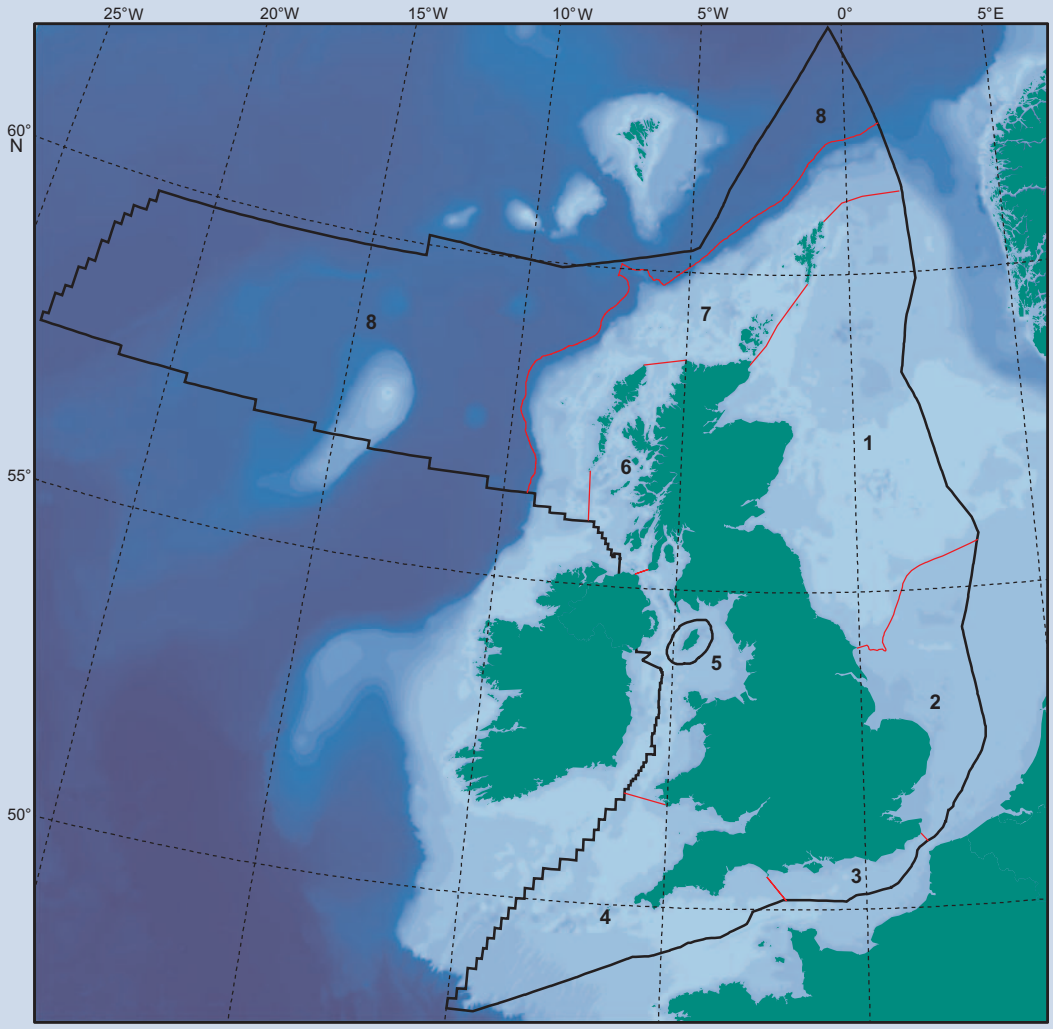
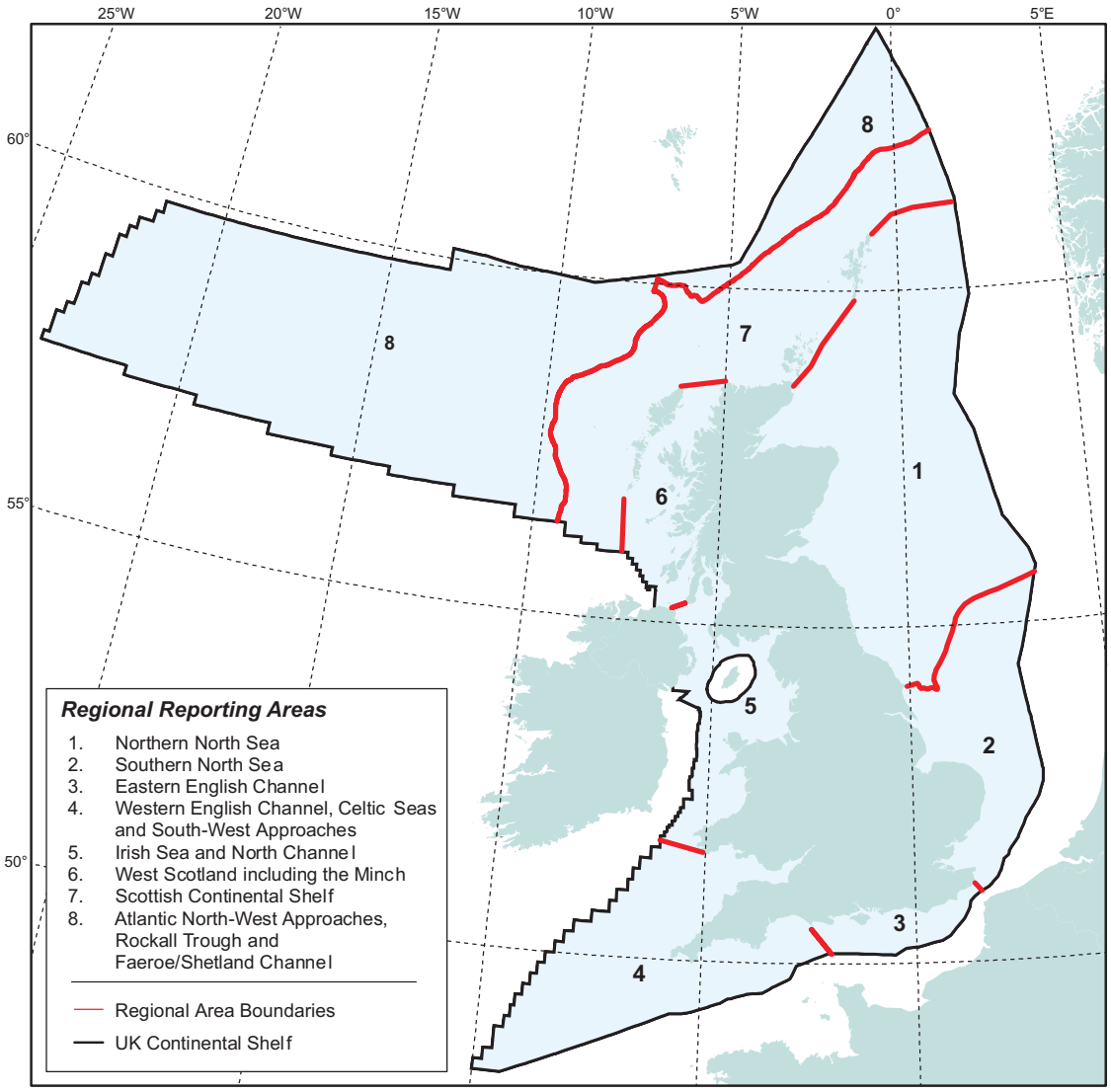
5: Integrated Regional Assessment



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.
Bathymetry data taken from the GEBCO One Minute Grid. BODC/GDA Licence No: 2003/4.

A contribution to
Charting Progress - an Integrated Assessment
of the State of UK Seas
(The 5th of 5 Reports)



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.

Figure 1. The Regional Reporting Areas around the UK

This report is one of five that have been produced to provide detailed scientific assessment in support of '*Charting Progress – an Integrated Assessment of the State of the UK Seas*'; published by the Department for Environment, Food and Rural Affairs on behalf of the UK Government and Devolved Administrations in March 2005.

The five reports in the series are as follows:

1: Marine Environment Quality
2: Marine Processes and Climate
3: Marine Habitats and Species
4: Marine Fish and Fisheries
5: Integrated Regional Assessment

All reports can be found on the Defra website: www.defra.gov.uk

The 5th of 5 reports produced to support **Charting Progress** –
an Integrated Assessment of the State of UK Seas

Integrated Regional Assessment

2005

Contents

Preface

This review of the state of the regional seas around the United Kingdom is based on information drawn from four main source documents all four of which are available, in full, in association with this Integrated Assessment. None of these documents sought, or claims, to be a comprehensive review of all the available literature. Rather each document (sector report) seeks to set out what is known about a particular sector of the environment and provides example data or reference sources as appropriate. These sector reports address:-

- The physical environment in terms of weather, climate and marine processes
- Environmental quality in terms of the presence and impact of contaminants and man's activities such as dredging and construction
- Fish assemblages and fishing, including the status of fish stocks and the impact of fishing on other species and the environment
- Habitats and species more generally, including plankton, benthos, seabirds and marine mammals.

Almost all the information provided in the following chapters dealing with individual Regions is derived from these sector reports. Generally, therefore, reference sources are not cited in this Integrated Assessment. However, where other sources have been used the origin of the information is indicated. In almost all cases such information is drawn from one of four contract reports commissioned under a Defra funded Marine Environmental Change Network programme in one of four areas - North-east coast of England, Western English Channel, Irish Sea and Tiree Passage. Such instances are indicated accordingly. In a few instances, particularly in relation to historical concentrations of contaminants, the author has drawn upon personal experience and knowledge to refer to data older than those provided in the sector or contract reports. Such instances are indicated by the words '*Author's note*'. There are two further exceptions. The first relates to benthos where the most relevant regionally specific and comparable information referred to in the sector report on Habitats and Species was an assessment of data from the National Marine Monitoring Programme. The details were not included in the final version but were available in the NMMP publication and are referrenced as MEMG 2004 (see below for details). The remaining exception relates to some regionally specific information on seabirds, e.g. main species in a region, proportion of the UK or global population, or regionally specific population declines. This information was added in response to suggestions made concerning an early draft of this Integrated Assessment and has been retained despite the fact that it has not, in all cases, been included in the seabird section of the sector report on Habitats and Species.

MEMG, 2004 UK National Marine Monitoring Programme – Second Report (1999 – 2001) CEFAS, Lowestoft pp136

The Regions used in this Integrated Assessment were defined by Defra based on initial proposals by JNCC intended for implementation of nature conservation strategies. The proposals were modified to give a smaller number of Regions but each was intended to be an ecologically meaningful subdivision of the UK continental shelf, to reflect the distribution of natural resources and to reflect the socio-economic uses made of the area. All the sections dealing with individual Regions have been checked by representatives of the sectors. In many cases these representatives were the lead authors or co-ordinators. Thus, the data and comments in this review should correspond with the original source material. The only major exceptions to this rule relate to regionally specific data on microbiological contamination. Such details were not available in the sector report dealing with environmental quality and the necessary details were obtained from the appropriate Government Departments. Only in the final section, which

provides an integrated assessment of how the Regions compare and the extent to which they are biologically diverse, ecologically sound, healthy and sustainable, has the author attempted to: -
interpret possible interactions,
offer possible explanations as to why changes have occurred and might occur in the future or
indicate the present overall state of the seas around the UK and how that status has changed, is changing and may change in the future.

Figure 1 (page 2) shows the overall location and geographical coverage of the eight Regions addressed in this Integrated Assessment. Although much of the information in the sector reports used as source material could readily be related to individual Regions this was not always the case. Nevertheless, to the extent possible, each Region is dealt with as an individual unit in order that the reader interested in only one Region can obtain a full picture of the state of that Region by reading only the relevant section of this Integrated Assessment. Readers should note that in commissioning the individual sector reports and this Integrated Assessment, Defra recognised the role of the Environment Agency in assessing estuarine quality and that of the immediate coastal zone in relation to the Water Framework Directive. Therefore neither this Integrated Assessment nor the four sector reports seeks to address the status of such areas in detail. More detailed information on these inshore areas will be made available by the EA and by SEPA and DARDNI in due course.

Region 1:
Northern North Sea

INTRODUCTION

This Region comprises the Northern North Sea and takes in the entire east coast of Scotland up to John O'Groats, skirts just south of the Orkneys and just north of Fair Isle and then takes in the eastern coast of Shetland. Also included is the east coast of England as far south as Flamborough Head. The Region is bounded by the Flamborough Front to the south and deeper stratified waters to the

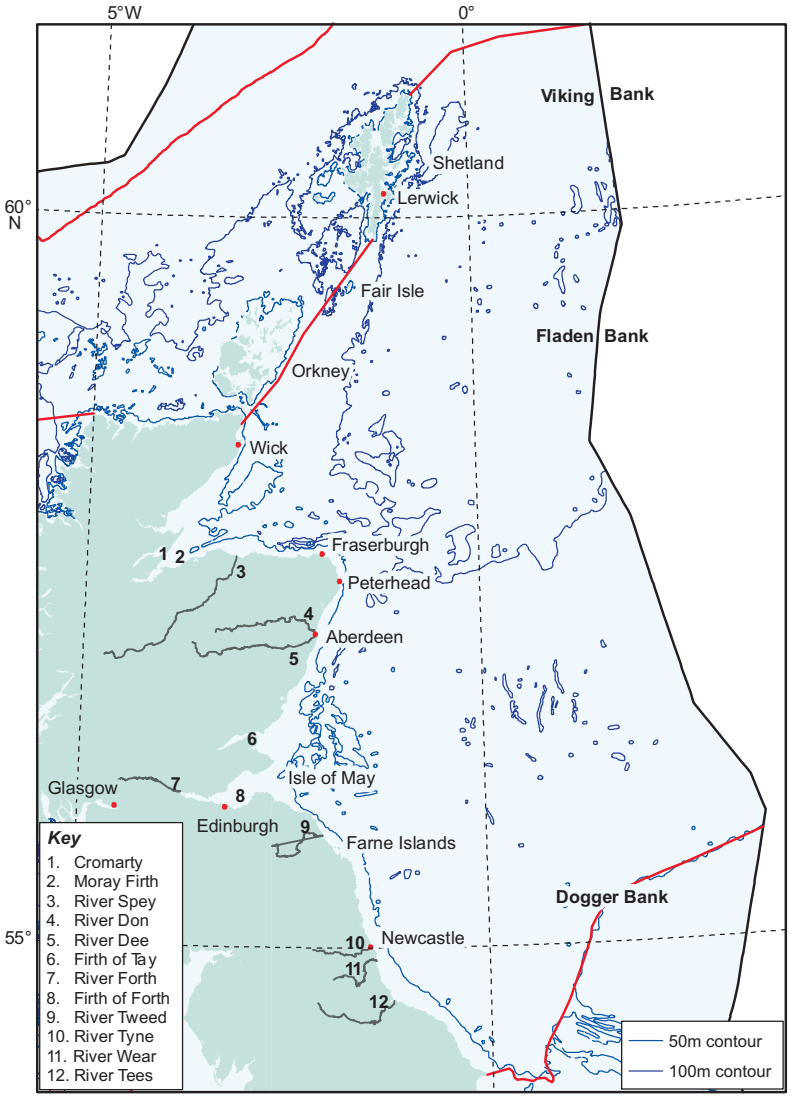


Figure 1.1. Map of Region 1. Bathymetric contour data copyright UKHO

north and an associated transition to muddier sediments. The eastern edge of the Region is bounded by the Norwegian Deep where North Atlantic Drift Water mixes with lower salinity water originating from the Baltic Sea. Figure 1.1 shows the location of the Region relative to its neighbours Regions 2 and 7 and the location of the major places named in this chapter. The offshore area typically has a water depth of around 200 m. The area is exposed to northerly and north-easterly winds but the landmass gives some shelter from the westerly winds, which normally prevail over the British Isles. The major centres of population are Aberdeen and Edinburgh in Scotland and around Newcastle and Teeside on the north-eastern coast of England. The remainder of the coastline is not densely populated. Major rivers flow into the northern North Sea in Scotland e.g. the Dee and Forth and on the north-east coast of England e.g. Tweed, Tyne, Wear and Tees. The Region has the most productive waters in fisheries terms of all the regions considered in this review and it is where much of the current oil production takes place.

PHYSICAL ENVIRONMENT

WEATHER AND CLIMATE

The three main weather features that drive ocean circulation and, on a more local scale temperature and salinity, are wind speed and direction, air/sea heat exchange and evaporation/precipitation. The influence of all three features is controlled or modified by the North Atlantic Oscillation (NAO) as this causes changes in strength and direction of the westerly wind flow over the North Atlantic. The intensity of the NAO is traditionally calculated as the normalised sea level pressure difference between a station characteristic of the sub-tropical high (Gibraltar or Lisbon or Ponta Delgada in the Azores) and one characteristic of the polar low (Iceland). The Azores/Iceland data set produces an Index better representative of the strength of the Atlantic westerly winds during the whole year, whereas the Lisbon/Iceland data set better captures the NAO related wintertime variability in sea level pressure over the North Atlantic sector and yields a time series back to 1864. The Gibraltar/Iceland data set also gives an adequate Winter Index and extends over a longer period (Figure 1.2).

The NAO affects the paths taken by storms and their intensity and number, as well as rainfall and temperature, particularly in winter when the biggest changes in the NAO occur. A positive phase in the NAO tends to lead to mild wet winters over northern Europe. The influence of the NAO on the area to the east of the UK is however, less than that seen to the north and west but changes in those regions do feed through to changes in the northern North Sea region.

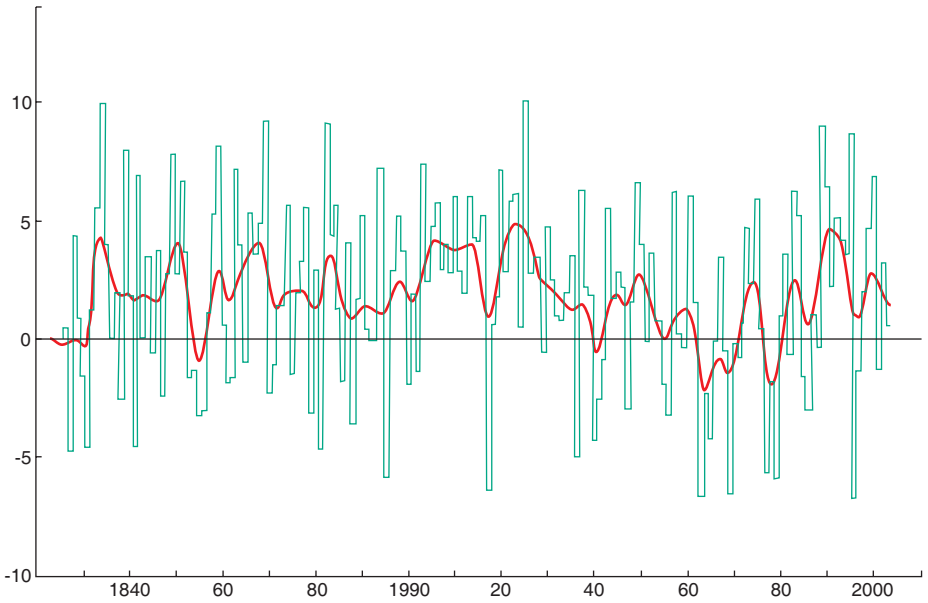


Figure 1.2. NAO Winter index Based on the normalised pressure difference between Gibraltar and Reykjavik. Data series ends at December 2003. Courtesy of CRU, UEA

The Fisheries Research Services (FRS) Laboratory in Aberdeen has collected temperature, wind speed and rainfall records from a number of coastal sites around Scotland one of which is at Lerwick in Shetland to the extreme north of the region.

The records at this station go back to 1961 and show a long-term warming, although the values for the first two years of the new century were lower than those recorded in 1998 and 1999. The changes observed in all three records can be seen to have followed the same pattern of change exhibited by the NAO (Figure 1.3).

Data have also been collected for a Scottish Islands Index based on Stornoway and Lerwick, with data compared for the 30 year period 1873-1902 and 1961-1990. This also clearly demonstrates a warming trend, most of which was found to result from an increase in the mean minimum temperature rather than any significant change in the mean maximum temperature.

SEA TEMPERATURE

One would expect from the evidence of a warming trend in air temperature over land and the general warming detectable in sea surface temperature (SST) over the eastern North Atlantic that a similar pattern would be detectable in the northern North Sea. The K16 Met Office automatic weather station situated east of Aberdeen suggests that above average temperatures certainly occurred over the short period 2000-2002. However, data collected by FRS from a position somewhat

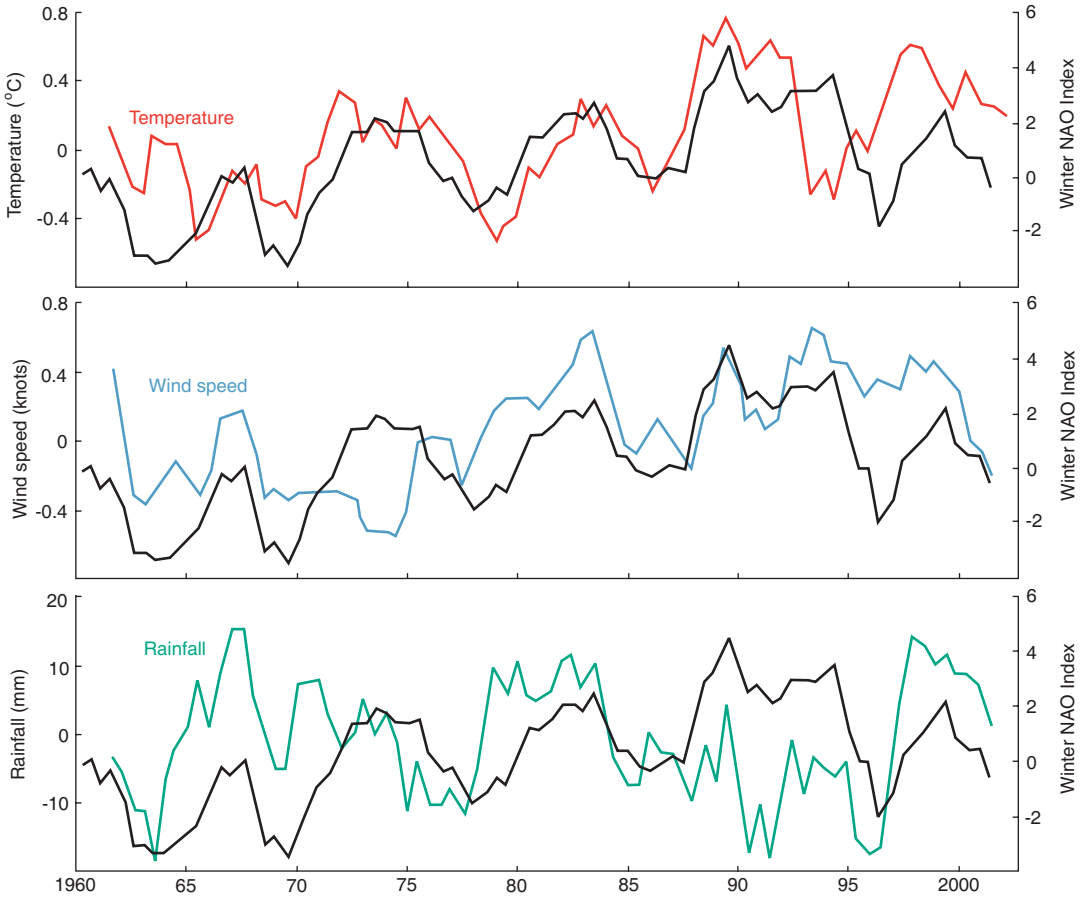


Figure 1.3. Long-term changes in the monthly average air temperature, wind speed and rainfall at Lerwick Long term changes in the monthly average air temperature, wind speed and rainfall at Lerwick and changes in the NAO Winter Index. For temperature and wind, the large change through the year due to seasonal changes has been removed by subtracting the long-term (1961-1990) monthly averages, leaving the smaller change from year to year. Courtesy of FRS

further north in the Fair Isle current shows that whilst there has been an overall warming trend, there has been cyclic variability since 1977 (Figure 1.4). Since the cool period in the late 1970s indicated by this record, there has been a long-term warming trend in winter bottom water temperature at all North Sea fishing grounds of between 0.3 and 0.6°C/decade.

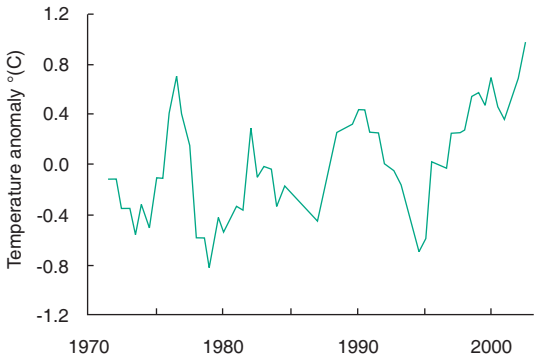


Figure 1.4. Fair Isle Current Water temperature anomalies Nominal position: 59° 17'N, 2° 10'W. Courtesy of FRS

Low temperature water was observed at a number of fishing grounds in the central North Sea during the winter of 1979 (Figure 1.4). This was attributed to a north-westerly spread of water from the southern North Sea due to very persistent strong south-easterly winds.

