern Ireland)
EN – English Nature
EU – European Union
Eutrophication (as defined by OSPAR) – the enrichment of water by nutrients causing an accelerated growth of algae and higher form 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
FRS – Fisheries Research Services
ICES – International Council for the Exploration of the Sea
IACMST – Inter-Agency Committee on Marine Science and Technology
JNCC – Joint Nature Conservation Committee
MNR – Marine Nature Reserves
MPA – Marine Protected Areas
NAO – North Atlantic Oscillation
NERC – Natural Environment Research Council
NMMP – National Marine Monitoring Programme
OSPAR – OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic
Pelagic fish species – Fish living in the surface waters or middle depths of the sea
RMNC – Review of Marine Nature Conservation (Defra, 2004)
SAC – Special Areas for Conservation
SAHFOS – Sir Alister Hardy Foundation for Ocean Science
SMRU – Sea Mammal Research Unit
SPA – Special Protection Areas
SSSI – Sites of Special Scientific Interest
WFD – European Union Water Framework Directive
WSSD – World Summit on Sustainable Development

References & Acknowledgments

The evidence on which this report is based are the Sector reports and the Integrated Regional Assessment – these contain the original reference sources. They can be found on the CD enclosed with the printed copy of this report or on the Defra website **www.defra.gov.uk/environment.**

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Acknowledgments

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Annex 1: List of contributors

The evidence used to compile this report and its five feeder reports have been collated from a number of organisations and individuals and departments across the UK. The views expressed here do not necessarily reflect those of the contributors. We are grateful for all contributions of data, text, figures, photographs and expertise provided from:

ABPmer
British Geological Survey
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Climatic Research Unit, University of East Anglia
Countryside Council for Wales
Department of Agriculture and Rural Development, Northern Ireland
Department of Trade and Industry
English Nature
Environment Agency
Environment Heritage Service, Northern Ireland
Fisheries Research Services, Aberdeen
Halcrow
HR Wallingford Ltd
Hull University
Inter-Agency Committee on Marine Science and Technology
International Council for the Exploration of the Sea
Intergovernmental Oceanographic Commission
Joint Nature Conservation Committee
Marine Conservation Society
Met Office
New Forest District Council
Nottingham University
Ordnance Survey
Permanent Service for Mean Sea Level
Plymouth Marine Laboratory
Proudman Oceanographic Laboratory
Queen's University, Belfast
Satellite Observing Systems Ltd
Scottish Environmental Protection Agency
Scottish Executive Environment and Rural Affairs Department
Scottish Natural Heritage
Sea Mammal Research Unit
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