SALINITY

The salinity of the northern North Sea area is strongly influenced by water inflow by the North Atlantic Current, which brings oceanic water of high salinity into the area through the Fair Isle Channel off the north of Scotland, and a more significant inflow along the western slope of the Norwegian Trench. The salinity of the area is also influenced by the NAO and the meteorological forcing of the ocean–atmosphere heat exchange and resulting rainfall. Strong positive values of the NAO Index are linked to low surface summer salinity, whereas strongly negative values are linked to high surface summer salinity.

Unfortunately there are no really long time series of salinity relating to the northern North Sea but records extending over more than 100 years exist for a station off the German coast in the southern North Sea (to the east of Region 2). These show no significant trend. There are however shorter term records collected by FRS in the Fair Isle current which indicate a freshening since 1970. Similarly, the records collected in association with the regular International Bottom Trawl Survey (IBTS) in the North Sea, which is organised by ICES, indicate a trend of declining salinity since the 1970s at three of the stations in the northern North Sea although at the Viking Bank station the trend is in the opposite direction (Figure 1.5).

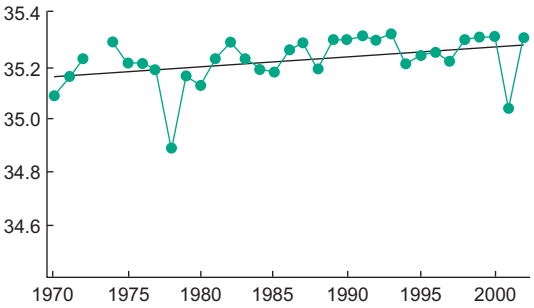


Figure 1.5. Bottom salinity time series in the North Sea (Viking Bank), 1970-2002. Time series based on IBTS data and produced by averaging the data sets by year. Courtesy of the ICES Oceanographic Data Centre

WAVES

The height of offshore waves depends upon the strength of the wind and the distance and length of time the wind can influence the sea surface (fetch). Measurement of waves relied on rather crude instruments until the mid-1950s. Since then a number of more reliable instruments have become available and by the 1970s wave following buoys using accelerometers were in routine use. More recently measurements made from satellites have become available. In UK waters the wave climate is strongly seasonal with maximum mean wave heights peaking around January although extreme waves may be encountered at other times, most notably between October and March. This seasonality is well illustrated in Figure 1.6 which shows mean wave height and wind as derived from the Geosat, ERS-1, ERS-2, TOPEX/Poseidon and Jason altimeter data from 1985 onwards for an area east of Aberdeen.

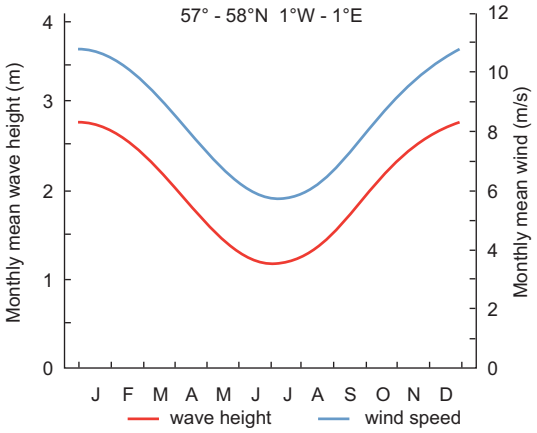


Figure 1.6. Monthly mean wave heights and wind speeds derived from ERS-2 and TOPEX-Poseidon altimeter data from 1985 onwards. Courtesy of Satellite Observing Systems Ltd.

In deep water, high waves can have consequences for the operation and safety of platforms and pipelines and the offshore oil industry operating in Region 1 has collected records of wave heights over a number of years. The oil industry's records thus provide an extensive and consistent set of records for the northern North Sea. These show that between 1973-1995, in the northern North Sea there appears to have been an upward trend in the mean significant wave height (Hs) in the period January to March, with an increase of 5-10% (0.2 to 0.3 m), but a decrease thereafter.

CIRCULATION

The net movement of water, the circulation, comprises residual currents due to net tides, mean meteorological forcing and mean density distribution. Circulation is often portrayed in very simplistic terms by arrows on a chart. Such diagrams give a good idea of the average picture but they can also be misleading and circulation is in reality very variable in both space and time, especially in the short-term (daily to monthly) and shows seasonal and inter-annual variability. Circulation is nevertheless an important concept because it controls movement of passive objects such as suspended sediments, eggs and flotsam as well as contaminants.

The bulk of the waters in the Region become thermally stratified during April/May due to solar heat input. This results in a well-mixed surface layer of warmer water of about 30-40 m depth overlying a cooler bottom layer. The southern North Sea (Region 2) is much shallower and the waters are well mixed throughout the year. Where the stratified northern and unstratified southern waters meet a front becomes established. This produces a major contribution to the circulation of the central North Sea with a persistent narrow (10-15 km) near-surface flow along the 40 m contour between the Firth of Forth and the Dogger Bank. This flow is associated with a strong bottom front bounding the cold dense bottom water below the seasonal thermocline.

'Flushing time' is another term often used in connection with circulation and is intended to indicate how long it takes on average between water or material entering an area and leaving it. For the North Sea as a whole it is generally reckoned to be between one and three years, but clearly it will vary depending on location, season etc.

SEDIMENT CONCENTRATION AND TRANSPORT

Information on the nature of the seabed in the Region is provided in the Habitats and Species section of this chapter. Sediment transport is important because it is the means by which much of the evolution of the foreshore and coastline is determined after the initial action of wave energy. Thus, material suspended in the water column is either carried by currents or deposited. In shallower water, storm conditions lead to resuspension of the finer sediment leading to onward transport. Much of the northern North Sea coastline is rocky and water depth increases relatively quickly offshore. Satellite imagery (Figure 1.7) shows that in most of Region 1 suspended sediment loads are low. The images do show increased sediment loading off the Scottish east coast north of Aberdeen, particularly in winter, and along the north-east coast of England. On the north-east coast of England from St Abb's Head to Flamborough Head there is considerable coastal erosion, water depths progressively decrease and suspended sediment is conveyed in a southerly direction, both in the water column and by transport along the seabed.

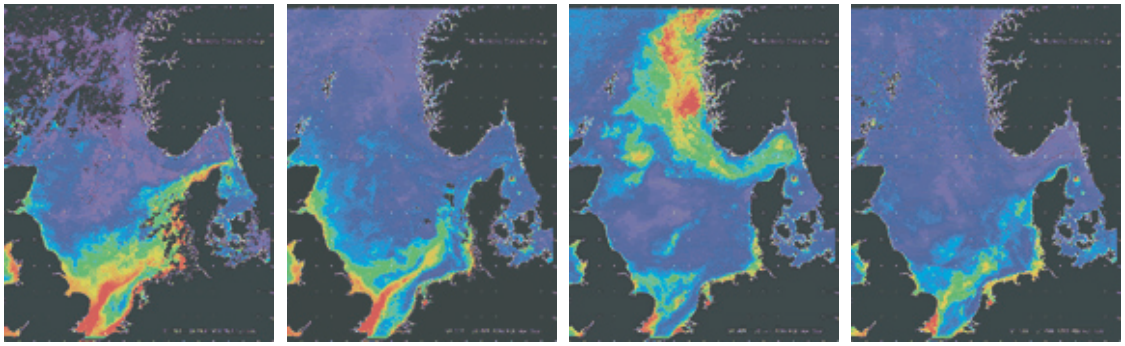


Figure 1.7. Satellite images of reflectance at 555nm during 1998 in the North Sea, closely related to SPM concentrations. The images are NASA SeaWifs composites at a resolution of 1.1km.Courtesy of NASA and PML Remote Sensing Group. Courtesy of Satellite Observing Systems Ltd.

The circulation pattern described above, tends to move material offshore in an east-west direction into the central North Sea though coastal transport also continues further south. The main offshore convergence in the North Sea is off Flamborough Head.

CHANGES IN SEA LEVEL, COAST AND SEABED

Observed sea levels are a combination of tidal level, surge level, mean sea level and waves. Lunar tides increase and decrease by up to 3.7% over an 18.6 year period, the last maximum was in 1997 and the next minimum will be in 2006. Surges are caused by storm events and can result in increases or decreases of several metres over predicted tidal heights. Mean sea level (MSL) is the height averaged over a period of time and thus removes most of the regular tidal variation and intermittent surge activity. MSL does however, change over time in response to global changes in sea level and land uplift or subsidence as a consequence of post-glacial adjustment. One of the five longest records of MSL is for Aberdeen and the records show a positive trend (Figure 1.8). This record is a composite of records from more than one gauge but the trend is much the same as that shown by the other four long term records for other UK sites including that for North Shields. 'Absolute' sea level is a value derived by removing the influence of land movement and globally shows an increase of about 10 cm during the last century. Allowing for land uplift in Scotland this scale of rise fits well with the small increase in MSL suggested by the record for Aberdeen.

As described earlier, most of the coastline of Region 1 is eroding to a greater or lesser extent with erosion rates being particularly high along the north-east coast of England increasing in a southerly direction to Flamborough Head. Off the coast of Scotland much of the sediment reworked off the coast is of marine origin but in the outer estuaries of the Tay and Spey it is largely river derived. Some concern has been expressed that in the Spey any reduction of sediment input due to river or land management would rapidly result in erosion. This pattern of erosion of the Scottish coast, as assessed between 1969 and 1981, should be considered against previous recent history. During the early to mid-nineteenth century the coastline changes were mainly accretional, erosional conditions then set in around the turn of the century but there was some recovery and accretion during the period 1920-1960. Whilst these coastal erosion trends clearly affect the immediate coastal seabed their influence on the deeper seabed of the majority of the northern North Sea is unlikely to be significant.

ENVIRONMENTAL QUALITY

NUTRIENTS

The microscopic plants on which the marine food chain is based are collectively known as phytoplankton. Phytoplankton growth is regulated by light and the availability of nutrient forms of nitrogen and phosphorus and to a lesser extent silicate and carbon. Excessive growth in response to an increased supply of nutrients is termed eutrophication and a number of measures

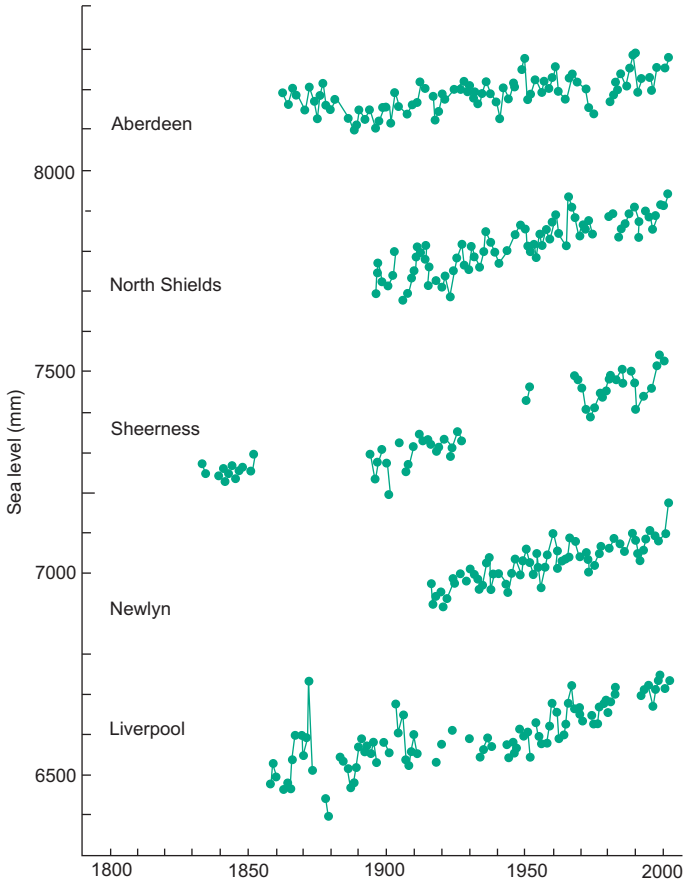


Figure 1.8. MSL at Aberdeen, North Shields, Sheerness, Newlyn and Liverpool Each record has been de-trended over the period 1921- 1990 and the de-trended values averaged. Courtesy of PSMSL

have been taken to avoid eutrophication through restrictions on inputs of nitrogen and phosphorus. In order to guide decisions on where restrictions are necessary in order to avoid the problems that can be associated with eutrophication, common assessment criteria have been proposed by OSPAR. These set normal and elevated levels for dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP) and chlorophyll. For the North Sea these are set at 10 to >14 μmol/l for DIN and 0.6 to >0.8 μmol/l for DIP and a guideline which states that chlorophyll concentrations should be no greater than 50% above the offshore or historical background concentration for the area concerned. Lower levels are set for DIN and DIP in the Channel (Region 3) and higher levels for the Irish Sea (Region 5) in recognition that there are natural regional differences due to natural inputs to different areas.

In Region 1 concentrations of both DIN and DIP and of chlorophyll are normally below the levels at which eutrophication is regarded as likely to occur and nutrient concentrations over most of the northern North Sea are considered typical of the background for the North Atlantic. This situation is largely a reflection of the fact that inputs of nutrients from land are generally low and the fact that there is active tidal mixing and water movement. Thus for the northern North Sea as a whole nutrients do not present a cause for concern. Minor problems do arise in a few restricted localities - the Ythan estuary on the Scottish coast north of Aberdeen, around Lindisfarne on the north-east coast of England and in an area of the Tees estuary known as Seal Sands. In these areas the problems are caused not by excessive phytoplankton growth but by accelerated growth of benthic macroalgae which

restricts the growth of invertebrates on which wading birds feed. Both the Lindisfarne and Ythan problems are believed to be attributable to run off from agricultural land. In the Tees estuary a combination of industrial sources and urban sewage discharges, plus the use of fertilisers in agriculture inland is involved.

HAZARDOUS SUBSTANCES – METALS

Within the northern North Sea all concentrations of metals in sea water, except for zinc in the Tyne estuary are reported to be below the EQS values i.e. those defined as being unlikely to harm aquatic life. In 1997 OSPAR established a set of background reference concentrations (BRCs) which were based on the concentrations regarded as typical of the more remote areas of the OSPAR region. These reference concentrations have been under review for some time and new values were assigned during the later stages of producing the Environmental Quality sector report but too late for them to be accommodated either in that report or in this review. Within the northern North Sea the background concentrations for metals in sea water were only exceeded in the Tyne and Tees estuaries. In both estuaries the concentrations of lead were as high as 6mg/l, which is well above the upper end of the BRC range of 0.01 – 0.02 μg/l. Ecotoxicological Assessment Criteria (EACs) i.e. the concentrations above which it is considered there may be impacts on biota, have also been set by OSPAR in 1997. (As with the BRCs these have also been under review and have been revised.) For lead the range was defined as 0.5-5.0 μg/l. Both the Tees and Tyne estuaries have had a long history of industrial activity along their shores and the high concentrations of lead found in water in these two estuaries is a result of that legacy. Mercury concentrations in the Wear estuary (0.041-0.045 μg/l) also indicate possible impacts on biota, based on the OSPAR EAC values.

BRCs were also established for metals in sediments and the BRC metal to aluminium ratio for lead in sediments was exceeded in both the Tees and Tyne estuaries and in the Wear estuary, all of which are on the north-east coast of England. The situation regarding Tees estuary sediments is somewhat worse, because the BRC ratio values for cadmium, zinc and mercury are also exceeded, as is that for cadmium in the Wear estuary. In all three estuaries the EAC concentrations for cadmium, lead, copper and zinc are also all exceeded. All three estuaries have seen considerable industrial activity in the past and their catchment areas were the scene of considerable metal ore mining activity. Consequently, although present day inputs are considerably lower than previously, the legacy remains in the form of contaminated sediments. The concentrations of metals in both water and sediments collected elsewhere in the northern North Sea area were, in many cases, among the lowest recorded for all sites around the UK. For example mercury concentrations in sediments from the Moray Firth and offshore Tay and Forth estuaries were lower than all other areas except the Solway Firth (Region 5). Cadmium, copper and zinc concentrations were also all generally low and comfortably below the EAC concentrations at all sites, other than the three estuaries on the north-east coast of England.

Concentrations of metals are measured in the muscle tissue of fish and, within the northern North Sea, the concentrations were mostly well within the normally accepted range. The only exception was lead, where the concentrations in both dab and flounder from the Tyne, Wear and Tees estuaries were all above to the 200 μg/kg wet weight level considered normal for these species. Metals are also measured in mussels, which are regarded as a good indicator species because they remain in one position. OSPAR did not agree EACs for metals in mussels but BRCs were established. In common with samples collected elsewhere around the UK mussels from northern North Sea coastal sites were generally found to contain concentrations of mercury, cadmium, and lead above the BRCs, but copper and zinc concentrations were mainly below the BRCs. Concentrations of mercury in mussels from the coast of Northumberland and Durham i.e. close to the Tyne, Wear and Tees estuaries, were found to contain between 50 and 74 μg/kg wet weight i.e. they exceeded the upper BRC concentration of 10 μg/kg wet weight.

HAZARDOUS SUBSTANCES – CHLORINATED ORGANICS

Certain chlorinated organic compounds combine persistence and a tendency to bioaccumulate with toxicity, accordingly controls have been applied severely restricting the use of many of these compounds. As a consequence the

concentrations found in the marine environment have declined. OSPAR did not establish BRCs for such compounds but EACs have been derived. Concentrations of most of these chlorinated compounds are undetectable in water in the northern North Sea with the exception of hexachlorocyclohexane (HCH), the gamma isomer of which (lindane) was used as an insecticide until 2002 when its use in the EU was banned. The EAC range for lindane was 0.5 to 5ng/l and, within the northern North Sea area, concentrations in the various estuaries sampled were all below the upper figure.

Polychlorinated biphenyls (PCBs) are another group of chlorinated organic compounds, which were used extensively in a wide range of industrial and domestic applications. Concentrations are usually expressed in terms of 7 selected CB compounds (the commercially available products were mixtures) and the EAC range set by OSPAR was 1-10 μg/kg dry wt in sediments and 1-10 μg/kg wet wt in whole fish. The most recently available NMMP data show that within the northern North Sea area the Moray Firth and the Firths of Tay and Forth all yielded sediments with concentrations of CBs in sediments of less than 1mg/kg dry wt. However, the concentrations of CBs in sediments from the Tees exceeded the upper EAC of 10 μg/kg dry wt. CBs are also monitored as part of the NMMP in fish liver and in mussels. None of the concentrations of CBs found in the livers of fish caught in the northern North Sea were considered high. Generally the fish from Scottish waters had a higher proportion of the lower chlorinated CBs, suggesting a predominantly atmospheric input route to the northern North Sea. Concentrations of CBs were lowest in mussels from the Tay estuary and were generally below the upper EAC set by OSPAR (5 to 50 μg/kg dry wt) in the mussels collected from monitoring sites in the northern North Sea area

HAZARDOUS SUBSTANCES – POLYCYCLIC AROMATIC HYDROCARBONS (PAH)

PAHs occur naturally e.g. as a consequence of forest fires but man's industrial activities and the burning of fossil fuels add further quantities to the input inventory. OSPAR established EACs for eight individual compounds in sediments (Table 1.1) and these eight are included in the group of ten PAH the environmental concentrations of which are monitored under the NMMP.

Table 1.1. EAC values for PAH (OSPAR)

PAH compound	upper EAC (μg kg^{-1} dw)
naphthalene	500
phenanthrene	1000
anthracene	500
fluoranthene	5000
pyrene	500
benz[*a*]anthracene	1000
chrysene	1000
benzo[*a*]pyrene	1000

The concentrations of PAH found in the northern North Sea area show very marked differences depending on the location of the sampling site in relation to centres of population and industry. Thus in the Moray Firth the sum of the ten PAH measured was recorded as below detectable levels. However, at sites in the Tyne, Wear and Tees estuaries the sum of the concentrations of the ten PAH measured was >10,000 μg/kg dry wt, which compares to the sum of the eight EAC concentrations set by OSPAR of about 10,000mg/kg. An alternative method of assessing the significance of PAHs is to express the summed concentrations in terms of the equivalents to Benzo(a)pyrene (BaPE) a known carcinogen. At two stations in the Tees estuary the BaPE concentrations exceeded 25,000 μg/kg. Such levels are considered likely to be acutely toxic to animals living in the sediments and chronic effects such as induction of neoplastic liver disease may occur in bottom dwelling fish. In terms of BaPE values, concentrations in mussels collected under the NMMP in Region 1 were generally low although, as would be expected from the sediment data, higher than normal concentrations were found along the Northumberland coast and in the Tees estuary. The data set available for PAHs only covers the years 1999-2002 and this is too short for any trends to be detectable.

ORGANIC CONTAMINANTS RECENTLY RECOGNISED AS PRESENT IN THE MARINE ENVIRONMENT

In addition to the routine surveys undertaken for substances commonly recognised as hazardous investigations are also undertaken aimed at assessing potential new problems. These are usually undertaken on a pilot scale

and recent studies have examined brominated flame retardants and alkyl phenols. Both studies included sites within Region 1 but only within the sector south of the border with Scotland.

Alkyl phenol ethoxylates are non-ionic surfactants, the most common of which are the octyl and nonyl forms. They are widely used in both commercial and domestic applications and once in the environment they readily break down into alkyl phenols. Within Region 1 most of the samples of sediment were found to contain concentrations of nonyl phenols and of nonyl phenol mono- and di-ethoxylates of less than the limit of detection used (1 mg/kg and 0.2 mg/kg respectively) except within the Tees estuary where in 1998 concentrations of nonyl phenol ranged from 2-42 mg/kg with the highest concentrations being found close to the Tees outfalls. Total concentrations of nonyl phenol mono- and di-ethoxylates of up to 30 mg/kg were also found near the Tees outfall in 1999. All concentrations of octyl phenol were either below or just above the limit of detection of the method used.

Bromine based flame retardants are applied to a variety of polymer products. Some 70 different chemicals are involved with a total global use of around 300,000 tonnes. Like PCBs most products contain mixtures of compounds. The first studies in the UK focussed on polybrominated diphenyl ethers (PDBEs) but with the exception of deca-brominated diphenyl ether, use of these compounds has been discontinued within the EU and manufacture within the UK is being transferred to the USA. Studies are therefore now being focussed on hexabromocyclodecane (HCBD) and tetrabromo-bisphenol-A (TBBP-A). PBDEs were manufactured at a site on the Tees estuary and relatively high concentrations of deca-BDE were found in sediments in this area but none was detected in biota. However, within Region 1 tetra- and penta-BDE compounds were detected in livers of fish from offshore reference sites and concentrations of up to 1500 μg/kg (sum of three measured compounds) were found in the livers of dab and flounder from Tees Bay. Subsequent wider ranging studies, involving analysis of up to 15 individual BDE compounds, showed their presence in two invertebrate species (seastars and hermit crabs) at various coastal and offshore sites within the region.

RADIOACTIVITY

Radioactivity has both natural and anthropogenic sources. Natural radioactivity stems from the decay of radionuclides present in the earth's crust and from interactions with cosmic radiation in the atmosphere. Anthropogenic inputs of naturally occurring radionuclides arise from industrial practices such as oil and gas production, uranium mining, steel processing and phosphate ore processing. Anthropogenic inputs also arise from weapons testing, nuclear accidents e.g. Chernobyl, and from nuclear power production and fuel production and reprocessing. Such anthropogenic inputs include both natural and artificial radionuclides. The past and present inputs of radionuclides from the nuclear fuel plant at Sellafield on the Cumbria coast and their effects on humans and marine organisms are addressed in Chapter 5 of this Integrated Assessment. However, within the North Sea the presence of radionuclides such as ^{90}Tc and ^{137}Cs from the Sellafield plant is clearly detectable and serves as a tracer demonstrating transport from the Irish Sea through the North Channel and via the Scottish Coastal Current into the North Sea and thence towards the Arctic. Concentrations of ^{137}Cs in the North Sea water range between about 2 and 20 mBq/kg compared to 10 – 100 mBq/kg in the Irish Sea. The background due to weapons testing fallout etc is regarded as about 2 mBq/kg and at least some of the Cs in the North Sea is derived from contamination of the Baltic Sea following the Chernobyl accident. In terms of public exposure and effects on marine organisms, the presence of radionuclides in the Irish Sea does not pose a problem (see Region 5). As concentrations of radionuclides in Region 1 are generally at least a factor of five lower than in the Irish Sea it can be concluded that they are insignificant in terms of the radiation dose they cause to either man or marine organisms.

MICROBIOLOGY

Under the terms of three EU Directives the UK is required to undertake monitoring of microbiological quality of the marine environment at a number of sites around UK coast. All 3 Directives lay down acceptable standards for bacterial indicators of faecal contamination but all use different measurements. In compliance

with the Bathing Waters Directive (for which new, tighter standards are currently in the process of being agreed) monitoring was conducted in 2003 at 565 identified bathing beaches in the UK 554 of which were coastal. Of these 489 were in England and Wales and 483 (98.8%) passed the mandatory standards. Of the six failing sites two were in Region 1 on the Yorkshire coast. The 2003 compliance figure compares with an overall rate of 78.1% compliance in 1990, and is a reflection of the considerable investment made in recent years in improved sewage treatment and disposal arrangements. Continuing failures may at least in part be attributable to diffuse sources, including run off from agricultural land.

In Scotland there are fewer designated bathing waters but in 2003 monitoring was undertaken at a total of 60 sites and 57 (95%) passed the mandatory standards. This compared to 65% in 1990. In 2003 all of the sites on the North Sea coast within Region 1 in Scotland passed the mandatory standards whereas in 1990 six (out of a then identified total of 31) sites in this region failed the mandatory standards. Thus, as in England, there has been a marked improvement.

The Shellfish Hygiene Directive sets out standards for *E. coli* and faecal coliforms in bivalve shellfish flesh as opposed to water. The standards define whether the shellfish can be sold directly for human consumption (class A), after passage through an approved purification system (class B) or must first be relayed for an extended period in either a class A or B site. There are very few sites in the northern North Sea area on the mainland coast of England or Scotland where shellfish are harvested or cultivated. Only one site is in England, on the Northumberland coast; a further five are located in Scotland on the Firth of Forth (three sites) and the Moray Firth (two sites). Nine more sites are located in Shetland. In 2003 on the Firth of Forth two sites were graded B and one site was given a seasonal A/B classification. In the Moray Firth one site was classified B and a further site A/B. On the east coast of Shetland two sites were classified A and seven sites A/B. A/B classifications are issued when higher levels of contamination occur intermittently but tend to be seasonal.

The third EC Directive requiring microbiological monitoring is the Shellfish Waters Directive. This lays down standards for a variety of contaminants and is aimed at the protection and improvement of the quality of shellfish growing waters. The standards are defined differently to those for the Shellfish Hygiene Directive but are broadly similar in effect to the conditions for class A under the Shellfish Hygiene Directive. The areas designated under the two Directives do not yet coincide in every case, although the current policy is that they should broadly do so. In the northern North Sea area the one site designated in England is the same as that monitored under the Shellfish Hygiene Directive and it has passed the required guideline standard for the last four years. In Scotland assessment of compliance with this Directive is based on data in shellfish flesh quality and within Region 1 there are ten designated areas. Of the 14 sites sampled only three failed to comply with the Directive's guideline standards for faecal coli in shellfish flesh in 2002 and the remainder either complied or were deemed to be likely to comply.

Several sites have consistently failed to comply with the guideline standard in the Directive for faecal coliforms but improvements to local discharges are now underway as a response to the requirements of the Urban Waste Water Treatment Directive and are expected to result in better compliance. However, a number of failures remain unexplained and may be the result of diffuse or agricultural sources.

OIL AND OIL SPILLS

The entire sea area around the UK is within the European Waters Special Area established by IMO in 1999. Consequently there should be no discharges of oil or oily water from ships. However, illegal discharges still take place and about 37 oil slicks believed to be of vessel origin were reported in 2002 in the northern North Sea. Most of these, about two thirds, were in the open waters well offshore to the east, although a number were reported as having been seen close to land. No oil spills have occurred as a result of shipping accidents since the *Braer* spill in Shetland in 1993. Although this led to the release of 85,000 tones of North Sea crude oil, due to the weather conditions almost no oil was stranded on the shore and no conventional slicks occurred. The oil became thoroughly mixed in the water column and some adsorbed onto suspended sedimentary material and was deposited on two main areas of the seabed; Burra Haaf on the south-west coast (Region 7) and south-east of Fair Isle in Region 1. The impact in Region 1 was

small with no toxic effects on marine organisms and the visible effects were minimal both in extent and duration. (The main lasting impacts were in Region 7 - see Chapter 7).

The northern North Sea is where most of the oil reserves on the UK continental shelf are located and although exploration has substantially reduced in recent years, exploitation of this oil and associated gas resource is still undertaken on a large scale. The oil is transported to shore either by tanker or by pipeline to terminals in Shetland, Orkney, Aberdeenshire and Teeside. The associated gas is transported by a group of pipelines to a major terminal near Peterhead on the northeast coast of Scotland (Figure 1.9).

Almost inevitably the exploitation of oil offshore results in discharges of oil. Historically these arose on drill cuttings, in produced water and from accidental spillages but the relative proportions have changed considerably over the years. Figure1.10

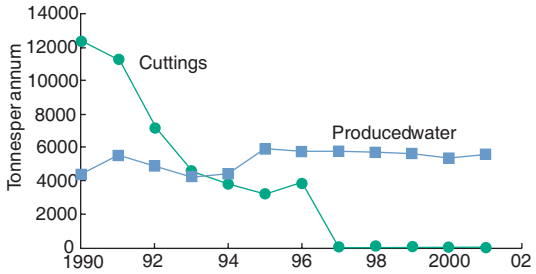


Figure 1.10. Operational oil discharges from the offshore industry

The oil on drill cuttings arose from the use of oil based drilling muds and inputs via this route have a ceased following the ban on the discharge of wastes arising from the use of such muds, predominantly contaminated cuttings. However, the legacy of previous discharges remains and within 100-200m of a platform very high concentrations can be found in the sediments. Such levels of contamination usually fall away

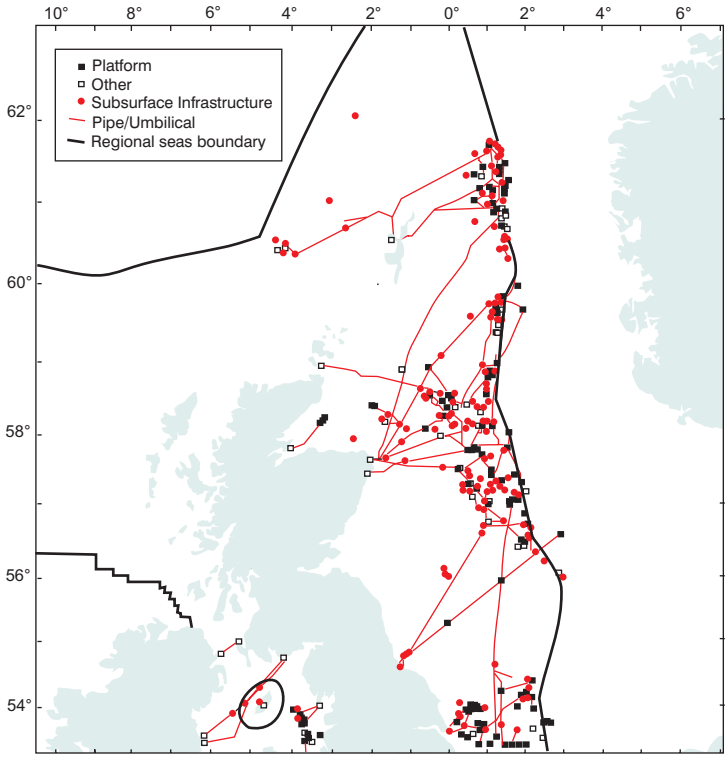


Figure 1.9. Oil Fields and pipelines (Northern Sector)

rapidly with distance from the platform, with background concentrations reached 1-2km away.

The total numbers of recorded spills has increased in recent years but this is believed to be attributable to better reporting rather than a real increase. Total amounts spilt are usually less than 100 tonnes/year but, as there are between 300 and 400 reported spills annually, each is typically small and their impact is negligible.

The concentrations of oil discharged in produced water have been progressively reduced over the years as tighter controls have been imposed under international agreements such as OSPAR. Although the permissible concentration (40 ppm) is, under most sea conditions, below that at which visible oil can be seen, the UK industry has over the last ten years achieved an average of 21 ppm and is committed to a further 15% reduction in total oil discharged in produced water relative to 2000 by 2006. This will be a major achievement since input of oil by this route has increased somewhat due to the increasing volumes of produced water (roughly doubled in 10 years) arising as the oil reserves are progressively depleted. Currently the amount discharged annually from this source is about 5,500 tonnes. OSPAR has defined an EcoQO for seabirds that states no more than 10% of the common guillemots found dead or dying on beaches must be oiled. No formal surveys have been conducted in Region 1 to establish whether this EcoQO is being met but data from Orkney and Shetland have been included in the testing of this EcoQO by Netherlands.

NAVIGATION DREDGING AND AGGREGATE EXTRACTION

In order to maintain or increase water depth in harbours and their approach channels dredging is an essential operation for most ports. Dredging to maintain water depths is distinguished from new dredging to deepen channels or create new harbour areas. The former is described as maintenance dredging and the latter as capital dredging. The total quantity of material arising each year fluctuates somewhat, particularly in response to the amounts of capital dredging taking place. Currently in the northern North Sea area only one such project is in progress in the upper Forth at Leith and Granton. Most major ports carry out maintenance dredging more or less continuously and those in the northern North Sea area are no exception. In 2001 in Region 1 approximately 1.7 million dry tonnes of dredged material were relocated in 15 licensed disposal sites in the course of harbour maintenance projects. The bulk of this total coming from operations in the Tees, Tyne and Firth of Forth areas.

Dredged materials, especially maintenance dredgings are usually composed of muds and fine sands but these can carry substantial contaminant loads as a consequence of inputs, mainly from earlier times, of such materials into harbour areas or the neighbouring estuaries. In order to avoid seriously contaminating the sediments in the disposal sites, measurements are undertaken to ensure that contaminant levels are within those regarded as acceptable under current disposal to sea regulations. The range of contaminants is slowly being extended and there have been a number of instances where for example TBT concentrations have been considered too high (>0.1 mg/kg dry wt) to allow disposal to sea e.g. dredged material from certain dock areas in the Tees estuary. As a consequence of these controls on contaminant levels and reductions in direct inputs of contaminants to rivers and estuaries, the quantities of several metals disposed of with dredged material roughly halved between 1986 and 2001 with the largest reduction occurring in the first 5 years of that period (Figure 1.11, overleaf).

Disposal of dredged material is only permitted at defined sites and only following an assessment of the likely effects on the disposal area. The assessment procedure is especially rigorous if the site involved is close to a site designated as being of importance for nature conservation reasons.

Increased effort is being applied to find ways of using dredged material rather than simply disposing of it. The quantities that can be used in practice are dictated by the nature of the dredged material and how close the use area is to the dredging site. The proportion so used has risen by a factor of almost ten-fold over the last 10 years but still represents less than 1% of total arisings.

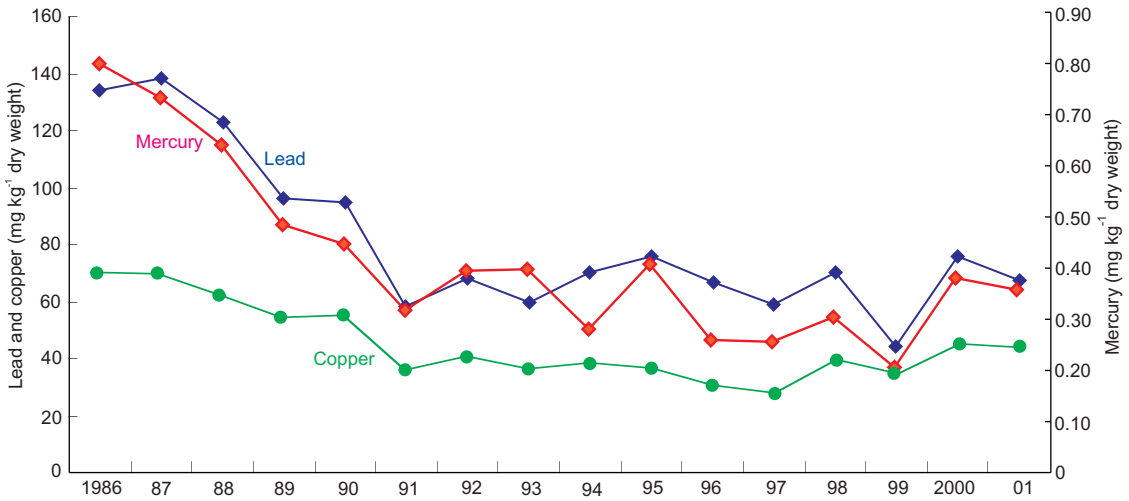


Figure 1.11. Mercury, copper and lead concentrations in UK dredged material

In certain areas around the UK coast there are deposits of coarse sand or gravel which have major potential value either for beach replenishment or as aggregates in the building industry. However, no such deposits are exploited in the northern North Sea area and no extraction is currently planned in this area.

CONSTRUCTION

A substantial proportion of the coastline of the northern North Sea is relatively unaffected by coastal defences or urban development and can thus be regarded as less modified than more populated areas of the coastline such as in Regions 2, 3 and 4. Nevertheless, agricultural practice and numerous small towns and harbours mean the coastline has been modified. New coastal developments are subjected to a rigorous assessment procedure that seeks to ensure if the project does proceed the impact on the environment is minimal. One such development in the northern North Sea is the large-scale port development of Leith and Granton Ports in the Firth of Forth. Also in Scotland there are numerous proposed projects to improve sewage disposal practices that involve construction of new pipelines. The assessment procedures seek to minimise impact on fisheries and other interests in the marine environment.

A particular form of construction, which is the focus of considerable attention at present, is the construction of offshore wind farms. Within the northern North Sea area there is already one small development onshore at Blyth on the north-east coast of England and one new development is proposed offshore on Teeside with an additional test site proposed on the east coast of Shetland. However, a number of other renewable energy projects have been proposed for construction in the Region and the Government's aim that 10% of all UK electricity should come from renewable sources will ensure proposals for more such developments. No construction will be permitted without a thorough assessment of possible impacts and monitoring thereof after construction in order that the findings can be fed into the regulation of future developments.

MARICULTURE

Mariculture is an important activity in Region 1 with fish farms around both Orkney and Shetland. However, unlike the practice in Region 6 most of the cages and rafts are moored in waters off the coast. These are generally deeper and have stronger current regimes. As a consequence there have been fewer concerns over increases in nutrient concentrations, residues of medicines and antifouling agents or accumulation of unused food material, fish faeces etc below the cages. Winter N:Si ratios did exceed levels thought to influence phytoplankton species composition at all sites examined around Shetland but no problems have been encountered and the ratios are thought simply to reflect the norm for that area. The possibility of escaped fish interbreeding

with their wild counterparts is however just as much an issue of concern as in Region 6. The concerns apply particularly to salmon because farmed salmon have a low genetic diversity. It is thus possible that offspring of wild and escaped farmed salmon may benefit from hybrid vigour but this is not passed to later generations which in fact are likely to have lower fitness and productivity. This is less of a problem with other species such as cod, halibut and haddock because the majority of the breeding stock for these species still comes from the wild.

In 2003 the Scottish Executive published a Strategy Framework for the Aquaculture Industry in Scotland which sets out objectives and priority actions designed to achieve sustainable development of the industry in Scotland. All fish and shellfish farms require registration of the business and site and a discharge consent must be obtained. This will specify the production tonnage and quantities of medicines that can be discharged. The overall aim is to minimise adverse impacts of mariculture activities and encourage production of fish and shellfish to fill the gap left by reduced wild stock catches. A growing issue the industry has to face however, is the impact the increasing production of farmed fish could have on stocks of the wild species used as the source of fish feed materials. Exploitation of these stocks is not considered to be sustainable in the long term. However, the increased use of fisheries by-products in fish feeds and the development of new feed materials, in which vegetable oils can be used to replace fish oil and up to 75% of the fish meal can be replaced by plant proteins, may minimise this potential obstacle to continued expansion of the industry and avoid over exploitation of the wild fish species currently used for fish meal based feeds.

CONTAMINANT SPECIFIC BIOLOGICAL EFFECTS

In general marine organisms cope with different levels of exposure to metals by converting toxic forms into less toxic bound forms which can be stored and subsequently excreted. One such mechanism is the induction of metallothionein (MT). This is a natural response to exposure particularly of mercury, copper, cadmium and zinc and can provide an indication of exposure, though not the health of the organism concerned. Surveys of MT in dabs from offshore sites showed high variability, no correlation between males and females from the same sites and little apparent link with existing data on metal concentrations in livers. The MT contents of mussels from a small number of estuarine sites were compared with those found in mussels from a site at Brancaster on the North Norfolk coast. There was no correlation with MT levels in flounder livers from the same estuaries. However, in Region 1 MT levels in mussels from a site in the Tees estuary were elevated compared to the Brancaster control site, although they were lower than those found in mussels from the few other estuaries included in the pilot study.

Certain organic chemicals can disrupt normal endocrine function and in fish this can result in feminisation of male fish. In extreme cases this manifests itself by the presence of eggs in various stages of development in the male gonad. Lower exposure levels can be detected by vitellogenin (VTG) assay. Within the northern North Sea area elevated plasma VTG concentrations have been found regularly in male flounder from the Tees estuary with occasional high concentrations being encountered in fish from the Tyne and Forth estuaries. Following the introduction of secondary sewage treatment for Tyneside in 2000 a clear reduction in plasma VTG concentrations has been noted in male flounder caught near the sewer outfall. However, no such improvement has been noted in flounder caught in the Tees, although similar improvements have been made in sewage treatment in that area.

Exposure to PAH, and to certain CBs, has been found to alter the rate of synthesis of a group of enzymes by fish liver. The extent of exposure can thus be assessed by measuring enzyme activity and reliable methods exist for one such enzyme known as EROD. Significant differences in EROD activity tend to be found between male and female fish and this is believed to be associated with spawning activity, with males showing the most marked variations relative to their reproductive cycle - highest activity during the spawning period and lowest post-spawning. Within the northern North Sea in 2000 relatively high levels of EROD activity were found in dab caught off Flamborough Head and at three sites further north, including one well offshore from the Firth of Forth. The levels found in these fish were higher than those found in other regions that year. However, only one year earlier the highest levels of activity were found in fish from the Irish Sea (Region 5). In order to examine PAH exposure in more inshore species flounder is used instead of dab. Data for the two species cannot be directly

compared because EROD activity in flounder is ten times lower for the same toxicant stimulus. This lower sensitivity may explain why levels of EROD activity found in flounders from several east coast estuaries sampled were remarkably similar at around 15 pmol/min/mg protein. Insufficient data are available to allow any temporal trends to be assessed but high levels of activity, such as those encountered in dab off the Tees, might be expected to be associated with various pathological changes in fish livers.

Pathological examination of fish livers is therefore one of the techniques deployed under the NMMP to assess the well-being of flatfish. The presence of foci of cellular alterations (FCA) is one of the tests used and clear differences have been observed between fish from different areas. Flounder from the Tyne were found to exhibit the second highest prevalence (12.2%) of FCA with the highest level (18.4%) being found in flounder from the Mersey in Region 5. A site in the Firth of Forth was used as the control site and here the prevalence was 2.1% although at another site in the Forth known to be more contaminated, the prevalence was 6.8%. Numbers of liver nodules are also assessed in dab but, with the exception of samples caught off Flamborough Head on the boundary between northern and southern North Sea, where the prevalence seems to have decreased, no trends were apparent.

NON-SPECIFIC BIOLOGICAL EFFECTS

The oyster embryo bioassay has been used over a number of years as a means of assessing general water quality. Embryos of the oyster *Crassostrea gigas* are exposed to water samples for 24 hours and their success in developing normally to 'D' hinge larvae provides a measure of the water quality. The studies have shown that poor water quality is only encountered in estuarine areas. Between 1999 and 2001 water samples from sites in the Tyne, Wear and Tees estuaries showed variable response. In the Wear more than 20% response was noted on one survey with lower or no effects being observed on other occasions. In the Tyne and Tees estuaries there were significant effects in 1999 but essentially no effects were observed subsequently. These recent results compare with results obtained ten years earlier when typically responses of 50 to 100% were measured. The highest response in the period 1999-2001 was less than 30% - in the Tyne in 1999.

An integrative tool for assessing the overall health of fish populations is the measurement of a range of fish disease conditions. Surveys have been conducted for a number of years using dab and flounder. These surveys use carefully developed and laid down protocols aimed at creating a time series of comparable data. External diseases in flounder from estuaries have been found to be present at low levels although liver pathology studies (see above) indicate exposure to a variety of organic chemicals in several of the estuaries surveyed. Diseases in dabs were generally at a low level, especially in dab from Scottish waters in the northern North Sea. However, dab caught off Flamborough Head, in or close to Region 1 were found to exhibit higher levels of disease than those from the control site in the English Channel (Region 3).

Two sediment bioassays have been developed and are routinely deployed to assess sediment quality in four estuaries, two of which are the Tyne and Tees. Figure 1.12 shows the results obtained using these bioassays on sediments

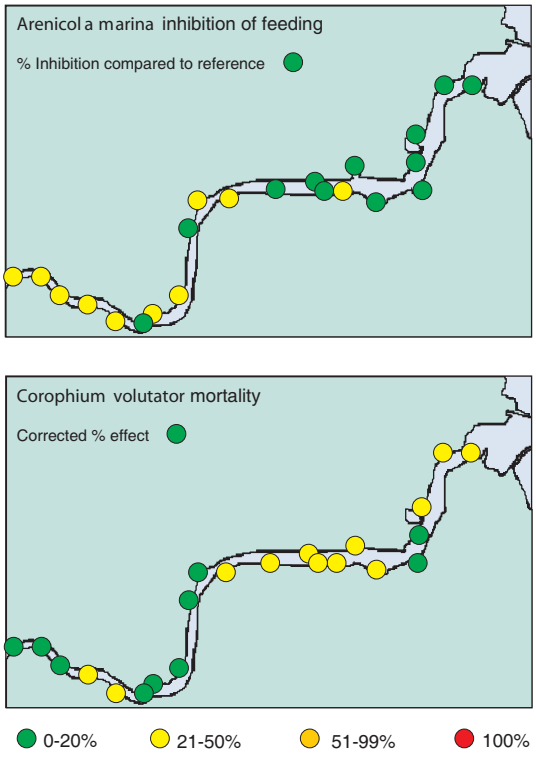


Figure 1.12. Sediment bioassay results for the Tyne estuary 2001

from the Tyne. Results from the Tees estuary suggest that sediments from there are more contaminated than those from the Tyne. At two sites in the Tees *Corophium volutator* (a small crustacean) suffered 100% mortality, whereas in the Tyne the worst level of effect was less than 50%. One sample of sediment from the Tees also killed 100% of the exposed polychaete *Arenicola marina*. Use of these tests is a comparatively recent development and it is not yet possible to make any assessment of trends over time.

LITTER

The sector report on Environmental Quality gives only a very limited amount of information on the regional prevalence of litter based on a single survey conducted by the Marine Conservation Society (MCS) in 2003. Equally there is no regional information on the regional effects of litter in the sector report on Habitats and Species. Consequently, it is not appropriate to go into any detail in this chapter. However, a brief summary of the overall incidence, scale and significance of the litter issue is provided in the final chapter of this Integrated Assessment. In the 2003 MCS Beachwatch survey Region 1 had the second lowest density of beach litter, with an average of 1.32 items/m surveyed. The most significant sources of litter on that occasion were beach visitors who accounted for just over 41% of all litter found and fishing debris (just over 11%).

HABITATS AND SPECIES

FISH ASSEMBLAGES

The northern North Sea is deeper than the southern North Sea becoming increasingly deeper in a northerly direction. Most of the area south of Fraserburgh is between 100 and 200 m deep with waters >200 m deep further offshore north of this latitude. The deeper waters are generally colder and the combination of depth and temperature are key factors in determining the make up of fish assemblages. The dominant demersal fish species include whiting (*Merlangius merlangus*) and haddock (*Melanogrammus aeglefinus*) and pelagic species such as mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*). In the shallower waters closer to the coasts and in the extreme south of the area fish populations are dominated by haddock, whiting, herring (*Clupea harengus*), dab (*Limanda limanda*), plaice (*Pleuronectes platessa*) sand eels (*Ammodytidae*) and sand gobies (*Pomatoschistus* spp.). In the deeper (100-200 m) northern waters Norway pout (T*risopetrus esmarki*) dominate. The northern waters also have a number of boreoarctic species rarely found further south e.g. Vahl's eelpout, (*Lycodes vahlii*) and Esmark's eelpout (*L. esmarkii*). The common skate (*Dipturus batis*) is also found in the Region but mainly off Shetland and wolf eels (*Anarhichus lupus*) are also present. This large species has a comparatively low fecundity and although not seriously threatened at present may become endangered in the future.

COMMERCIAL STOCKS AND LANDINGS

Annual landings (by all countries) of fish and shellfish from the North Sea (Regions 1 and 2) account for about 11% of the total world production of fish and more than half of these landings come from the northern North Sea. The most productive areas are less than 200m deep. Four main types of fishing are undertaken, demersal fisheries using mainly bottom trawls, pelagic fisheries which are directed at species that occur in dense shoals and industrial fisheries which catch species of no value for human consumption but which are processed into oil and fish meal. The fourth group of fisheries target a range of shellfish.

Although landings for the demersal fisheries in the northern North Sea have declined during the last 20 to 30 years they remain the most productive around the UK. Beam trawlers target plaice extensively in the deeper waters north of the Dogger Bank (southern part of the region) and this fishery also produces lemon sole, turbot, brill and angler fish. Cod, haddock and whiting are caught throughout the Region. Round fish (cod, haddock etc) landings peaked in the 1970s (Figure 1.13) at around 1 million tonnes (from both Regions 1 and 2).

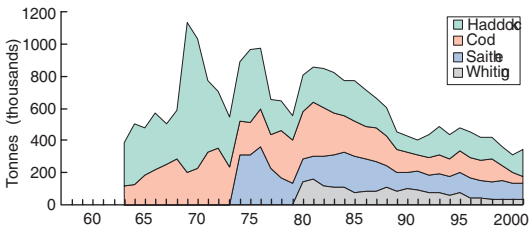


Figure 1.13. Landings of Roundfish from the North Sea and eastern Channel (VIId)Species shown are haddock, cod, saithe, whiting

Landings of flatfish peaked somewhat later (late 1990s) but have also since fallen to lower levels. The landings of cod, haddock etc reaching historically low levels in 2002. Although by far the most important in value terms, the species caught in the bottom trawl demersal fishery make up a relatively small part of the fish biomass in the North Sea. The main landings of commercially exploited species are caught in the pelagic and industrial fisheries. In contrast to the landings of demersal species those of pelagic species, particularly herring have shown a substantial rise over the last 20 years. Landings of both herring and mackerel declined sharply in the 1970s under high fishing pressure and a four year closure of the fishery was imposed in the mid-1970s. Herring has since recovered following management measures to reduce fishing pressure on juveniles. The North Sea mackerel fishery has not recovered and is currently closed. The industrial fishery targets sandeel and Norway pout and for the past 20 years landings have averaged close to one million tonnes but these fell substantially in 2003. The sandeel fishery has a low by-catch of other demersal fish but higher levels of by-catch occur in the Norway pout fishery.

There are valuable pot fisheries for edible crab and lobster along most of the rocky coastline of the northern North Sea and offshore fisheries for edible crab off the Yorkshire coast. Scallops are caught in the Moray Firth but landings have declined in recent years due to poor recruitment. The main shellfish fisheries in the northern North Sea, are for *Nephrops* and pink shrimp (*Pandalus borealis*). The *Nephrops* fisheries take place over discrete areas of the northern North Sea characterised by muddy bottoms into which the species can burrow. The main fisheries are inshore in the Moray Firth, Naup, Firth of Forth and Farne Deeps and offshore on the Fladen and Botney Gut grounds. The Fladen ground is a large area and the estimated *Nephrops* biomass is large. These fisheries use bottom trawls with finer mesh than is permitted in the whitefish fisheries. This can result in substantial discards of undersized fish though technical measures such as square mesh panels help to reduce this. The *Pandalus* fisheries on the Fladen ground also use small mesh cod-ends, but despite the small mesh used there is a relatively low by-catch of other species.

Stocks of the main commercially exploited fish species are assessed annually by the International Council for the Exploration of the Seas (ICES) and for the last 10 years their Advisory Committee on Fisheries Management (ACFM) has expressed concern over the level of fishing effort and declining stocks. High rates of exploitation severely reduce the number of older fish in the stock and thus the number of mature (breeding age) fish, making fisheries highly dependant on juvenile survival rates. A precautionary approach to fisheries management was introduced in 1999 and in 2004 four out of eight demersal stocks were considered either to be harvested unsustainably or at risk of being harvested unsustainably.

Cod has been severely affected and although there has been some reduction in fishing effort the stock remains severely depleted. Cod is subject to emergency management measures, including mesh regulations and effort controls, and will be under a recovery plan from 2005. Whiting stocks have also declined over the last 20 years but their status in 2003 was considered uncertain. Fishing mortality however, remains unsustainable. Plaice stocks have declined to less than a quarter of the 1960s peak. The herring stock is at full reproductive capacity and, following strong recruitment, is expected to reach 2 million tonnes in 2004, the highest biomass since the collapse in the 1970s. The status of the sandeel stock is unclear. There was poor recruitment in 2002 and the spawning stock biomass is expected to decline and the fishery in 2003 was one of the poorest on record. Norway pout stocks have also shown a severe decline in recent years despite relatively low fishing pressure. All the shellfish fisheries are believed to be being harvested sustainably.

(In 2004 ICES defined “at risk of being harvested unsustainably” as referring to stocks where the fishing mortality is above the precautionary reference point (F_{pa}). This is equivalent to the previous terminology “harvested outside safe biological limits”. The term “full reproductive capacity describes stocks where the spawning biomass is above the precautionary reference point (B_{pa}). This is equivalent to the previous terminology “inside safe biological limits”) A more detailed description of the changes can be found in the sector report on Fish and Fisheries.)

IMPACT OF FISHING

Apart from the obvious effects on stocks of the target species fishing can impact non-target species such as marine mammals, seabirds other fish species and benthic fauna all of which can be caught during fishing operations. There may also be indirect effects on other species, especially seabirds, if the stocks of species on which they feed are depleted. There may also be more subtle effects on the genetic make up of fish stocks for example removal of the older mature fish in a stock may lead to selection of sub-species that mature earlier. A recent estimate suggests that in the North Sea the biomass of all fish in the 4-16 kg range is 97.4% lower than it would be in the absence of fishing and 99.9% lower for fish in the 16-66 kg range. Figure 1.14 further illustrates this decline in mean weight of commercially exploited fish from the northern North Sea. All such changes run contrary to the policy of maintaining a marine ecosystem with as wide a species and genetic diversity as possible.

Considerable attention has been paid in recent years to reducing the rates of by-catch. However, in the North Sea some seabird populations have become increasingly reliant on discards of commercial species and by-catch as a food supply. The number of Harbour porpoises caught in the North Sea gill and tangle net fisheries, which take place in the central North Sea in both Region 1 and 2, is a cause for concern as numbers caught were thought to exceed the ASCOBANS –IWC limit of 1.7% of the population per year. This level has since been adopted as an EcoQO and is being piloted by the UK. It is known that by-catches have fallen as fishing effort has declined but it remains unclear whether the EcoQO is being met.

Bottom trawling disturbs the seabed and can kill or damage many benthic species and some populations especially those of the larger more fragile species can be severely reduced. One of the invertebrate species of concern is the bivalve *Arctica islandica*. ICES is at present assessing the feasibility of defining EcoQOs based on numbers of fragile and opportunistic species. Fishing effort is however remarkable patchy and it has been estimated that much of the North Sea is either not fished at all or is trawled less than once every seven years. On the other hand some areas are trawled much more frequently – ten times or more each year. There can be little doubt that disturbance of the seabed by fishing gear, especially at such frequent intervals, affects benthic species structure. Set against the adverse effects certain opportunistic species are attracted by the food supply presented by fishing gear disturbance and flourish as a consequence.

The adverse effects of fishing on the food supply of seabirds has been clearly recognised and in an attempt to mitigate this, fishing for sandeels

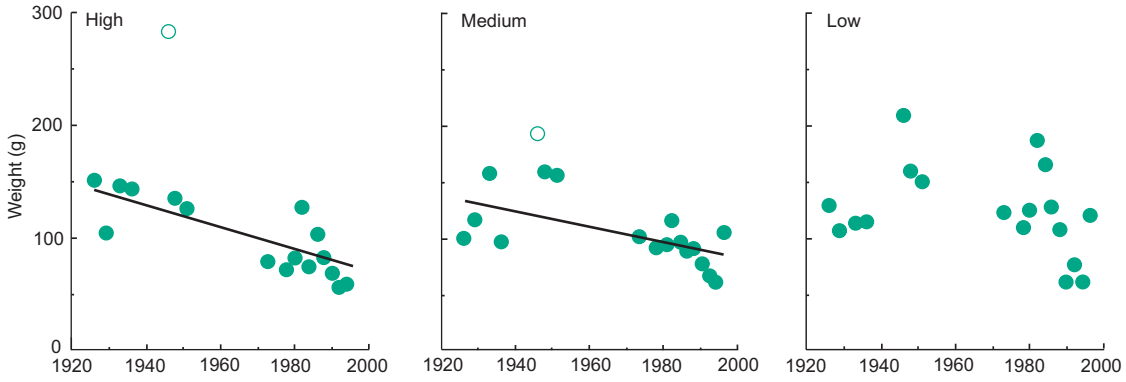


Figure 1.14. Trends in the mean weight of North Sea bottom dwelling (demersal) fish in areas subject to high, medium and low levels of otter trawl effort, as estimated from catches on the FRS funded Scottish August Groundfish Survey. Lines show significant linear trends. Unfilled circles are statistically significant outliers, which have been excluded when fitting trend lines

has been restricted in the vicinity of seabird colonies. Thus, along the coast of the northern North Sea an area of 20,000 km^2 has been closed to sandeel fishing to protect seabird food supply. The FRS Laboratory in Aberdeen has been monitoring the effect of this closure on both seabirds and gadoid fish, which also feed on sandeels, since 1997. The results show that variation in breeding productivity of Black-legged kittiwakes can provide an indication of local variations in the abundance of their sandeel prey. This measurement is currently being trialled by OSPAR as a potential EcoQO.

PLANKTON

The first studies of the variability of plankton in UK waters began in the 1890s and a more extensive and semi-qualitative study took place as part of the early collaborative studies organised by ICES between 1902 and 1908. Since then, apart from the Continuous Plankton Recorder (CPR) studies, there have been few systematic studies and most have covered only one station or small offshore areas. Since 1996 FRS on behalf of the FSA have undertaken routine sampling at a number of sites for toxic phytoplankton species. Also in the northern North Sea a time series of plankton observations has been collected off the Northumberland coast since 1968 by the Dove Marine Laboratory.

The CPR studies in the North Sea began in 1948 and monthly samples have been collected since then along shipping routes across the North Sea. In the northern North Sea four routes are operated, one from Aberdeen to Shetland, one from Aberdeen to Stavanger in Norway and another from Aberdeen to the Humber. A fourth route runs across the North Sea from Newcastle to the southern tip of Norway. The length of the available records is proving more and more valuable in showing trends over time and the reasons for them. A particularly important conclusion to emerge is that, on the basis of the evidence from the plankton, the seas around the UK are relatively unaffected either by inputs of contaminants or by eutrophication.

The CPR collects both phytoplankton and zooplankton on a silk filter system that progressively winds on as the CPR is towed behind a ship. Although identification of all individual phytoplankton species is not possible the greenness or Phytoplankton Colour Index gives a measure of phytoplankton biomass/ chlorophyll. A range of zooplankton species is identified and these data yield indices of biomass abundance and density and allow determination of baseline conditions for planktonic species. Preliminary studies show that the Colour Index fits well with satellite measurements of chlorophyll.

Within the North Sea as a whole the CPR data show there has been a sequence of changes over the last 50 years each of which was represented by similar levels of plankton abundance and characteristic communities. The most recent of these changes occurred around 1987 and was sufficiently pronounced to be described as a regime shift. This was first detected in the Colour Index which had shown a positive increasing trend and a convergence of the spring and autumn blooms up to 1987. Thereafter chlorophyll levels increased by almost a factor of two throughout the year, especially during the winter and summer. Within the North Sea the first obvious explanation was eutrophication but the change was apparent over the whole North-east Atlantic out to about 20°W, i.e. west of Ireland, and thus could not be attributed to land-based inputs of nutrients. The composition and biomass of the dominant phytoplankton and zooplankton species sampled by the CPR showed changes around the same time. These changes have since been found to be mirrored by an increase in the biomass of benthos in the North Sea and to be highly correlated with estimates of the flow of oceanic water from the North Atlantic made using a 3-D mathematical model. Overall it now seems that since 1987 the North Sea has become more productive. Less plankton appears to be grazed and the increased amounts of settling detritus explain the higher biomass of benthic species. The changes have also been linked to changes in recruitment and biomass of cod in the North Sea (see also Region 2).

The change in biodiversity of marine plankton has resulted in a northward shift of more than 10° latitude of warm water species in the last 10 years and a complementary reduction in the diversity of colder water species. The changes in the plankton assemblages were correlated with changes in the Northern Hemisphere Temperature (NHT) anomalies and to a lesser extent with the winter NAO Index suggesting that global warming may be involved. Evidence in support of this theory, or at least an upward shift in the temperature regime of the northern North

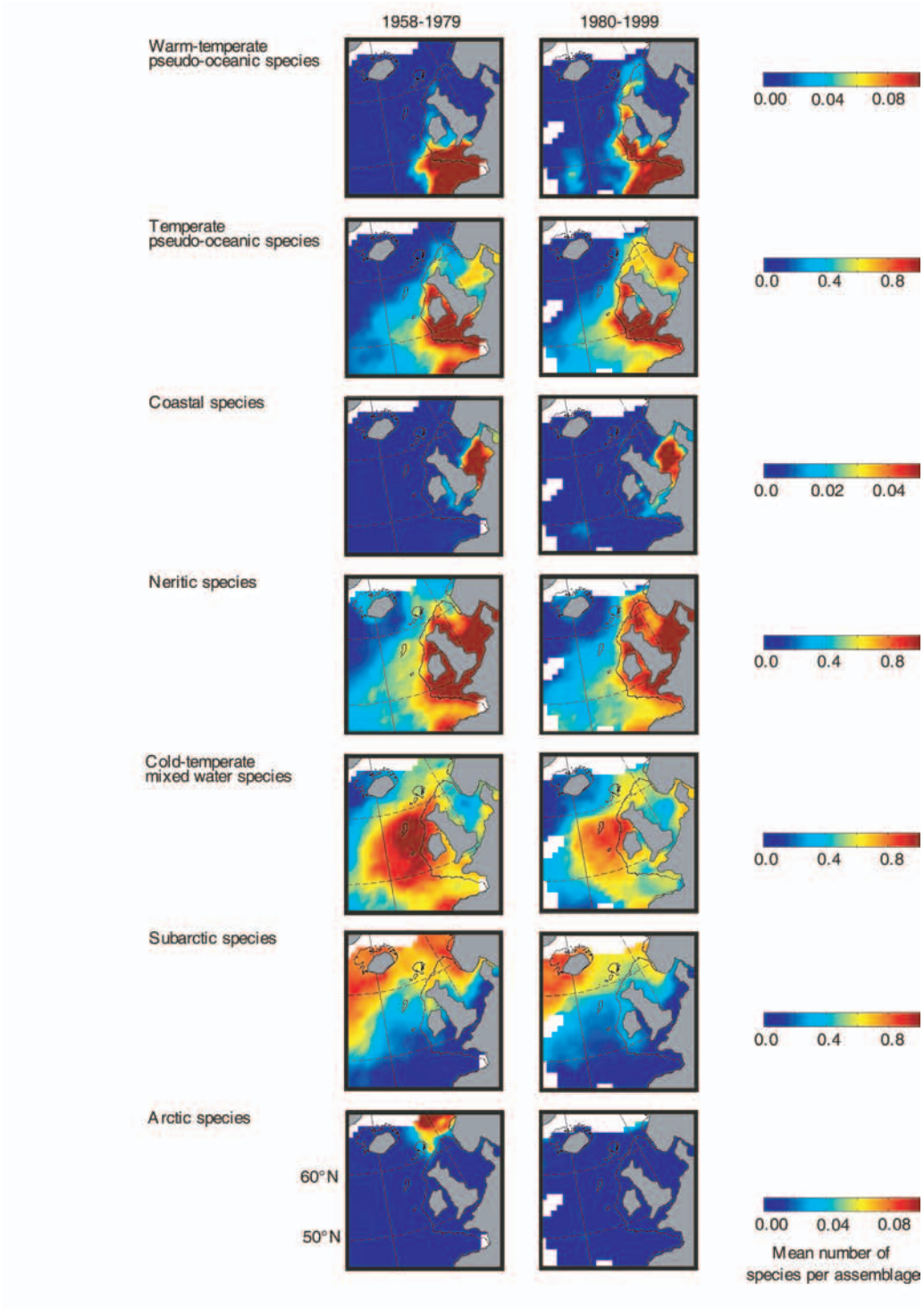


Figure 1.15. Maps of the Indicator Associations: Artic, Subartic, cold-temperature mixed water, Shelf Sea Neritic, Coastal Neritic Temperate pseudo-oceanic and Warm temperate pseudo-oceanic averaged for the periods 1958-1979 and 1980-1999

Sea, can be found in the relative abundance of two copepods sampled by the CPR *Calanus finmarchicus* and *C. helgolandicus*. The former is characteristic of colder northern waters and the latter is more typical of warmer southern waters. The relative abundance ratio of these two species suggests two colder periods between 1962 and 1967 and between 1978 and 1982, but that since 1988 conditions have been markedly warmer and have resulted in a change in their abundance and the timing of their peak productivity. Analyses of copepod assemblages (Figure 1.15, previous page) shows warmer water species extending further north to the west of the British Isles and flowing into the North Sea following the normal circulation routes north and east of Scotland.

Valuable confirmation of the changes seen from the CPR records in the North Sea is provided by the fact that the same taxonomic changes have been observed in the plankton records collected by the Dove Marine laboratory at their coastal station off the Northumberland coast (*MECN Research Contract Report to Defra*)

BENTHOS

The North Sea has a long history of benthic ecological research with qualitative studies going back as far as the late 1700s. However, the data from most of the earlier studies are neither continuous nor spatially consistent. During the last few years the JNCC has devoted considerable effort to collecting and mapping data on all the sampling of benthos undertaken in the last 100 years. In particular during the past 30 years the conservation agencies have commissioned many surveys in support of the selection and designation of marine protected areas (i.e. Special Areas of conservation (SACs)). These include large UK-wide systematic surveys: the Intertidal survey of Great Britain and Ireland and the Marine Nature conservation Review. Attention is now turning to assessment of the data to identify changes, the extent to which cause can be attributed and through this to assess how changes may arise in the future particularly as a consequence of potential changes in anthropogenic activity. The sector report on Habitats and Species reviews a number of studies of these various effects and concludes that fishing activity has a major impact on many benthic communities in the northern North Sea.

An assessment has been made of changes in North Sea benthos through a study of data from selected sites in the northern North Sea as part of a Marine Environmental Change Network study (*MECN Research Contract Report to Defra*). Two of the stations used are sited off the Northumberland coast and have been studied since the early 1970s. The records show that between 1972 and 1980 the benthos was stable; thereafter there was a shift in community structure and an increase in abundance that mirrored an increase in phytoplankton. There have also been several studies of the local effects of disposal of dredged materials, fly ash, and sewage sludge off the north-east coast of England and of sewage sludge in the Firth of Forth. Such studies were specifically designed to map the scale of impact of the particular activity and do not produce results suitable for assessing broader geographic scale changes (*Author's Note*). Much the same applies to the studies undertaken around the North Sea oil production sites.

Within the northern North Sea the NMMP undertakes benthic monitoring at eight estuarine sites and four coastal sites. Although these sites have been monitored for a number of years the run of data is insufficiently long to permit identification of changes over time. However, the data have recently been assessed (*MEMG, 2004*) in terms of abundance and diversity of benthic species at each site and scores were allocated according to an experimental version of a Biotic Index (AMBI). As it currently exists under this scheme a zero score is meant to indicate a normal healthy regime whereas a maximum score of seven indicates one which is heavily polluted or stressed. At the coastal sites the scores ranged from 0.63 on the Durham coast off Seaham, which used to be seriously affected by colliery waste, to 5.68 at Budle Bay in Northumberland. The other two sites in the Forth and off the Tyne scored 0.67 and 2.80. The Budle Bay site is not known to be subject to contamination but wave motion could well be the cause of sediment disturbance and thus be the cause of the high score stressed environment. At the estuarine sites the one in the Forth was allocated a score of 0.67 indicating a stress free environment whereas those in the Tweed, Tyne, Wear and Tees all scored between 1.32 and 5.86. Whilst the scores for the Tyne, Wear and Tees all probably reflect pollution stress the highest

score was allocated to the Tweed which is far less polluted. In this case the stress is probably one caused by low salinity and water movement disturbing the seabed.

SEABIRDS

Seabird numbers and breeding success are assessed annually throughout the British Isles by the Seabird Monitoring Programme (SMP), which began in 1986 and is co-ordinated by the JNCC's Seabird Colony team. Since 1989 the results of the SMP have been published in an annual report. This is entitled "Seabird numbers and breeding success in Britain and Ireland" and is produced by JNCC in collaboration with RSPB and the Shetland Oil Terminal Environment Advisory Group (SOTEAG). While the SMP conducts annual monitoring of a sample of the seabird population in the UK, complete censuses of all seabirds in the UK have been conducted to obtain total population estimates, which provide a baseline against which subsequent monitoring can be compared. The most recent UK population estimates were obtained in 1998-2002 during Seabird 2000 a JNCC-led census of breeding seabirds in the UK and Republic of Ireland. The SMP monitors various aspects of seabird demography and focuses particularly on a number of key sites. Three of these are in the Northern North Sea at Isle of May in south-east Scotland, Fair Isle and Grampian in North-east Scotland. The data for these sites are also published annually.

Twenty-five species of seabird are known to breed in the UK and total numbers have increased from around 4.4 million in 1969-70 to 6.7 million in 1998-2002. Not all species have experienced the same success and there are considerable variations between species year to year and between breeding sites. For example Atlantic Puffin breeding success at colonies along the northern North Sea coasts has increased substantially over the last 15-20 years whereas numbers elsewhere have remained stable. There are also marked variations in distribution. For example although European Storm Petrels, Leach's Storm Petrels and Manx Shearwaters are found in the northern North Sea they are confined to Orkney and Shetland.

Seabirds are long-lived and display high rates of annual survival of adults and low rates of post-fledgling survival. Consequently breeding population size is more heavily affected by factors affecting adult survival than by annual breeding success. Factors affecting adult survival include disease, predation and reduced food availability. Food availability is of particular relevance to assessment of the state of the seas and has a more dramatic effect on breeding success than adult survival.

Between 1985 and 1990 the sandeel stock around Shetland collapsed and this led to successive years of breeding failure of Arctic Terns, Arctic Skuas, Great Skuas, Black-legged Kittiwakes and Atlantic Puffins. Since 1990 sandeel populations and the breeding success of these seabird species have fluctuated. As a consequence of the poor breeding success between 1985 and 1990 the breeding populations of Arctic Skuas, Arctic Tern and Black-legged Kittiwakes on Shetland fell by 42% 19% and 62% respectively. Breeding success in the European Shag population on the Isle of May also seems to be affected by sandeel availability, even though this is a diving species and can take a wider range of fish species. Up to 60% of the Shags on the Isle of May deferred breeding in years when sandeel availability was low. Although initially the collapse of the sandeel population around Shetland was attributed to exploitation by the industrial fishery, research has suggested that the change was due to changes in the physical environment, which in turn has affected plankton and thus sandeel recruitment. Nevertheless, a precautionary ban on sandeel fishing was imposed between 1990 and 1995 and catches have subsequently been limited to low levels. A similar closure was applied to the eastern North Sea fishery in 2000 and will only be lifted when kittiwake breeding success improves, of which there are as yet no signs. Black-legged kittiwake breeding success is being used in trials of an EcoQO of sandeel availability near their colonies.

Fishing activities can be a source of food for some seabirds and Great Skuas around Shetland learned to be much more reliant on discards from trawlers than on sandeels. They have also shown a tendency to become more predatory on other seabirds. Whilst it is clear that a number of seabird species, for example the Northern Fulmar owe their success to scavenging behind trawlers, not all species find this source of food so beneficial. For example the survival of Great Skua chicks on Shetland declined considerably when more than 50% of the food they received was made up of

discards and offal. Better growth was observed when discards represented 20-30% of their diet (*MECN Research Contract Report to Defra*).

SEALS

There are two species of seal resident in the UK and both are found in the northern North Sea. The grey seal (*Halichoerus grypus*) is the larger of the two and typically breeds at haul out sites on exposed coasts and caves, though they may be found in most coastal areas at other times of the year. The major breeding sites in Region 1 are the Farne Islands, St Abb's Head, the Isle of May, Helmsdale and Berrisdale south of Wick on the extreme north east of Scotland and on Shetland. The second resident seal species is the common or harbour seal (*Phoca vitulina*). This species is found all around the UK coast and, like the grey seal needs haul out sites at which they rest and give birth. They are however, less dependant on sites remote from human disturbance and their young can swim very soon after birth. The main haul out sites for common seals in the northern North Sea are in the Firth of Forth, Firth of Tay and Moray Firth and northwards along the north-east coast of Scotland and on Shetland. Smaller numbers are found on the Farne Islands and in the Tees estuary. In the northern North Sea grey seals give birth between mid-September and mid-November in Shetland and from mid-October to early December in the Isle of May and Farne Islands. Common seal pups are usually born between late May and early July.

Almost 40% of the world population of grey seals is found in Britain and 90% of the UK population breeds in Scotland and Shetland. Total numbers were estimated to be between 98,000 and 123,000 in 2002. This represents a considerably larger population than in the 1960s when records were first collected but there is increasing evidence that numbers are stabilising. Despite the name, common seals are less numerous in the UK than their larger cousins and total numbers were estimated to be between 50,000 and 60,000. It is difficult to assess numbers accurately because both pups and adults spend much time in the water. Only at a few sites is it possible to conduct accurate visual counts and one such count is made annually in the inner Moray Firth.

Phocine distemper virus (PDV) affected both species of seals in 1988 and 2002 but mortality rates were higher in common seals than in grey seals. The population of common seals had largely recovered from the 1988 outbreak by 2002 and although it is estimated that about 10% of the total number died, common seals in the northern North Sea largely escaped the outbreak. One EcoQO has been established for seals and one proposed. They are expressed simply in terms of numbers and utilisation of breeding sites and will allow relative numbers to be tracked over time. There is no suggestion that either species is at risk in the northern North Sea. However, both grey and common seals are on Annex II of the EU Habitats Directive because they are rare or threatened in other parts of their range in Europe. A number of SACs have therefore been proposed. These include a number of representative breeding colonies for grey seals and a number of haul out sites regularly used by common seals for moulting and pupping. These include, one in each of the Moray Firth and Tay estuaries, two on Shetland and one on the Farne Islands, which are part of the Berwickshire and north Northumberland SAC.

CETACEANS

Cetacean distribution in north-west European waters has been mapped in an atlas publication and shows that the species complement in UK waters has been as diverse and otherwise similar to other areas in the same latitude during the latter part of the 20th Century. One of the three databases used in the atlas was the Small Cetaceans Abundance in the North Sea (SCANS) survey conducted in June/July 1994. Of the 28 species recorded during the latter half of the twentieth century as present over the UK continental shelf only about 10 are commonly recorded in UK waters. Even in the North Sea accurate estimates of population exist only for a few species but population estimates are considered to be reasonably good for *Lagenorhyncus* dolphins (ca.11,800), Minke whale (8,500 including Celtic Sea and Skaggerak), white-beaked dolphins (ca. 8,000) and the harbour porpoise throughout the North Sea (280,000) and for common bottlenose dolphin in the Moray Firth (ca. 130). It should be noted that with the exception of the Moray Firth the figures cited are for the North Sea as a whole and that except for harbour porpoise they are very approximate e.g. white-beaked dolphin between 4,000 and 13,300. There are no dedicated surveys for cetaceans conducted routinely in the North Sea but effort related sightings are collected by the Sea Watch

Foundation and the European Seabirds at Sea observing systems. There are also opportunistic records from vessels conducting seismic surveys and fisheries by-catch records.

Strandings of cetaceans occur all around the UK and are recorded and summarised by the Institute of Zoology in England and Wales and by the Scottish Agricultural Centre's Veterinary investigation Centre in Scotland. No particular pattern of cetacean strandings or numbers sighted has yet emerged, except for harbour porpoises where concern over the numbers caught in fishing gear led to the introduction of protection measures and an EcoQO aimed at reducing the by-catch to less than 1.7% of the estimated population annually. The Moray Firth population of common bottlenose dolphin is likely to be given protection through designation of the area as an SAC.

HABITATS

The sector report on Habitats and Species describes the various measures that are available, have been and are being taken to protect habitats and species around the UK coasts. It reviews a range of key habitat types and indicates the areas where important examples of each can be found and the threats they currently face or may face in the future. The northern North Sea is clearly recognised as being of considerable importance in terms of the diversity of its ecosystem and the presence of examples of relatively rare habitat types. There are no official marine nature reserves in the northern North Sea but St Abb's Head has been designated as a voluntary marine nature reserve since 1984. This area receives additional protection under the Berwickshire and North Northumberland European Marine Site (EMS) designation which protects a series of rocky reefs, sea caves and cliffs for breeding seabirds. Within this same general region there are also numerous SACs and SPAs.

Of the 14 habitat types identified under the terms of the 1992 Convention on Biological Diversity mudflats are considered to be at risk from sea level rise. Although this is more of an issue in the south of England where the land mass is sinking thus compounding the effect of water volume increase due to warming, concern has been expressed that the major Firths in Scotland may also be affected. Sea grass beds (*Zostera* spp.) are relatively uncommon in the UK but the Cromarty Firth supports what is probably the largest total area of dwarf eelgrass (ca.1,200 ha). *Zostera noltii* is also found in the neighbouring Moray Firth. A few beds of horse mussels (*Modiolus modiolus*), which can form dense beds in water depths of 5 –70 m, are found in the northern North Sea in Shetland and off the Berwickshire coast, though none are as dense as those found in Region 5. *Sabellaria spinulosa* is a tube building worm and can form extensive reefs. It is fairly common off the Berwickshire coast but here it forms crust like deposits which each year become broken and dispersed by winter storms, though they quickly reform each spring. Sub-littoral sands and gravels are found extensively as far north as the Firth of Forth. The major concern in relation to this type of habitat is disturbance by bottom trawls or by licensed aggregate extraction although neither of these is currently a particular issue in the northern North Sea .

Maerl is a collective term for calcified red seaweed. Most maerl is found in waters as deep as 40 m. Within the northern North Sea maerl has been identified as being present in Shetland and Orkney. Deep water mud habitats occur extensively in the northern North Sea and are subject to disturbance by fishing for *Nephrops* and although it is considered likely that populations of burrowing urchins e.g. *Brissopsis lyrifera*, may have been reduced there appears to be no evidence that this has happened.

In summary although the location of most habitat types has been fairly well established and various threats from other activities are understood in a theoretical sense for the most part changes cannot be identified. This will only become possible with repeat surveys but biological surveys are time-consuming and expensive and frequent reviews of status are therefore impractical.

KEY POINTS AND CONCLUSIONS

So far as the physical environment is concerned in Region 1 there is clear evidence of an increase in the number of winter storms over the last 50 years, bringing conditions back to those experienced at the end of the nineteenth century. This was accompanied by an increase in mean significant wave heights between 1973 and 1995 of about 0.2 to 0.3 m but subsequently that trend reversed. Winters have shown a tendency to be wetter in north-east England. Perhaps related

to these wetter winters sea surface salinity has shown a decreasing trend since the 1970s. At a number of stations in the Region there is evidence that sea surface temperatures have risen by around 0.5°C/decade and most coastal stations indicate a continuing warming trend. Global mean sea level has risen by about 1mm per year for the last 100 years but, at least in the northern part of the Region, this is partly offset by upward land movement.

Coastal erosion is occurring at numerous locations in Region 1 but is most serious along the Yorkshire coast in the south of the Region where the average rate of loss is around 1m/year. In Scotland there are particular concerns in the Spey area that any decrease in inputs of sedimentary material from the land could lead to serious erosion in the estuarine area.

In terms of contaminants and pollution effects, most of Region 1 is essentially unaffected. Nutrient inputs have been reduced and although there have been changes in plankton composition these are in response to changes in the physical environment not eutrophication. The adverse visual impact of colliery waste disposal in the immediate coastal zone of the north-east coast of England has all but disappeared since the practice was stopped. Apart from the areas around small towns and villages and the major centres of population around Aberdeen, Edinburgh and the north-east coast of England the coastline is essentially unmodified and supports a wide range of habitats and species. Inputs of most recognised contaminants i.e. metals, chlorinated organics, PAHs, CBs and endocrine disrupters have been reduced and concentrations have in the Region's waters, sediments and biota have declined accordingly, in some cases e.g. chlorinated organics, to the extent that they are no longer detectable in many sea water samples. For CBs the main route of input now appears to be the atmosphere, especially to the waters to the east of Scotland. Biological effects are still clearly detectable however, where concentrations remain elevated due to past inputs, particularly in the Tyne, Wear and Tees estuaries and to some extent in the Firth of Forth.

Radioactivity, mostly originating from the Sellafield nuclear fuel plant on the Cumbria coast (Region 5) is detectable in the Region but in terms of human exposure levels or its possible impact on marine organisms, is insignificant.

The northern part of Region 1 off the Scottish coast is home to the majority of the offshore oil industry and inputs of oil via contaminated drill cuttings and produced water gave rise to considerable concerns in the past. Discharge of drill cuttings contaminated by oil is no longer permitted and although concern remains over the local effects of accumulated piles of contaminated cuttings from past activities the effects are essentially local and declining, provided the cuttings are undisturbed. Concentrations of oil in produced water have been reduced considerably but the quantities of oil discharged via this route have not decreased at the same rate due to increased volumes as the oil fields approach the end of their extractable reserves. However, there do not appear to be any measurable environmental effects and under most sea conditions the discharges do not give rise to visible oil slicks. As in other Regions litter presents a visual impact on many stretches of coastline though there is little quantified information on the scale of the problem specific to the Region. The effect of litter on marine organisms through entanglement or ingestion of small particles or even large pieces is equally unquantified. This may change if OSPAR successfully completes trials of an EcoQO based on the number of plastic particles found in the stomachs of northern fulmars

Sea bathing is not a major activity in the colder waters of Region 1 but there are number of bathing beaches designated under the Bathing Waters Directive of which two on the Yorkshire coast failed the current mandatory standards in 2003.

Region 1 is very important in terms of its yield of fish. There is no evidence that fish stocks or quality are affected by contaminants but the abundance of most commercially exploited species has decreased and landings and species have declined accordingly. With the exception of herring, *Nephrops* and coastal fisheries for crab and lobster, most species are considered to be being exploited at rates above those regarded as sustainable. There has however, been some improvement since 1999 when the precautionary approach to fisheries management was adopted. Cod is particularly at risk due to the level of fishing pressure and a recovery plan has been instigated. Successful recruitment of cod may be hindered by changes that have occurred as a result of changes in the phytoplankton and zooplankton regime, probably in response to

rising temperatures and northward migration of warmer water species of plankton. The changes in plankton have been considered so large since around 1987 that they have been described as regime shift. There has been increased primary productivity, merging of the spring and autumn blooms and a switch in relative copepod species dominance. All this has been accompanied by a northward movement of plankton species by about 10 degrees of latitude.

Fishing has a number of adverse side effects on the benthos and particularly in areas that are trawled frequently 'natural' benthic biodiversity and abundance probably no longer exists. However, not all areas are trawled frequently and some are very rarely fished. Changes in the size and demography of sandeel populations that appear to have been caused by natural events have had a substantial negative impact on the breeding success of some seabird species that rely on sandeels to feed their young. In some areas such as Shetland, successive years of poor breeding success has resulted in significant declines in population size of some species, most notably the black-legged kittiwake. The effect of commercial fishing on sandeel stocks and on seabird populations remains unclear and OSPAR is testing a system of EcoQOs, including the use of Black-legged kittiwake breeding success as an indicator of sandeel availability near their colonies. Bans have been imposed on the fishing for sandeels in the western North Sea and around Shetland in an attempt to enable nearby breeding seabird populations to recover.

Seabird numbers have increased overall in the UK although numbers of some species have declined in Region 1, for the reasons discussed above. The extent to which some seabirds have become increasingly dependant on fishing vessel discards does give rise to some concern, especially as efforts are being made to reduce the scale of discards of both offal and by-catch species. By-catch of harbour porpoises was a problem in the central North Sea in the south of the Region and measures have been taken to reduce this. Whether they have yet been reduced to acceptable levels remains unclear.

A substantial proportion of the seals found in the UK live and breed in Region 1, particularly along the northern coasts and on Orkney and Shetland. Numbers have increased and despite PDV epidemics there is no evidence that either of the two resident species are at risk in Region 1. The range and numbers of cetacean species encountered in the Region is believed to be typical of other similar regions and latitudes. There is a reasonably good data base for benthos throughout the Region but little or no data suitable for trend assessment and despite concerns over the impact of fishing gear, little quantifiable data on scale of impact. There is also a lack of agreed objectives and indicators of benthos performance.

Region 2:
Southern North Sea

INTRODUCTION

Region 2 comprises the southern North Sea with the eastern seaward boundary being the median line between England and its continental neighbours. The coastline extends from Dover in the south to Flamborough Head in the north, from which the northern seaward

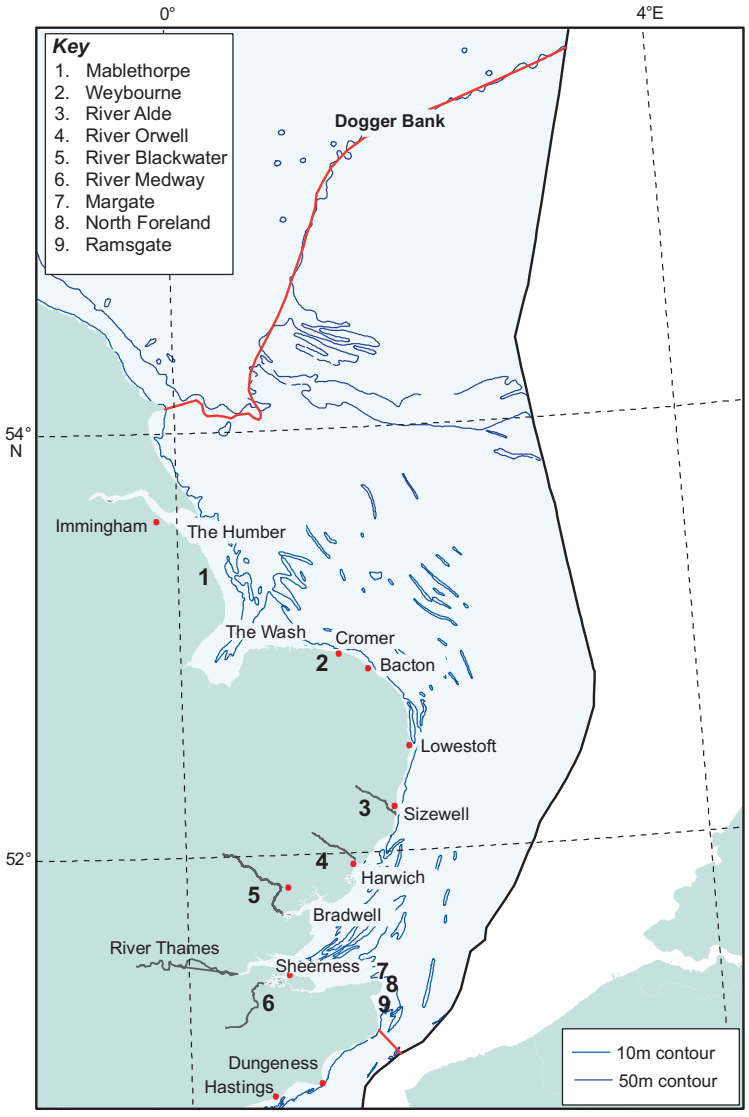


Figure 2.1. Map of Region 2. Bathymetric contour data copyright UKHO

boundary extends in a north-easterly direction along the Flamborough Front to include the Dogger Bank. Figure 2.1 (previous page) shows the location of the Region relative to its immediate neighbours Region 1 (northern North Sea) and Region 3 (eastern English Channel) and the locations of the major places mentioned in this chapter. The Region is exposed to northerly winds and to a lesser extent to easterly and north-easterly winds but is relatively sheltered from prevailing westerly winds. Major river systems flow into the southern North Sea via the Humber and Thames estuaries and the Wash. Water depths in the Region are much shallower than the northern North Sea and are generally less than 50m and the seabed is mainly made up of sands and gravel. There are marked seasonal variations in temperature between winter and summer. Although much of the coastline is rural, urbanisation increases progressively in the southern part of the Region from the Orwell estuary to Margate, with major conurbations on Humberside and the Thames.

Although the coastline at Flamborough Head is rocky it becomes softer and lower lying as far south as the North Foreland and long stretches of the coast are crumbling and eroding, in some areas quite rapidly and sinking as a consequence of isostatic (post-glacial) adjustment following the last ice age. In addition to supporting the usual marine activities of fishing and shipping the southern North Sea has valuable seabed resources in the form of gas reserves and sand and gravel deposits, both of which are actively exploited.

PHYSICAL ENVIRONMENT

WEATHER AND CLIMATE

The three main weather parameters driving oceanic circulation are the wind speed and direction, air/sea heat exchange and evaporation/ precipitation. These same parameters affect the distribution of temperature and salinity in UK waters. Stronger more frequent westerly winds over the North Atlantic drive more Atlantic water into the area around the UK and bring more rainfall and warmer temperatures. Higher rainfall results in lower salinities, especially in coastal waters and shallow areas like the southern North Sea, due to increased river run-off. The warmer air increases water temperatures, again particularly in the shallower southern North Sea.

A major factor influencing North Atlantic circulation and in turn that around the UK is the North Atlantic Oscillation (NAO) - for a brief description of this see Chapter 1. From about 1960 the NAO has experienced its biggest change since the 1860s with the Winter Index (December to March) showing an upward trend. Although there is evidence of similar changes over the past 500 years the rise in values from the 1960s to the 1990s appears larger. The effect of changes in the NAO can be seen in increases in rainfall, with positive NAO leading to milder, wetter winters over northern Europe. These changes in the NAO also account for much of the increase in temperature experienced in the latter half of the 20th Century, which in turn is linked to northward shifts in plankton and the presence of fish which previously were regarded as absent or rare visitors.

There is clear evidence from the Central England Temperature records that air temperature over mainland England has risen by about 0.5°C during the last 100 years. The warmest years since records began in 1659 were 1990 and 1999 with the 1990s being the warmest decade on record. There is some evidence from the Met Office records that air temperatures over the southern North Sea have also risen in recent years. Wind is a major forcing factor in determining circulation and work at the Hadley Centre has shown that the average number of storms between October and March has increased over the last 50 years. However, the magnitude of storminess now is not significantly different to that observed in the early years of the last century. There are records for wind speed and direction in the southern North Sea area from a land station at Shoeburyness and Figure 2.2 shows frequency, force and direction at this site during the winter months December to February, between 1983 and 1993.

Increased rainfall increases land run-off and lowers salinity and at least in the short term can increase inputs of contaminants such as nutrients through land drainage. There is clear evidence that rainfall in recent years has been increasing, with the 2 year period to March 2001 being the wettest since records began in 1766. However, there has also been a trend towards relatively more rainfall in winter and less during the summer months.

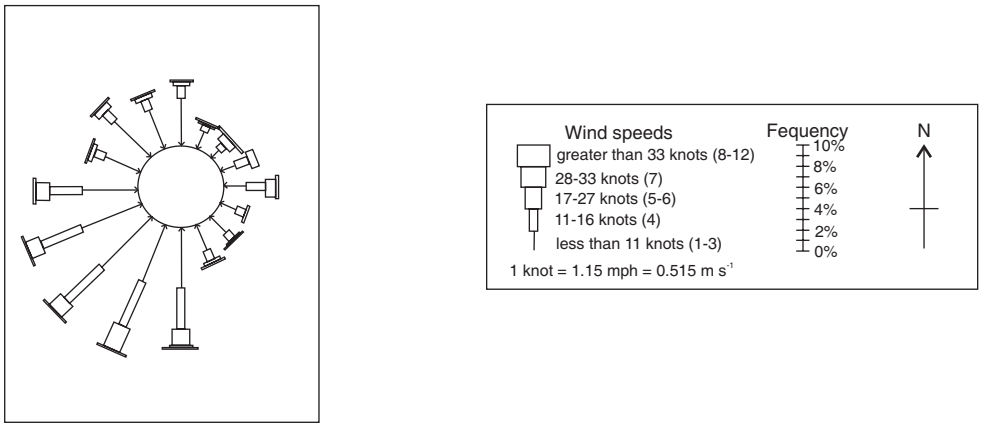


Figure 2.2. Wind roses for full data series for Shoeburyness Frequency, force and direction of the wind at Shoeburyness, for winter (December to February, 1983-1993). Courtesy of BADC and Andy Tabor

Table 2.1. Trends in sea surface temperature

North Sea SST	Nominal position	Data Span	Trend (°C/decade)
Spurn Point	53.5°N 00.0°E	1966-2002	+ 0.17
Humber LV	53.5°N 00.0°E	1880-1989	+ 0.01
Newarp LV	53.0°N 02.0°E	1880-1986	+ 0.02
Lowestoft	52.5°N 02.0°E	1966-1991	+ 0.16
Sizewell	52.0°N 01.5°E	1967-2002	+ 0.77
Bradwell	52.0°N 01.0°E	1964-2001	+ 0.15
Dover	51.0°N 01.5°E	1926-2001	+ 0.09

SEA TEMPERATURE

Sea surface temperature in the southern North Sea shows a similar warming trend to that observed over land. Figure 2.3 suggests that all waters around the UK have experienced a warming since the 1980s with the southern North Sea rising in temperature by about 0.8°C/decade.

However, records extending over longer periods (Table 2.1) confirm that temperature has risen in the southern North Sea though not as rapidly as indicated in Figure 2.3, overleaf.

The record from Dover is one of the longest available for UK waters and suggests an overall rise over the last 100 years of about 0.6°C. Records were collected on the Humber and Newarp Light Vessels until the 1980s and both show a similar warming trend as do data from coastal stations at Spurn Point, Sizewell and Bradwell.

Since 1970 data on North Sea bottom water temperatures in winter have been collected in the course of the ICES International Bottom Trawl Survey (IBTS). Not surprisingly because waters in the southern North Sea are normally well mixed throughout the year, the records show the same sort of rising trend observed in SST of ca. 0.5ºC/decade over the Dogger Bank and 0.24°C/decade close to the eastern boundary of the Region east of the Humber and 0.33°C/decade further south due east of Lowestoft but also close to the eastern boundary of the Region. In 1979 the bottom water temperature was unusually low

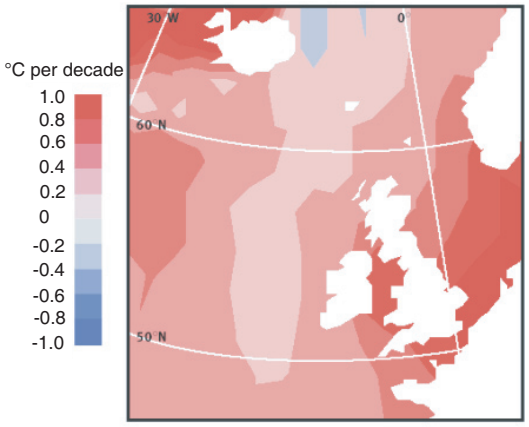


Figure 2.3. SST trend for 1981-2000 Red shading indicates warming (a positive trend in temperature) and blue shading indicates cooling (a negative trend in temperature). Trend values are °C per decade. Courtesy of the FRS, taken from Reynolds Optimally Interpolated Sea-Surface Temperature dataset provided by the NOAA-CIRES Climate Diagnostics Center, Boulder, Colorado, USA, from their Web site at http://www.cdc.noaa.gov/

(ca.4°C) at all three IBTS stations in the southern North Sea and indeed at the more southerly stations in the northern sector. This was attributed to persistent strong south-easterly winds, which spread water in a north-westerly direction. At the most southerly of the IBTS stations, due east of Lowestoft, similarly low temperatures were recorded in the winters of 1986 and 1996, although the overall warming trend continued.

SALINITY

The Region receives most of its freshwater input from the rivers along its eastern boundary and most of the Region is, as a consequence, less saline than the northern North Sea (mainly<35). Saline water of North Atlantic origin enters the southern North Sea via the Dover Straits and this tends to lead to generally more salty water in the most southerly parts of the Region. The extent to which this occurs is influenced by the NAO. Strongly positive values of the NAO Index are associated with low summer salinity values and strongly negative values of the NAO with higher salinity. There are few long time records of salinity in the southern North Sea but those from the IBTS since 1970 suggest a slight decreasing trend in salinity in the winter months, although there are substantial year to year variations, particularly at the most southerly station due east of Lowestoft.

WAVES

In the southern North Sea waves are mainly generated by local wind conditions and wave conditions in the North Atlantic have little influence on the size of waves in the Region. Mean significant wave height (Hs) tends to be greatest during winter months and to be higher in the more northerly part of the Region than in the south as illustrated by Figure 2.4.

This shows the monthly mean wave heights derived from Geostat, ERS-1, ERS-2, TOPEX-Poseidon and Jason altimeter data for two areas

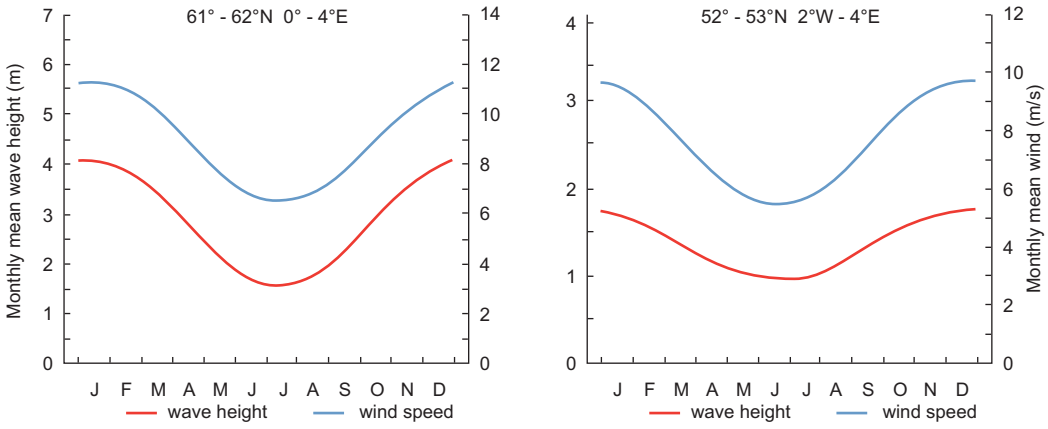


Figure 2.4. Monthly mean wave heights and wind speeds derived from ERS-2 and TOPEX-Poseidon altimeter data from 1985 onwards. Courtesy of Satellite Observing Systems Ltd

in the southern North Sea. The offshore oil and gas industry has collected data on wave heights over the last 30 years as part of Shell's METNET network. The data for the central North Sea i.e. the more northerly part of the Region, indicate that Hs during the period January–March was upwards until 1993/94 with a decrease thereafter. In the more southerly part of the Region there has been no discernible trend in Hs for January to March and a slight indication of a downward trend from 1980/81 for October to December.

CIRCULATION

The net movement of water, the circulation, in an area is important because it is this that determines whether a material entering a water mass e.g. from a coastal discharge will stay in the area or be moved somewhere else. Within the southern North Sea the broad scale movement is anti-clockwise with water entering from the south through the Dover Straits and moving in a generally northward direction. The anti-clockwise currents which flow southwards along the east coast of England eventually veer eastwards towards the continental coast. The exact location at which this occurs varies according to season and weather conditions and the amount of fresh water entering the sea from rivers. Waters carried by these currents then merge with the generally northerly flow from the more southern parts of the Region.

The distance material is moved by the circulation depends on the nature of the material, Thus dissolved nutrients and fish eggs or phytoplankton, which are essentially neutrally buoyant, move with the water body, whereas particulate materials such as suspended sediments tend to sink. It is important to recognise that circulation patterns in the southern North Sea can change markedly according to the direction and strength of the wind locally and intermittent pulses of water inflow from the North Atlantic superimposed on the more normal or average flow conditions. The flushing time is a term often used in connection with circulation and indicates how long it typically takes for water entering an area to completely pass through it. For the North Sea as a whole i.e. Regions 1 and 2 together, the flushing time for water to pass from the Dover Straits through the North Sea is generally reckoned to be between 1 and 3 years.

SEDIMENT CONCENTRATION AND TRANSPORT

Details of seabed type can be found in the section dealing with Habitats and Species but in very general terms the seabed of large parts of the southern North Sea is either mud or sand with various mixtures and with extensive areas of sand ripples or waves according to the strength of local, mainly tidal currents. There are also deposits of coarse sand and gravel, mainly relict of the last ice age. Water depths are relatively shallow and stormy conditions lead to resuspension of seabed material. Suspended sediment concentrations can be obtained relatively crudely by measuring the depth at which it becomes impossible to see a Secchi disc or from instruments mounted on satellites. Given the number of physical and chemical measurements made in the southern North Sea it is perhaps surprising that there are relatively few Secchi disc readings. However, the available data show high turbidity levels in the southern North Sea and this is probably a reflection of the strong tidal currents and shallow depth. The data from satellite measurement confirm this and also show seasonal variation with maximum suspended sediment levels during the autumn/winter months during which period a larger area of the Region is affected.

Sediment transport offshore in the southern North Sea shows two distinct patterns due to different tidal directions. Thus from Flamborough Head to the Wash the offshore direction is northerly whereas around the coast of East Anglia it is southerly but off the North Norfolk coast is westerly into the Wash. Nearshore transport is more consistently in a southerly direction. The main nearshore source of sediments in the southern North Sea is the eroding cliffs of the East Anglian coast. There are nearshore divergences along a line from Dunwich (south of Lowestoft) to Hook of Holland, in the Humber estuary, The Wash, Stour and Orwell estuaries and in the Thames. Onshore/offshore exchange occurs off the North Norfolk coast.

CHANGES IN SEA LEVEL, COAST AND SEABED

Sea level at a particular place at a particular time is a combination of tidal level, mean sea level and waves. Mean sea level (MSL) is the height

of the sea relative to the land averaged over a period that is long enough to remove fluctuations due to tides and waves. Around the UK MSL changes seasonally by about 10 cm, being at a maximum in late summer. MSL, as measured by coastal tide gauges, includes real changes in ocean level and vertical movement in the land on which the gauges are situated. Since the last ice age the UK land mass has been adjusting to the retreat of the ice sheet. This results in the south of England sinking by around 1 mm/yr. In the southeast of England there is an additional effect due to compaction of the sediments of which the land is composed. This adds a further sinking of 0.5-1.1 mm/yr effectively leading to an additional rise in sea level. As a consequence the coast in this part of the Region is one of the most vulnerable to increased flooding in the UK. Within the southern North Sea, sea level records at Dover show local short-term fluctuations but no long-term trends and there is no evidence either of trends in surge levels since the 1960s. Surges occur as a result of the combined effects of wind and a decrease in atmospheric pressure. They can result in sea level changes of up to several metres, lasting a few hours to days. In terms of effects on coasts and potential flood events the most important variable is an increasing trend in MSL. One of the longest UK MSL records is for Sheerness on the North Kent coast (see Figure 1.8 in the previous chapter). Although there are several breaks in the record this record show a clear increase in MSL since records began around 1840.

Extreme sea level is also relevant to the likelihood of coastal flooding and an analysis of peak over threshold sea levels has been undertaken for two sites in the southern North Sea area, Lowestoft and Dover. Both records only span about 40 years but both show a positive trend in extreme sea level and this is in line with the results for Newlyn (Region 4) which cover the period 1915-2001. The coastline of the southern North Sea is very mobile. Most of the south Yorkshire coastline is eroding with annual loss rates exceeding 1m/yr in many places. In East Anglia the situation is more complex with rapid erosion taking place in some places, up to almost 73 m in a year on occasions with extensions occurring in others, occasionally up to 64 m in a year. Such figures are of course misleading as they represent episodic events rather than a steady rate. Table 2.2 gives further details of the average rate of erosion or accretion on the coastline of the Region.

Most of the east coast estuaries are slowly silting as a consequence of the open coast eroding. This has implications for harbour maintenance and the frequency and scale of dredging required.

ENVIRONMENTAL QUALITY

NUTRIENTS

The marine food web is based on microscopic plants known as phytoplankton. Phytoplankton growth is regulated by light and the availability of nutrient forms of nitrogen and phosphorus and

Table 2.2. Present average rates of shoreline movement. Values are number of individual locations where shoreline position has been measured. Courtesy of OST

Region	Little change (movement less than +/- 0.1 m/yr)	Erosion				Accretion (greater than 0.1 m/yr)
		0.1-0.5 m/yr	0.5-1.0 m/yr	1.0-2.0 m/yr	Greater than 2.0 m/yr	
St Abb's Head to Flamborough Head	88	20	1	4	1	8
Flamborough Head to Humber Estuary	6	6	4	9	4	0
Humber Estuary to Weybourne	15	1	0	2	1	6
Weybourne to Felixstowe	39	9	4	10	3	4
Harwich to Thames Estuary	23	4	0	4	3	1
Thames Estuary to North Foreland	22	0	4	4	1	0

to a lesser extent silicate and carbon. Excessive plant growth in response to an increased supply of nutrients is termed eutrophication and measures have been taken to reduce inputs of nutrients to avoid this occurring. Common assessment procedures have been proposed by OSPAR to guide decisions on where such measures are required. These set normal and elevated levels for dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) and a guideline that states chlorophyll concentrations should be no more than 50% higher than historical offshore background for the area concerned. Lower levels are set for DIN and DIP in the English Channel (Region 3) and higher levels for the Irish Sea (Region 5) in recognition that there are regional differences due to natural differences in inputs to different areas.

The common assessment procedures criteria for DIN and DIP relate to winter concentrations and in the southern North Sea winter DIN concentrations are above the criteria in all nearshore areas where salinity is lower than 34. Although the correlation with inputs is weak, this almost certainly is a reflection of inputs from the land as areas further from the coast in the northern part of the Region are less affected. Higher DIP concentrations were also found in the southern North Sea, particularly in the south off the south-east coast where salinity was low. Despite reductions in inputs there does not seem to be a reducing trend in water concentrations of DIP in coastal waters of the Region. These elevated concentrations of winter DIN and DIP do not seem to have resulted in excessive phytoplankton growth as assessed by chlorophyll concentrations. These have not exceeded 10 mg/l, the level that would indicate cause for concern according to the common assessment procedure criteria. One possible reason for this apparent lack of response might be the high concentrations of suspended sediments found in the southern North Sea as these would limit light penetration of the water column. Particular attention has therefore been paid to the types of phytoplankton found in the area. Certain species are regarded as being associated with excess nutrients, one of which is the foam alga *Phaecystis* spp. *Phaeocystis* was common in the 1950s but declined throughout the 1960s and 1970s but since the mid-1980s, when concern began to be expressed about eutrophication, it has increased. 1999 in particular saw several very large blooms of this alga. However, it is now apparent that similar changes have occurred over a much wider area of the North-east Atlantic and it now seems that despite the elevated concentrations of nutrients effects on phytoplankton growth are not excessive. Within the southern North Sea no patterns of excessive seaweed growth have yet been reported and no estuaries have been identified as problem areas.

HAZARDOUS SUBSTANCES – METALS

Within the southern North Sea all concentrations of metals in sea water are below the EQS values i.e. the concentration defined as being unlikely to harm marine life. However, concentrations of mercury in water did exceed the background reference concentrations (BRCs) in the Thames and Medway estuaries. In 1999 monitoring showed that the concentrations of copper in water also exceeded the List II standards set by the Dangerous Substances Directive in and around the Thames estuary. The reasons are unclear but may be related to use on boats. BRCs are the concentrations which OSPAR agreed in 1997 are typical of the more remote areas of the OSPAR region. BRCs and EACs (Ecotoxicological Assessment Criteria i.e. the concentrations above which effects on biota might be expected to occur) were also been set for metals in sediments. (It should be noted that the BRC and EAC values referred to in this review are those adopted by OSPAR in 1997. These levels have been reviewed and were recently revised but the new values were not available when the sector report on Environmental Quality was being prepared: they have not therefore been used in this review either.) Concentrations of metals in Thames estuary sediments exceed the BRC values for mercury and zinc and the EAC values for cadmium, lead and copper. In the Medway metal to aluminium ratios for mercury in sediments are below the BRC but concentrations of lead and copper exceed the EAC values, as does the concentration of lead in sediments from the Humber. The ratio of the concentration of a metal found in sediments relative to that of aluminium can be used to assess whether the concentration is likely to be the result of anthropogenic activity. The metal to aluminium ratios in those estuaries that exceeded the BRC or EAC values all suggest that the southern North Sea has been contaminated by anthropogenic activity, although in only a few areas to the extent that biota might be affected.

Metal concentrations are monitored in three species of flatfish and in mussels. BRC values were established for some metals in biota and for mercury in fish flesh the range set was 30-70 μg/kg wet wt. Mercury concentrations found in both fish and mussels exceeded these levels in the Thames estuary (range 212 –228 μg/kg wet wt) and were above 50 μg/kg wet wt in mussels from just north of the Thames in the Blackwater estuary. The concentrations of mercury in fish are however lower than they were in the past when historically discharges of mercury were made into the Thames estuary (*N*). The highest concentration of cadmium in the livers of fish from the southern North Sea was found in fish caught in the Humber estuary. Concentrations of cadmium were also unusually high in mussels from the Humber and in dab from the Dogger Bank.

HAZARDOUS SUBSTANCES – CHLORINATED ORGANICS

Certain chlorinated organic compounds combine persistence with a tendency to bioaccumulate and toxicity, and controls have been applied severely restricting the use of many of these compounds. As a consequence concentrations in the marine environment have declined. OSPAR had not defined BRCs for such compounds but EACs were derived. With the exception of hexachlorocyclohexane (HCH) concentrations of most chlorinated compounds are now undetectable. The gamma isomer of HCH (lindane) was used as an insecticide but its use in EU countries was banned in 2002. The EAC range for this compound was 0.5 –5 ng/l. Concentrations above this range have been found in the Wash and the Thames estuary (up to 16.7 ng/l). Although concentrations are lower in offshore waters, concentrations in the North Sea generally tend to increase in a north-south direction and concentrations of 1-2 ng/l are commonly encountered in the most southerly parts of the Region.

Polychlorinated biphenyls (PCBs) were used extensively in a wide range of industrial and domestic applications. Although sales of this group of substances were banned in most countries in the mid-1980s many of the individual compounds (they were sold as mixtures) are persistent. They are therefore routinely found in the marine environment. Concentrations are usually expressed in terms of seven selected CB compounds and OSPAR has set the EAC range for the sum of these as 1-10mg/kg dry wt in sediments. The most recently available NMMP data show that in the southern North Sea area sediments from the Thames and Medway estuaries exceeded the upper EAC and that the lower EAC was exceeded at many other estuarine sites. This suggests that CB concentrations remain an issue of concern. CBs are also monitored as part of the NMMP in fish liver and in mussels. The highest concentrations in fish from the southern North Sea were found in the livers of fish from the Thames estuary (up to 3,700 μg/kg wet wt). Concentrations were also considered to be high in the livers of fish from the Medway estuary. OSPAR defined the BRC for the sum of seven CBs in mussels as being 0.35 –1.7 μg/kg lipid wt. Median concentrations exceeded this range in mussels from a number of sites in the southern North Sea area and median concentrations in excess of 10mg/kg wet wt were found in mussels from the Medway. Although monitoring of CB concentrations has been conducted since the early 1970s the procedures followed have changed several times and assessment of trends over time is not possible.

HAZARDOUS SUBSTANCES – POLYCYCLIC AROMATIC HYDROCARBONS (PAH)

PAHs are produced naturally e.g. as a consequence of forest fires but man's industrial activities and the burning of fossil fuels add further quantities to the input inventory. EACs were set by OSPAR for eight individual PAH compounds in sediments and these eight included in the group of ten compounds monitored under the NMMP. The first such survey was conducted in 1999 and the total concentration of PAH found at one site in the southern North Sea area from a single sampling site in the Medway estuary, was exceptionally high at 207,000 μg/kg dry wt. However, sampling in subsequent years at this same site produced samples containing concentrations about 50 times lower than those found in 1999. At a second site in the Medway and at one site in the Thames estuary concentrations have also exceeded the 10,000 μg/kg sum of the EAC values. PAHs are also measured in mussels but at no site in the southern North Sea have concentrations of even individual PAH compounds exceeded the EAC values set by OSPAR. The significance of PAH concentrations, particularly in relation to assessment of risk to human health, can be assessed by expressing the concentrations of each compound in terms

of benzo(a)pyrene (BaPE), a known carcinogen. None of the higher concentrations of BaPE equivalents occurred in samples of mussels from the southern North Sea. With only four years of data collected so far it is not possible to make any assessment of trends over time.

ORGANIC CONTAMINANTS RECENTLY RECOGNIZED AS PRESENT IN THE MARINE ENVIRONMENT

In addition to the routine surveys undertaken for substances commonly recognized as hazardous, investigations are also undertaken aimed at assessing potential new problems. These are usually undertaken on a pilot scale and recent studies have examined brominated flame retardants and alkyl phenols. Both studies included sites within Region 2.

Alkyl phenol ethoxylates are non-ionic surfactants, the most common of which are the octyl and nonyl forms. They are widely used in both commercial and domestic applications and once in the environment readily degrade into alkyl phenols. Within Region 2 most of the samples of sediment were found to contain concentrations of nonyl phenols and of nonyl phenol mono- and di-ethoxylates of less than the limit of detection of the method used (1 mg/kg and 0.2 mg/kg respectively). Where octyl phenol was detectable (mainly in the outer Thames estuary) the concentrations were low, generally not more than 0.06 mg/kg.

Bromine based flame retardants are applied to a variety of polymer products. Some 70 different chemicals are involved, with a global use of around 300,000 tonnes. Like PCBs most products contain mixtures of compounds. The first studies in the UK focused on polybrominated diphenyl ethers (PBDEs) but, with the exception of deca-brominated diphenyl ether, use of these compounds has been discontinued within the EU. Studies are therefore now being focused on hexabromocyclodecane (HCBD) and tetrabromobisphenol-A (TBBP-A). Within Region 2 studies involving analysis of up to 15 individual BDE compounds showed their presence in hermit crabs from a number of sites e.g. Dogger Bank, off the North Norfolk coast and in the outer Thames estuary. BDEs were also detected in the livers of dab from the Dogger Bank and Sole Pit (130 and 330 μg/kg respectively) as the sum of 15 individual compounds.

RADIOACTIVITY

Discharges of radioactive materials into Region 2 include a range of natural sources such as rocks and industrial sources such as oil and gas production. Small amounts of radioactivity also arise from nuclear power stations and from hospitals. All such discharges are subject to formal authorisation procedures and are monitored accordingly. None of the discharges from such establishments give rise to any issues of concern in relation to public exposure or possible effects on public health or on biota. The impact of discharges from Sellafield (see Chapter 5 for details) is barely detectable in the southern North Sea and gives no cause for concern in the northern North Sea (see previous Chapter).

MICROBIOLOGY

The UK is required to undertake measurements of microbiological contamination under the terms of three EC Directives. The Bathing Waters Directive (for which new, tighter standards are in the process of being agreed) lays down mandatory standards that require 95% of samples of sea water from identified bathing waters to contain less than 10,000 total coliforms and less than 2,000 faecal coliforms per 100 ml. In 2003 monitoring was undertaken at 489 sites in England and Wales and the mandatory standards were passed at 483 (98.9%). This represented a marked improvement on the situation in 1990 when only 78.1% of the sites complied. None of the sites that failed in 2003 were in the southern North Sea. The improvement, both overall and in Region 2 is the result of the considerable amounts of money spent on improving sewage treatment and disposal.

The Shellfish Hygiene Directive sets out standards for *E. coli* and faecal coliforms in shellfish flesh. The standards define whether shellfish can be sold directly for human consumption (class A), after passage through an approved purification system (class B) or must first be relayed in for an extended period in either a class A or B site. Within the southern North Sea there are a number of production sites (Figure 2.5).

Most of these are in estuaries that are subject to sewage inputs making it difficult to achieve class A status and in fact few of the production areas designated in England and Wales as a whole achieve that standard. However, there has been

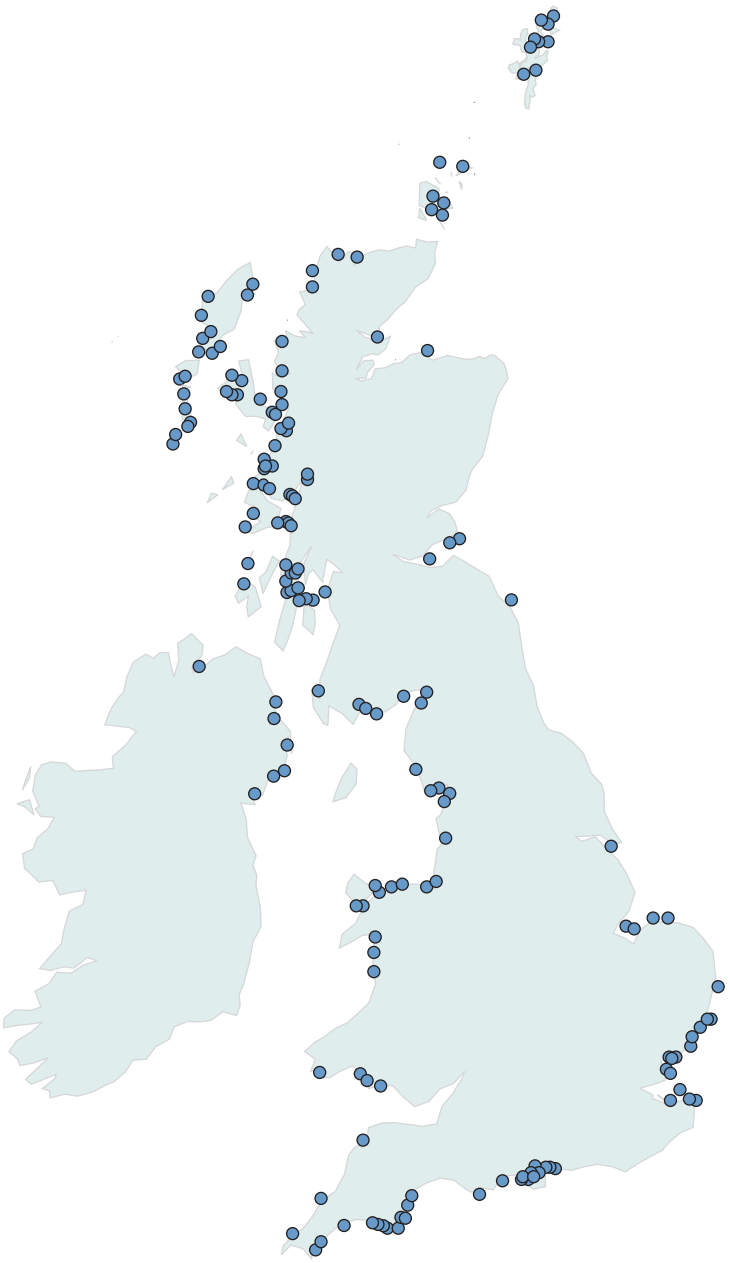


Figure 2.5. Classified bilvalve Mollusc productive areas in the UK

an improvement in the number of production areas achieving class B status with 104 sites in Region 2 being given that classification in 2003 compared to 48 in 1999.

The Shellfish Waters Directive sets guideline standards for contaminant concentrations in shellfish growing waters designed to ensure water quality is suitable for good shellfish growth. These standards include a guideline for faecal coliforms in shellfish flesh. This guideline standard is similar in effect to that which defines class A water quality under the Shellfish Hygiene Directive. However, there is not at present a total correspondence of the areas designated under the two Directives. The government has however

suggested that all waters designated as shellfish growing waters should be of a quality equivalent to class B under the Shellfish Hygiene Directive i.e. maximum faecal coli 300/100 ml. There are 119 designated shellfish waters in England and Wales and these have been surveyed each year since 1999. There has been no obvious improvement in the numbers achieving the nominal class B status in that period. Four percent of the designated shellfish waters that failed the 300 faecal coliforms/100ml standard in 1999-2002 were in the southern North Sea Region

OIL AND OIL SPILLS

The entire sea area around the UK is within the European Waters Special Area established by IMO in 1999. This means that any discharge of oil or oily water from a vessel is illegal. Unfortunately this does not mean that discharges have totally ceased and in the southern North Sea over 20 oil slicks believed to be of vessel origin were reported in 2002. Most of these were in the busy shipping lanes of the Dover Straits. No oil spills as a result of shipping accidents have occurred in the southern North Sea area in recent years. OSPAR has defined an EcoQO stating that of the common guillemots found dead or dying on beaches less than 10% should be oiled. No formal surveys have been conducted in the Region to establish whether this EcoQO is being met.

The southern North Sea is where most of the gas reserves in the UK sector of the North Sea are located. Pipelines connect the various fields together and there are numerous pipelines bringing the gas ashore. These terminate at three main sites, Humberside, the Lincolnshire coast near Mablethorpe and on the Norfolk coast at Bacton (Figure 2.6).

There was some use of oil based drilling muds in the southern North Sea but the hydrodynamic regime quickly dispersed the discharged cuttings. Consequently the piles of oiled drill cuttings that accumulated around northern sector drilling sites do not occur in the southern North Sea.

NAVIGATION DREDGING AND AGGREGATE EXTRACTION

With major ports on Humberside, Felixstowe/ Harwich and in the Thames, dredging to maintain depth of port facilities or to increase them is a major activity along the southern North Sea coastline. In 2001 almost 5.8 million tonnes of dredged material were removed from harbours and approach channels and deposited at 24 licensed disposal sites.

The navigation dredging industry makes a distinction between maintenance dredging operations, most of which involve relocation of silt, mud and sand, and capital dredging. Capital

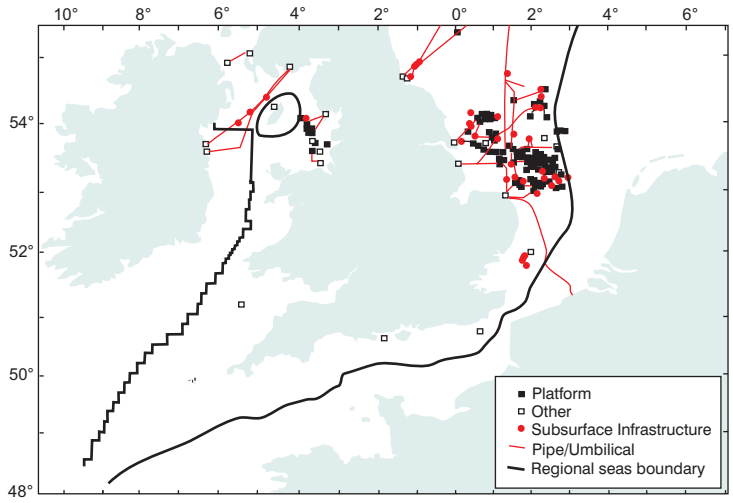


Figure 2.6. Gas fields and pipelines in the North Sea (Southern Sector)

dredging is the term used to describe deepening of docks and channels or creation of new ones. This can involve the extraction of large lumps of clay and boulders as well as finer material. Three major port developments are in progress on Humberside at Felixstowe/Harwich and on the Thames (where the Thames Gateway project will give rise to further dredging) and in 2001 these accounted for 446,000 tonnes of the material deposited at licensed disposal sites.

In recent years increasing attention has been focussed on the use of dredged material rather than its relocation elsewhere. For a variety of reasons this is only practicable in a few cases and although the quantities used have risen steadily over the last ten years they still only amount to about 1% of the total arisings. Examples of the beneficial use to which dredged materials have been put include replenishing salt marsh areas or beaches and the use of boulders in sea defence works.

Figure 2.7. Location of licensed marine aggregate extraction areas around the English and Welsh coastlines in January 2004. Crown Estate 2004

The southern North Sea has numerous areas off the coasts of Lincolnshire, Norfolk, Suffolk and Essex where banks of sand and/or gravel occur. It is part of the national policy that these deposits be exploited as a contribution towards the needs of the building industry for construction aggregates. It is also recognised that offshore deposits are the only practicable source of material for use in beach recharge schemes. The extraction of sand or gravel from offshore deposits is only allowed after careful consultation with other interested parties such as the fishing industry, nature conservation bodies and coastal defence interests. This consultation is part of a formal Government View procedure and involves collection of a large quantity of data for the associated Environmental Impact Assessment. Figure 2.7 shows the location of the sites at which dredging for marine aggregates is currently licensed around England and Wales. Together between 1993 and 2003 the sites in the southern North Sea accounted for 63% or just under 141 million tonnes of the total quantity of marine aggregates extracted off the coasts of England and Wales. Of this total about 9 million tonnes per year came from the deposits off East Anglia. The remainder came from deposits off the Humber and the Outer Thames. Projections for the future suggest that between 2001 and 2016 the requirement for marine aggregates will not change substantially from around the 223 million tonnes taken between 1993 and 2003 to 230 million tonnes. It is anticipated that this will involve a modest increase in the amounts taken from the southern North Sea to 98 million tonnes but this will represent only 42% of the total requirement. The reduced proportion is expected to be offset by the extraction of larger quantities from resources elsewhere, particularly the eastern English Channel (Region 3). Not all the marine aggregate extracted is used in the UK. In 2003 about 6.1 million tonnes or about 30% of the total extracted was exported.

As part of the policy for marine aggregate extraction the Government's objective is that such activities should not cause significant harm to the environment or fisheries or unacceptable effects on other uses of the sea. In order to achieve this the industry will inter alia be required to adopt practices that minimise the impact of dredging and to monitor effects during and after dredging. At present the scope for achieving these goals is limited due to the limited work undertaken thus far on which to base the conditions the industry must meet. This will require a body of case studies of the consequences of marine aggregate extraction developed over sufficiently long time scale and will have to be done in parallel with on-going and expanding extraction activity.

CONSTRUCTION

Apart from the impact of urban development on the coastline of the southern North Sea and the existence of the offshore gas fields and pipelines the coastline has been substantially modified in many places in an effort to minimise coastal flooding and even to reverse coastal erosion. Examples of such measures include construction of the Thames Barrier, sea walls around most of the Essex coastline and the sinking of barges and construction of groynes close to eroding shorelines in order to encourage deposition of material and/or to reduce long-shore drift. Other forms of construction currently taking place in the Region include large scale port developments at Felixstowe/Harwich and the Immingham Outer Harbour and Humber Sea Terminal on Humberside. The decision to proceed with the Thames Gateway development will also involve considerable construction along the Thames estuary. All construction activities are subject to assessment of impact on other interests particularly fisheries and conservation.

The development of offshore wind farms is a particular example of the conflicts of interest that can occur when construction projects are contemplated. In order to meet its targets for reducing carbon dioxide emmissions the Government has set a target that requires 10% of the nation's electricity to come from renewable sources. Although a number of other options are under investigation attention is currently focussed on the proven technology for harnessing wind energy. One such development is already in place on Scroby Sands off the north Norfolk coast and a further development is under construction on the Kentish Flats in the outer Thames estuary in the south of the Region. Further developments involving the placing of 30 turbines or more offshore are proposed for Inner Dowsing (off the Wash), Cromer off the Norfolk coast and the Gunfleet Sands in.the outer Thames estuary. Each of these developments will require an Environmental Impact Assessment and in the absence initially of much practical experience with such projects, these will rely on modelling predictions and experience with other types of construction. There is therefore a need for research into the possible impacts of this new activity and careful setting of monitoring requirements so that the findings can be used to set refined conditions for subsequent developments.

MARICULTURE

Apart from cultivation of some bivalve shellfish species mariculture is not at present an activity undertaken on any scale within the Region.

CONTAMINANT SPECIFIC BIOLOGICAL EFFECTS

In general marine organisms cope with different levels of exposure to metals by converting toxic forms into less toxic bound forms which can be stored and excreted later. One such mechanism is the induction of metallothionein (MT). This is a natural response to exposure particularly of mercury, cadmium and zinc and can provide an indication of exposure , though not the health of the organism concerned. Surveys of MT in dabs from offshore sites showed high variability, no correlation between males and females from the same sites and little apparent link with existing data on metal concentrations in livers. The MT contents of mussels from a small number of estuarine sites were compared with those found a site within Region 2 at Brancaster on the North Norfolk coast. There was no correlation with MT levels in flounder livers from the same estuaries. However, MT levels in mussels from a site in the Thames estuary were substantially elevated compared to the Brancaster control and two to three times higher than those from the Tees estuary (Region1).

Certain organic chemicals can disrupt normal endocrine function and in fish this can result in feminisation of male fish. In extreme cases this can result in the presence of eggs at various stages of development in the male goad. No such occurrences have been found in fish caught in the southern North Sea. Lower exposure levels can be detected by vitellogenin assay (VTG). Studies on flounder taken from the Humber, Alde, and Thames revealed only low plasma VTG levels suggesting that exposure to chemicals capable of disrupting normal endocrine function in the southern North Sea as a whole is low.

Exposure to PAH, and to certain CBs, has been found to alter the rate of synthesis of a group of enzymes in fish liver. The extent of exposure can thus be assessed by measuring enzyme activity and reliable methods exist for one such enzyme known as EROD. Within the southern North Sea surveys using dab and flounder in 2000 and 2001 found that EROD activity was low compared to the

highest levels found elsewhere. The mean values found in dab from a site south of the Humber were lower (46 pmol/min/mg protein) than those found in dab from Rye Bay (134 pmol/min/mg protein) in Region 3, which is was used as a control site. A survey conducted in 2002 using flounder from a number of estuaries confirmed the findings with dab from more offshore sites.

A more general method of assessing the general well-being of fish is pathological examination of fish livers. The presence of foci of cellular alterations (FCA) is one of the tests used. Studies of flounder found a prevalence of FCA in the livers of fish from the Thames to be 12% compared to the supposed control site in the Firth of Forth (Region 1) where it was 2.1%. In the Alde estuary, supposedly also a clean site, the prevalence was 8%. These values compare with the highest prevalence rate of 18.4% in flounder from the Mersey (Region 5). Numbers of liver nodules are assessed in dab taken from more offshore sites. One of the sites where this pathological abnormality was found to be highest was at West Dogger, just in Region 2). Dab from this area also exhibited a higher prevalence of pre-neoplasia and neoplasia pathologies than was found anywhere else around the UK except Liverpool Bay (Region 5).

NON-SPECIFIC BIOLOGICAL EFFECTS

Measurement of a range of fish disease conditions is an accepted integrative tool for assessing the overall health of fish populations. Surveys of dab and flounder have been conducted for a number of years using carefully designed and internationally agreed protocols aimed at establishing a time series of comparable data. Generally the surveys of dab show low levels of disease in fish from the southern North Sea but dab from the Dogger Bank consistently exhibit higher levels of disease than fish from the control area in Rye Bay (Region 3). A particularly prominent condition in dab from the Dogger Bank is hyperpigmentation. Flounder caught in a number of estuaries in Region 2 have consistently shown low levels of external diseases. Sediment bioassay techniques have recently been developed to allow an assessment to be made of sediment quality in estuaries. Although experimental work has been done on sediments collected within the southern North Sea area routine deployment is still at an early stage and no studies have yet been undertaken in the southern North Sea.

The oyster embryo bioassay has been used over a number of years as a means of assessing general water quality. Embryos of the oyster *Crassostrea gigas* are exposed to water samples for 24 hours and their success in developing to 'D' hinge larvae provides a measure of the water quality. The studies have shown that poor water quality is only encountered in estuarine areas. Between 1999 and 2001 water samples from sites in the Humber, Thames, Crouch and Medway estuaries were tested on several occasions. No significant exposure was observed in any of the samples collected from the Humber and on only one occasion, May 2000, was a response observed in the Crouch (less than 10%). In the Thames observed responses in 1999 and 2000 varied between zero and around 10 to 25% but no response was observed in 2001. The highest response of all was obtained in a single sample from the Medway in February 2001 (39%) but this was atypical for the estuary (previous high less than 10%) and compares with the situation ten years earlier when typically in any estuary responses of between 50 and 100% were obtained.

Recently sediment bioassay techniques have been developed to allow an assessment of sediment quality. Routine deployment is still at an early stage and no trials were reported for sites within Region 2

LITTER

The sector report on Environmental Quality gives only a very limited amount of information on the regional prevalence of litter based on a single survey by the Marine Conservation Society (MCS) in 2003. Equally there is no information on the regional effects oflitter in the sector report on Habitats and Species. Consequently it is not appropriate to go into detail in this chapter. However, a brief summary of the overall incidence, scale and significance of the litter issue is provided in the final chapter of this Integrated Assessment. The 2003 MCS Beachwatch survey concluded that beach visitors were the largest source of litter (over 44%) in Region 2, the highest percentage of any region. However, Region 2 had the lowest percentage of sewage related debris of the seven regions surveyed leaving it overall the third lowest density of beach litter (average 1.72 items/m surveyed).

HABITATS AND SPECIES

FISH ASSEMBLAGES

Several factors influence the nature of the fish assemblages found in an area but water depth, temperature and the nature of the seabed are the most important. These three factors certainly have a large bearing on the differences found between the dominant species in the northern and southern North Sea. The southern North Sea is relatively shallow (<50 m deep), tends to be somewhat warmer than the northern North Sea and the seabed is mainly sandy with gravel banks or muddy clay. The dominant fish species include plaice (*Pleuronectes platessa*), sole (*Solea solea*), dab (*Limanda limanda*) and whiting (*Merlangius merlangus*) and non-commercial species such as lesser weever (*Echiichthys vipera*), grey gurnard (*Eutrigla gurnardus*) and solenette (*Buglossidium luteum*) are an important part of the overall assemblage. Sandeels (*Ammodytidae*) and sand gobies (*Pomatoschistus* spp.) are also abundant and are important prey species for many species of larger fish. The area from the Wash to the Thames is still an important area for rays especially the thornback ray (*Raja clavata*) despite the fact that numbers of skate and ray have declined elsewhere in the North Sea. The sea lamprey (*Petromyzon marinus*), which lives in the sea but migrates up rivers to breed, is of conservation interest and is thought to be returning to the Thames to spawn where it was once quite common.

COMMERCIAL STOCKS AND LANDINGS

The landings from the northern North Sea and the southern North Sea together account for about 11% of the total world production of fish and although the bulk of the landings come from the northern North Sea those from the southern half are still important. NOTE These figures refer to the North Sea as a whole as it is impossible to extract figures solely for the UK sector i.e. Regions 1 and 2. Industrial fishing is not a major activity in Region 2 but there are extensive trawl fisheries for flatfish particularly sole and plaice and for roundfish such as whiting. There are small scale fisheries for pelagic species particularly herring, including the discrete stock of Blackwater herring. There are also important pot fisheries for edible crab along the Lincolnshire and Norfolk coasts where this species finds the gravel banks to its liking.

Stocks of the main commercially exploited fish species are assessed annually by the International Council for the Exploration of the Sea (ICES) and concern has been expressed for a number of years about the state of the stocks and the level of fishing effort. A precautionary approach to fisheries management was introduced in 1999 and in 2004 four out of eight demersal stocks were considered to be at risk of being harvested unsustainably. However, two of the species considered to be fished at full reproductive capacity (haddock and saithe) do not feature significantly in the landings taken from the southern North Sea, leaving only herring as being considered to be exploited at a sustainable level. The species of most importance from the southern North Sea are plaice and sole and both of these are harvested outside precautionary limits.

(In 2004 ICES defined "at risk of being harvested unsustainably" as referring to stocks where fishing mortality is above the precautionary reference point (F_{pa}). This is equivalent to the previous terminology "harvested outside safe biological limits". The term full reproductive capacity" describes stocks where the spawning biomass is above the precautionary reference point (B_{pa}). This is equivalent to the previous terminology "inside safe biological limits". A more detailed explanation of the new terminology can be found in the sector report on Fish and Fisheries.)

IMPACT OF FISHING

Apart from the effects of fishing on stocks of the target species fishing gears can also catch under-sized individuals and non-target species which are of no commercial value and are therefore discarded. These discards can provide a source of food for seabirds and for scavenging species such as crabs. Other species that are also caught inadvertently by fishing gear include marine mammals such as dolphins, porpoises and seals. Fishing may also cause other more subtle effects such as alteration of the genetic diversity of a population where the removal of the larger mature individuals may cause selection for those individuals that mature at a smaller size. The number of harbour porpoises caught in the North Sea gill and tangle net fisheries has been a matter if considerable concern in recent years because the numbers caught were thought to be more than the ASCOBANS-IWC limit of 1.7% of the population per year. That level has been adopted as an EcoQO and is now being piloted by the UK. The by-catch of harbour porpoises is known to have declined but it remains unclear whether the EcoQO is being achieved.

A substantial part of the fishing effort in the southern North Sea is conducted using beam trawls. This type of gear includes heavy chains which drag over the seabed disturbing any flatfish buried in the upper few centimetres. Beam trawls tend to dig further into the seabed than otter trawls where only the trawl doors scrape the seabed.

They also impact on a much bigger area of seabed. However fishing effort is remarkably patchy and it has been estimated that much of the North Sea is either not fished at all or is trawled less frequently than once every seven years. On the other hand some areas are trawled much more frequently – ten times or more each year. In a relatively dynamic area such as the southern North Sea, where the impact of storms and tides are frequently detected on the seabed, the initial impact of trawling activity may be less marked than in a deeper region dominated by structural fauna. Nevertheless, there are concerns over the scale of impact on animals living on or in the seabed which are either killed outright or are damaged by beam trawl gear. Figure 2.8 shows that beam trawling effort by international fleets is far from uniformly distributed in the southern North Sea. (Note that only part of the area shown in the Figure is in Region 2.)

In the light of these concerns over damage to benthic species and habitats, the densities of fragile, sensitive of opportunistic species that might exploit the food supply presented by the

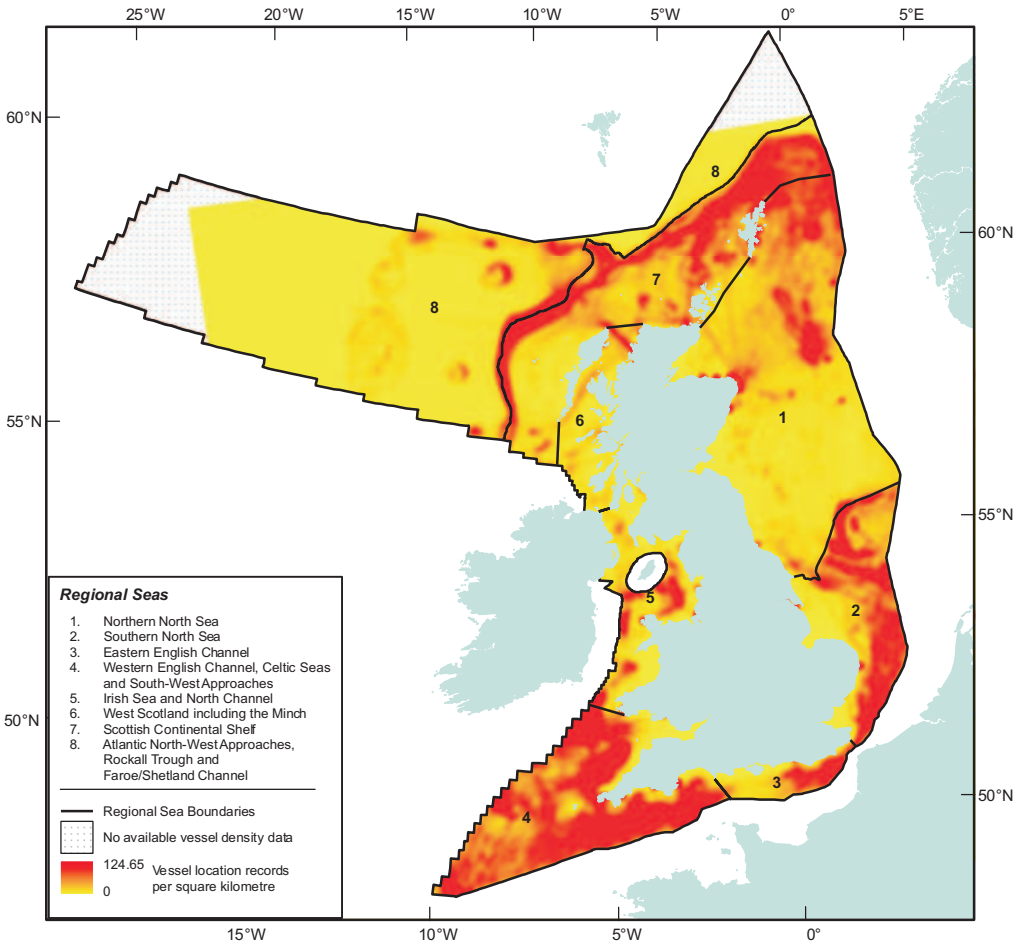


Figure 2.8. UK beam and scallop trawler density in 2002. Vessel positions filtered by speed (between five and eight knots) to remove steaming

dead and dying animals left in the wake of a beam trawl, have been proposed as EcoQOs against which the scale of impact can be judged. ICES is currently examining the feasibility of using such EcoQos and has so far concluded that using opportunistic species is not practicable but that the proposed use of fragile, sensitive species could usefully be pursued further on the basis of a limited suite of sensitive species.

PLANKTON

The free floating microscopic plant life of the sea (phytoplankton), at the base of the marine food web, provides food for the animal plankton (zooplankton) which in turn feed their predators. Copepods are the dominant zooplankton group in the North Atlantic and they and the phytoplankton are normally found mainly in the upper 40m of the water column where light can penetrate. Although there have been intermittent observations of the plankton in the North Sea at various times and places, there have been few systematic surveys and, with the exception of the Continuous Plankton Recorder (CPR) survey, all have been discontinued. CPR records for the southern North Sea started in 1932 along a route from Felixstowe to Scheveningen in The Netherlands. With a break in the early 1940s due to war, the record was continuous until 1960 and resumes again in 1980. A second route runs from the Humber to northwest Denmark and was also started in 1932. It was operated routinely with a break for the war years until 1984, was restarted with intermittent records in 1995 but has been operated routinely since 1997. A third route runs from the Humber to the Elbe light vessel and has operated continuously since 1984. The length of the available records has proved valuable in understanding what trends have occurred over time and the reasons for them. A particularly important conclusion is that, on the basis of the evidence from the phytoplankton, the seas around the UK are relatively unaffected either by contaminants or eutrophication.

Measurements of phytoplankton colour give a coarse visual assessment of phytoplankton biomass/chlorophyll. Preliminary studies show that this CPR Colour Index compares well with satellite measurements of chlorophyll. The CPR samples can be analysed for the main zooplankton species and it is possible to establish baseline conditions for a range of species as well as indices of abundance and biodiversity. It is also possible to determine dominant patterns of change in phytoplankton and zooplankton and it was these records that showed long-term trends in phytoplankton are closely related to changes in seabird and fish species. Within the southern North Sea area the records clearly show that, although there has been a sequence of changes in the past, around 1987 a change occurred of such magnitude that it is regarded as a regime shift.

At about that time a number of 'unusual' algal bloom events in the southern North Sea had occurred and attention was focussed on eutrophication as the cause. However, it was clear from the CPR records that similar changes were taking place over the NE Atlantic out to 20°W and were attributable to changes in water movement and increases in water temperature. The changes did involve greater phytoplankton productivity but this was also linked to less grazing by zooplankton. This in turn had knock on effects of greater food supply for benthic species (and a rise in benthic biomass) and the distribution and abundance of some fish species, particularly horse mackerel, salmon and cod. These changes are all inter-linked and appear to have been caused by an increase in Northern Hemisphere Temperature (NHT), in sea surface temperature and to a lesser extent the winter NAO.

The change in temperature has resulted in a northward shift of more than 10° latitude of warm water species over the last ten years and a complimentary reduction in the diversity of colder water species. The change in phytoplankton has been followed by a change in the relative abundance of the two dominant large copepods *Calanus finmarchicus* and *C. helgolandicus* and of Euphausiids. Both euphausiids and *C. finmarchicus* have declined in abundance whereas *C. helgolandicus* has increased. All three species are important in terms of their food value for cod and it is suggested that even without severe fishing mortality, cod stocks would be at a low level in the North Sea generally and in the southern part in particular. This is because although *C. helgolandichus* is of similar food value to *C. finmarchicus* its population peaks later in the year by which time cod larvae and juveniles are feeding on larger prey. This coupled with the reduction in Euphausiids, which form an important source of food and vitamin A for cod, means fewer cod survive. This is in marked

contrast to the conditions of the 1960s and 1970s when there was a "gadoid outburst" and catches of cod rose rapidly. A further change that has only recently become apparent is a 400% increase in numbers of echinoderm larvae in the North Sea (SAHFOS Annual Report 2003).

BENTHOS

There is a long history of benthos study in the North Sea but most of the studies relate to small areas and have been undertaken over relatively short time scales. In the last 30 years or so a concerted effort has been made to establish what conditions actually are so as to provide a baseline against which goals such as " biodiversity decline should be halted by 2010" can be judged. Two such studies were UK wide, the Inter-tidal survey of Great Britain and Ireland and the Marine Nature Conservation Review (MNCR). The two sets of data have been combined and published as the MNCR. These major efforts have produced good baseline data but assessing temporal change can only be achieved if there are similar data over an extended period. This is only the case for a relatively few sites at present.

Two surveys that prove exceptions are a North Sea Benthos Survey, which was undertaken in 1986 as systematic study organised by ICES. Many of the same stations were revisited between 1999 and 2001 under the North Sea Benthos Project (Figure 2.9).

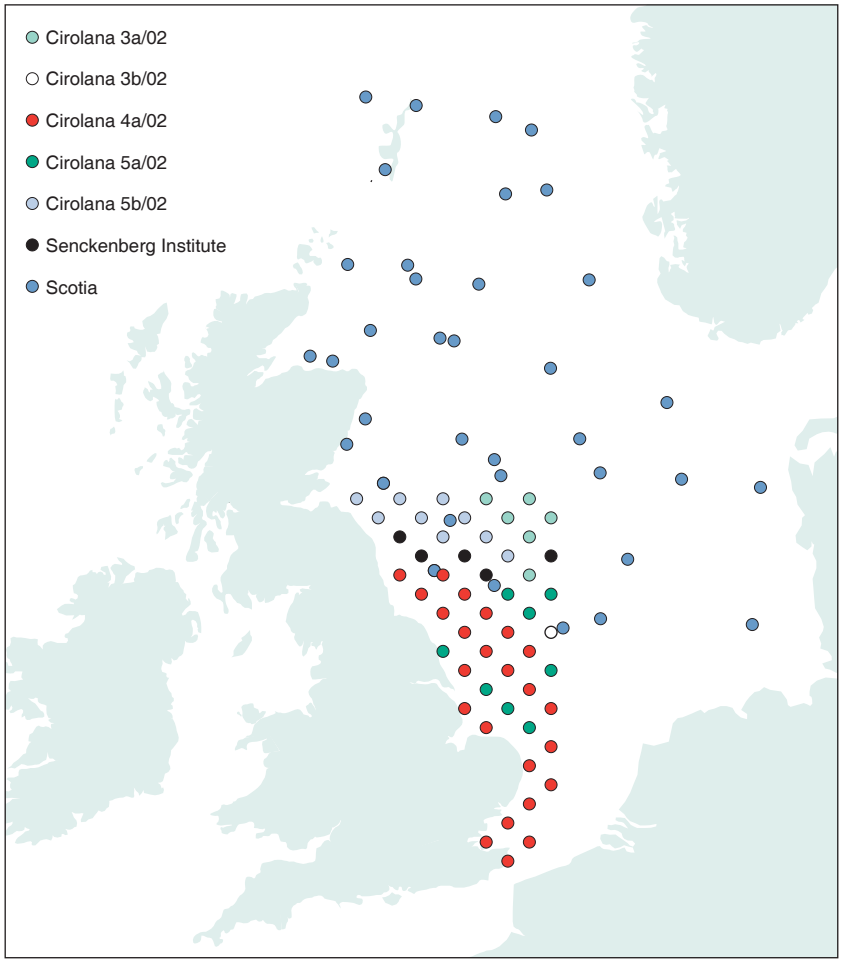


Figure 2.9. The location of the sampling stations for the North Sea Benthos Survey, 2000. The cruises were undertaken by CEFAS (Cirolana), FRS (Scotia) and Senckenberg Institute (Hinz). Data supplied by Hubert Rees, CEFAS Burnham

The majority of the stations revisited lie in the southern North Sea. Unfortunately the comparative data for the UK sector were not expected to be fully worked up before the end.of 2004. However, a preliminary report was made available for the sector report on Habitats and species and this indicated that the major factors determining the benthic population diversity, Species and abundance are seabed type and latitude.

The other source of benthos data over time comes from the NMMP, which includes collection and analysis of benthos samples from a number of sites around the UK. Although the surveys have been undertaken annually for a number of years the run of data is still too short to be able to assess changes over time. However, the data on abundance and diversity of species at these NMMP sites have recently been assessed (*MEMG, 2004*). Scores were allocated according to an experimental version of a Biotic Index (AMBI). Under this scheme as it currently exists a score of zero is regarded as being indicative of a normal healthy regime whereas a maximum score of seven indicates one which is heavily stressed or polluted. Within the southern North Sea the NMMP has three coastal sites and seven estuarine sites. Two of the coastal sites are in the Wash and these scored 2.55 and 3.11, the other coastal site is in the outer Thames estuary and scored 2.45. All these scores indicate some degree of stress but it probably reflects mobile sediments rather than pollution. The estuarine sites were given scores ranging from 0.15 to 4.72. The lowest of these scores was for a site in the Humber as were the two highest scores of 4.72 and 4.30. The remaining sites were in the Thames/Medway and were allocated scores between 1.33 and 3.37. Further work on the index is now needed to allow for factors such as sediment type as the scores are clearly heavily influenced by the stress of mobile seabed.

SEABIRDS

Seabird numbers and breeding success are assessed annually throughout the British Isles by the Seabird Monitoring Programme (SMP), which began in 1986 and is co-ordinated by the JNCC's Seabird Colony team. Since 1989 the results of the SMP have been published in an annual report. This is entitled "Seabird numbers and breeding success in Britain and Ireland" and is produced by JNCC in collaboration with RSPB and the Shetland Oil Terminal Environment Advisory Group (SOTEAG). While the SMP conducts annual monitoring of a sample of the seabird population in the UK, complete censuses of all seabirds in the UK have been conducted to obtain total population compared. The most recent UK population estimates were obtained in 1998-2002 estimates, which provide a baseline against which subsequent monitoring can be during Seabird 2000 a JNCC-led census of breeding seabirds in the UK and Republic of Ireland.

Twenty-five species of seabird are known to breed in the UK and total numbers have increased from around 4.4 million in 1969-70 to 6.7 million in 1998-2002. Not all species have experienced the same success and there are considerable variations between species year to year and between breeding sites.

Figure 2.10 (overleaf) shows the location of sites designated as Special Protection Areas (SPAs) under the EC Birds Directive. Accordingly as required by this Directive there are 16 sites between Flamborough Head and North Foreland that have been given SPA designations because of the presence of one or more seabird species and/or the large assemblage of seabirds found there (>20,000 adults). The most important seabird colonies in the Region are of terns which nest on the coastal margins and are vulnerable to sea level rise and flooding. Consideration is being given to developing biodiversity indices which include population indices for various seabird species. However, different seabird species are affected to different degrees by different factors, for example terns are very susceptible to nest-site disturbance and predation and there is therefore doubt over the use of these indices as an indicator of overall marine environmental quality. OSPAR has set a seabird EcoQO based on the numbers of oiled common guillemots found on beaches but no formal surveys have yet been organised in the southern North Sea by which compliance with this objective can be judged.

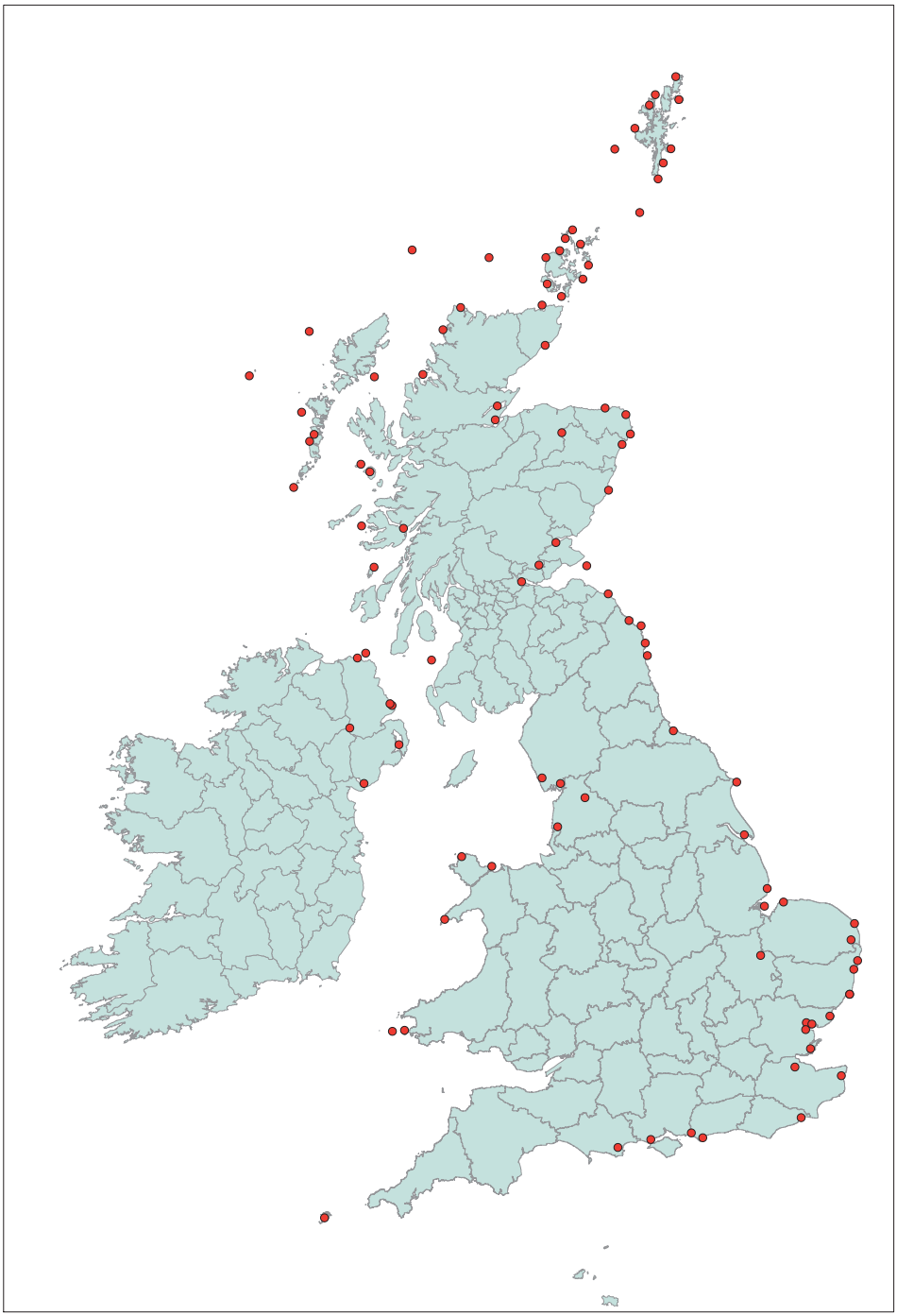


Figure 2.10. Sites designated as Special Protection Areas due to their qualifying interest in one or more seabird species and/or their seabirs assemblage

SEALS

Two species of seal are resident in the UK and both occur in the southern North Sea. The grey seal (*Halichoerus grypus*) is the larger of the two and favours sites away from human populations where it can rest, give birth and wean its young and mate. It is relatively uncommon in the southern North Sea with only one breeding site of any significance in the area. This is at Donna Nook at the very outer edge of the Humber estuary. The second seal species found in UK waters is the common or harbour seal (*Phoca vitulina*). This species also requires haul out sites where it can rest and where it can give birth. Common seal pups can swim very soon after birth and mating takes place in the water. The main haul out sites for the common seal in the southern North Sea are in the Wash, with smaller numbers being found at Donna Nook, on the north Norfolk coast and in the estuaries of several rivers along the Suffolk and Essex coast in the Thames estuary.

The fact that common seal pups spend only brief periods ashore makes it more difficult to assess numbers than for grey seals. At most sites the method used is thermographic aerial photography and this is used to assess numbers in the largest population in the Region in the Wash. The total population of common seals in the UK was estimated to have been between 50,000 and 60,000 before the outbreak of phocine distemper virus (PDV) in 2002. Epidemics of PDV affected both species of British seals in 1988 and 2002. The common seal was affected to a much greater extent than the grey seal and large numbers died in 1988. The population had largely recovered by the time of the 2002 outbreak but the population in the southern North Sea (mainly in the Wash) was particularly badly affected with up to 35% of the population dying. No cases were reported in 2003 and it is believed that the outbreak has run its course.

One EcoQO has been established for seals and another has been proposed but they are expressed simply in terms of numbers and utilisation of breeding sites and merely permit relative numbers to be tracked over time. There is no suggestion that either species is at risk in the UK. However, both species are listed in Annex II of the EC Habitats Directive because they are considered to be rare or threatened in other parts of their range in Europe. Accordingly, as required by this Directive representative breeding sites for grey seals and haul out sites for common seals have been proposed as SACs. The Wash is the only such site in Region 2 and is listed because of the large numbers of common seals found there.

CETACEANS

Cetacean distribution in northwest European waters has recently been mapped and depicted in a Joint Cetacean Database published by JNCC in atlas form. The cetacean species complement in UK waters is similar to that observed in other parts of the world at similar latitudes throughout the 20th century. Of the 28 species recorded as being present in UK waters in the latter half of the last century only ten are commonly recorded in UK waters. For most species accurate data on population size do not exist. Even in the North Sea where surveys have been conducted and reporting of sightings is encouraged, reasonably accurate estimates are available for only a few species. Good estimates are available for *Lagenorhynchus* dolphins, minke whales and the most abundant species in the Region, the harbour porpoise. The available data pertain to total populations in the whole North Sea rather than Region 2 specifically.

Strandings of cetaceans occur all around the UK and are recorded and summarised by the Institute of Zoology in England and Wales. No particular pattern of cetacean stranding or numbers sighted appears yet to have emerged except for harbour porpoises. This species was being caught inadvertently in the gill and tangle net fishery in the central North Sea (Regions 1 and 2) in numbers greater than those regarded by ASCOBANS-IWC as sustainable. An EcoQO has been set at the recommended ASCOBANS-IWC level i.e. maximum fishing mortality 1.7% of the population per year and it is known that by-catch deaths in the fishery have been reduced although not how this matches the EcoQO.

HABITATS

The sector report on Habitats and Species describes the various measures that are available, have been and are being taken to protect habitats and species around UK coasts. It includes a review of a range of key habitat types and indicates areas where important examples of each are to be found and the threats that they currently face or may face in the future. The

southern North Sea has a coastline and seabed that is typically low lying and fairly mobile i.e. it is either eroding or accreting, with several large estuaries and salt marsh areas. Its ecology does not therefore differ markedly and there are no marine nature reserves in the Region. There are seven SACs designated in the Region, either because they represent particularly important habitat types or because of their importance to particular species.

Of the main habitat types reviewed in the sector report, mudflats are particularly well represented along the coasts of Suffolk, Essex and Kent and there are important areas in the Humber and Wash. Although mudflats are considered to be at risk from sea level rise, the large areas of mudflats in the Region mean that this is not likely to pose a serious source of loss overall, especially as many estuaries are silting up and therefore new areas are being created. Salt marsh loss is however a different issue, especially as many areas are outside sea walls and subject to erosion. Concern has been expressed over the possible adverse effects of commercial fishing in the Wash using suction dredgers to harvest cockles. Sub-tidal sands and gravels occur off the Lincolnshire coast, in the Wash and in the outer Thames estuary. Many of these areas are subject to perturbation by trawling and especially by aggregate extraction and they have as result been severely modified.

Littoral and sub-littoral chalk type habitats occur at Flamborough Head where the chalk is particularly hard as a result of compression by overlying strata and glaciation, and in Kent. Some 56% of the coastal chalk habitat in Kent has been modified by coastal defence and harbour developments at Margate, Ramsgate and Dover. On the Isle of Sheppey up to 74% of the chalk habitat has been modified and a wide range of microhabitats on the upper shore has been lost and splash back zones have been removed.

Seagrass (*Zostera*) beds are considered scarce around the UK but the Maplin Sands (outer Thames estuary) are estimated to have the largest continuous population of dwarf eelgrass in Europe (ca.325 ha) and eelgrass is also known to occur on the north Norfolk coast. Extensive areas of *Sabellaria spinulosa* have been identified in the Wash and off north Norfolk and are included in the Wash and North Norfolk SAC. *S. spinulosa* is a small tube-building worm and, as in this area, can give rise to substantial reefs. In the Wash the reef is estimated to be about 60 cm high and covers a linear extent of 300 m. The full distribution of S.spinulosa reefs has not yet been established but other *S. spinulosa reefs* have been identified in the southern North Sea between Swarte Bank and Broken Bank and around the sand banks off the North Norfolk coast

KEY POINTS AND CONCLUSIONS

As with Region 1 there is evidence that the physical environment of Region 2 has changed during the last 100 years. Air temperatures over the land have increased by about 0.5°C and increases in sea surface water temperatures have increased by a similar amount. Increases in overall bottom water temperatures have also been observed although there have been periods when intrusions of cold water through the Dover Straits occurred under the influence of persistent south-easterly winds. There has been an increase in the frequency of storms, though not of their intensity and rainfall has increased, with the 2 year period to March 2001 being the wettest since records began in 1766. However, most of that increase has been during winter months and summers have tended to become drier. There is some evidence from the ICES IBTS that average salinity in the winter months has decreased slightly.

Coastal erosion is a major issue along the coasts of South Yorkshire and East Anglia and is accompanied by siltation in a number of estuarine areas from the Humber to the Medway. The major causes are the soft nature of the coastline, wave action especially during storms and the fact that sea level is rising and the land mass is sinking as a result of land mass tilt in response to post-glacial adjustment and compaction of sedimentary rock formations. The erosion of the coasts, coupled with strong tidal currents and generally shallow water depths means that 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.

The Humber and Thames estuaries in particular receive river input from heavily populated and industrialised catchment areas and in the past the scale of inputs and concentrations of contaminants were higher than those now experienced. Nevertheless, concentrations of a number of contaminants remain above

those set as indicative of background or likely to be associated with biological effects. Thus, although some reduction in nutrient inputs has been achieved, concentrations of both DIN and DIP have not shown concomitant reductions. There is however, little evidence of eutrophication in terms of algal blooms or elevated chlorophyll levels. There have been changes in plankton composition (both phyto- and zoo-) but these are attributable to changes in physical environmental conditions, particularly temperature, affecting the whole north-eastern Atlantic. In areas like the Humber and Thames estuaries concentrations of a number of metals are higher than those regarded as background in water, sediments and/or biota and this is clearly the result of anthropogenic activity. However, in only a few instances are the concentrations considered high enough to be likely to cause biological effects and in some cases, particularly mercury, they are substantially lower than they were in the past.

Data from monitoring show that concentrations of well studied organic contaminants such as HCH, CBs and PAH are also elevated in the southern North Sea and for CBs exceeded EACs, particularly in the Thames and Medway estuaries. As would be expected some biological effects are detectable, especially in those areas where concentrations exceed the EACs, but they are not widespread and much of the Region is unaffected.

Following the commissioning of several major sewage treatment schemes there has been a marked improvement in the number of bathing waters achieving the current mandatory standards set by the EU for the microbiological quality of bathing waters. Similar improvements have been recorded in the number of shellfish areas classified as Category B under the Shellfish Hygiene Directive. However, there has been little improvement in the quality of areas designated as shellfish growing waters under the terms of the Shellfish Waters Directive.

Exploitation of gas reserves is a major activity in Region 2 but most of the active development is now over and seabed disturbance as a consequence of drilling activity and pipeline construction is no longer an issue of concern. Oil pollution as a consequence of illegal discharges from ships does still arise, with most of the reported incidents occurring in the busy shipping lanes of the Dover Straits. However, in terms of damage to marine life or beach pollution the scale of effect is minimal. Litter, in particular on beaches, continues to be an issue of aesthetic concern but its significance in terms of effects on marine life is unclear and certainly has not been quantified for any species.

Due to the risk of flooding as a result of coastal erosion, storms and overall sea level rise, much of the coastline in Region 2 has been modified by sea defence works. There is also extensive modification to the coastline around urban areas and port complexes and much of the development of offshore wind powered electricity generation is taking place, or is scheduled to take place, in the Region. Dredging to maintain or extend harbours and navigation channels is an on-going activity and although the quality of dredged material allowed for disposal at sea has improved (in terms of contaminant concentrations) and use rather than disposal is encouraged, large quantities continue to be disposed of at sea (about 6 million tonnes in 2001). About 9 million tonnes/year of aggregates are extracted from the seabed in Region 2 for use by the construction industry, either in the UK or abroad. This quantity is not expected to change much in annual terms in the future. Before any of these activities are allowed to proceed the proposals are subjected to extensive assessment procedures intended to ensure that adverse effects on the environment and other user interests are minimised.

In habitat terms the species structure is heavily influenced by the predominantly sandy or muddy nature of the coastline and seabed and by the high suspended solids loading in the water column. The Region does have a number of SACs designated, due to the fact that they hold particularly important examples of specific habitats. Saltmarshes are extensive but some areas are eroding under the influence of waves and rising sea level and fears have been expressed that the muddy substrates of the Wash may be being damaged by harvesting of cockles using suction dredgers. Seagrass beds in the outer Thames estuary are extensive and hold one of the largest continuous populations of dwarf eelgrass (about 325 ha) in Europe. Important *Sabellaria spinulosa* beds are found in the Wash and off the north Norfolk coast.

There is no suggestion that fish stocks have been affected by chemical contaminants and the Region supports a varied fishing industry.

However, although the Region is less important in catch terms than the northern North Sea the fish stocks are in an equally poor state and only the herring stock is regarded as being harvested sustainably.

Fishing also affects other species on an incidental basis and in areas that are heavily fished using bottom trawls the benthos is affected to the extent that species abundance tends to be reduced, there are fewer numbers of the larger more fragile species and larger numbers of opportunistic and smaller species. Seabirds and sea mammals may also be affected and in the central North Sea sector of the Region particular concerns have been raised over the by catch of harbour porpoises in gill and tangle nets. Efforts are being made to reduce this though it remains unclear how successful these are proving in terms of meeting the agreed targets. As in the northern North Sea recovery of the stocks of cod is unlikely to be helped by some of the changes in plankton structure that have been noted in recent years. This is because these have tended to result in changes in the species and timing of blooms that are less favourable to the young stages of cod. Overall productivity of plankton has increased with major increases being noted in certain zooplankton e.g. a 400% increase in echinoderm larvae since 1998. Although affected to some extent by the effect of fishing gear, current benthic structure within the southern North Sea is considered to be dominated by the nature of the seabed, latitudinal influence and temperature and 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.

Sea mammals are represented by a variety of cetaceans considered typical for the latitudinal range experienced in the Region and although the scale of fishing mortality of harbour porpoises remains an issue of concern numbers overall remain high. Both species of seal found in UK waters are represented in the Region although the grey seal is at the southern end of its breeding range and only breeds in the outer Humber estuary. The common seal is more widespread, with large numbers being found in the Wash where, despite the effects of PDV epidemics in 1988 and 2002, the species continues to flourish. There are number of major seabird colonies in the Region and a number of SPAs have been designated on account of their importance to seabirds. No particular issues of concern are recorded in relation to seabird populations in the Region. However, the most important seabird colonies in the Region are terns nesting on coastal margins that are vulnerable to sea level rise and flooding.

Region 3:
Eastern English Channel

INTRODUCTION

Region 3 comprises the eastern English Channel. Figure 3.1 shows the location of the Region in relation to its immediate neighbours Region 2 (southern North Sea) and Region 4 (western English Channel) and the location of the major places mentioned in this chapter. The landward boundary extends from Dover in the east to Portland Bill in the west, with the seaward boundary being the line marking the division between the UK and French continental shelf. Water depth is generally less than 50 m although to the western end of the Region, in the centre of the Channel, depths of up to 100 m are reached. Water temperatures show marked seasonality, typically ranging between 7 and 17˚C. Little of the coastline can be described as undeveloped and there are major conurbations at Hastings, Eastbourne, Brighton, and Bournemouth and major ports at Portsmouth and particularly Southampton. Industry is primarily centred around the two port areas with refineries at Fawley on Southampton Water. Many of the coastal towns had active inshore fishing fleets, mostly smaller boats, but this activity has declined in recent years. Medium sized rivers enter the area at Portsmouth/Havant and Southampton. Most of the coastline consists of shelving sand, shingle or pebble beaches but there are cliffs at Dover and Beachy Head and around the Isle of Wight and at Portland Bill. There are substantial deposits of sand and gravel offshore e.g. on Hastings Bank, and these are actively exploited now and expansion into other areas is forecast. The area is also one of the busiest in the world in terms of shipping with movements both in east-west and west-east directions and across the Channel. To minimise the danger of collisions shipping is expected to use designated shipping lanes according to their direction of travel.

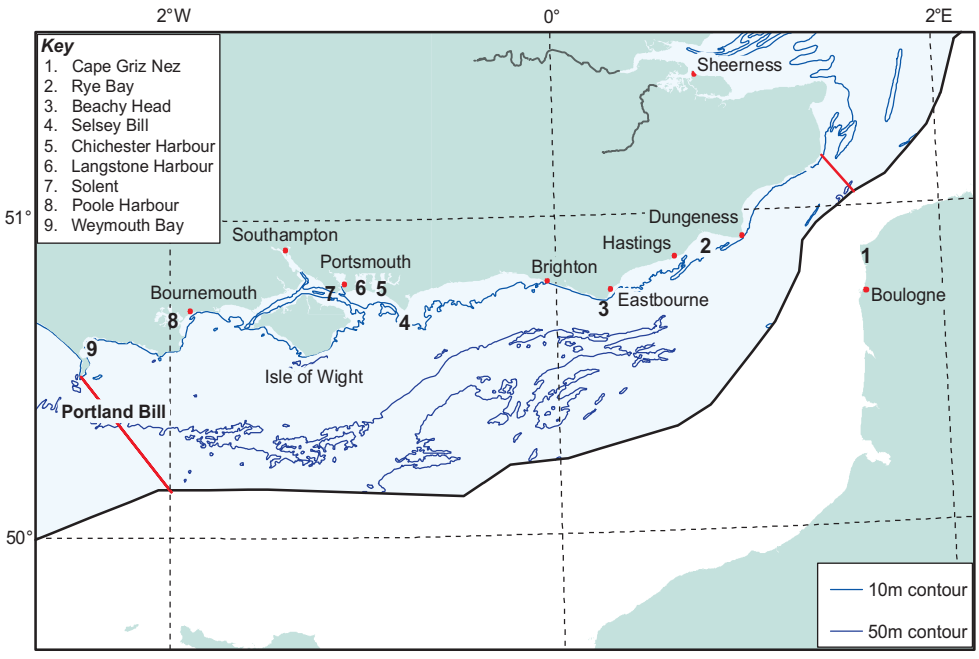


Figure 3.1. Map of Region 3. Bathymetric contour data copyright UKHO

PHYSICAL ENVIRONMENT

WEATHER AND CLIMATE

The three main weather features that drive ocean circulation also have a major influence on a local scale. These features are wind speed and direction, air/sea heat exchange and evaporation/ precipitation. Circulation in the eastern English Channel is influenced by these same features but is also heavily influenced by the tides, with the area around the Isle of Wight, unusually, featuring four tides a day. The prevailing winds over the UK come from a westerly direction and if these are stronger than average or usual for the time of year they will bring warmer air and more moisture with them and also will tend to drive more water into this funnel shaped region, adding to the effect of tidal currents and the earth's rotation.

A major factor influencing North Atlantic circulation is the North Atlantic Oscillation (NAO) – for a brief explanation of this see Chapter 1. Since about 1960 the NAO has experienced its most extreme change since the 1860s with the December to March (Winter Index) showing an upward trend. There have been similar trends over the last 500 years but the one since 1960 appears to be larger than previous changes. The changes account for much of the increase in temperature experienced in the latter half of the 20th Century. This increase in temperature has been accompanied, in south-eastern England particularly, by a tendency to drier summers. Wind records also suggest that there has been an increase in storminess between October and March over southern Britain in particular over the last 50 years or so. This is consistent with a southerly movement of the Atlantic storm track associated with the changes in NAO.

SEA TEMPERATURE

Changes in sea surface temperature (SST) cause sea level rise through thermal expansion and induce shifts in geographic distribution and biodiversity of marine biota. Global SST shows two distinct warming periods from about 1910-1940 and again since the 1970s. Most areas of the eastern North Atlantic have experienced a warming trend of between 0.2 and 1°C per decade since the 1980s. The longest continuing records of SST in UK waters include two sites in Region 3, Dover and Eastbourne and these records show an increase of about 0.65°C over the last 75-100 years (Table 3.1). A shorter record for Shoreham indicates a rise of 0.96°C between 1966 and 1999.

SALINITY

In the eastern North Atlantic salinity has shown a number of fluctuations since 1950 with the most marked one being a reduction in the1970s known as the Great Salinity Anomaly. This was formed by fresh water from the Arctic Ocean feeding into the Nordic Seas and thence to the Atlantic Ocean during an extreme negative phase in the NAO in the late 1960s. There are few long-term records of salinity for the seas directly around the UK and there appear to be none for Region 3. Records do exist for stations in Region 4 (western English Channel) and these indicate either no change or a slight rising trend.

WAVES

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 sea surface. Waves approaching the UK could have been generated well out in the Atlantic Ocean (swell) but within Region 3 the most potent influence is the local wind climate and wave heights are not generally large and certainly not as large as those experienced in Regions 7 and 8 to the west of Scotland. This is illustrated by Figure 3.2 which shows the wave data as recorded at the Sandettie LV in the extreme east of Region 3.

Figure 3.3 shows the monthly means of significant wave heights (and wind speed 10m above the sea surface) derived from altimeters on the satellites Geosat, ERS-1, ERS-2, Topex-Posiedon

Table 3.1. Trends in sea surface temperature

	Nominal position	Data Span	Trend (°C/decade)
Eastbourne	51.0°N 00.0°E	1892-2002	+ 0.06
Shoreham	51.0°N 00.0°E	1966-1997	+ 0.31

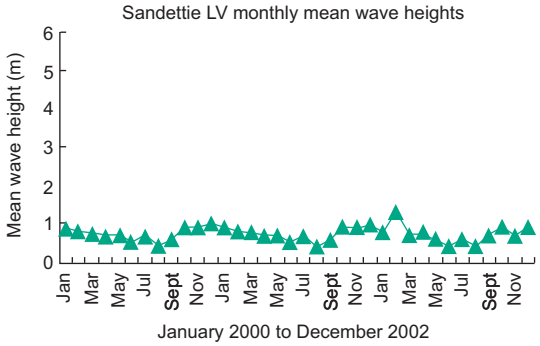


Figure 3.2. Wave data from MAWS Network. Courtesy the Met Office

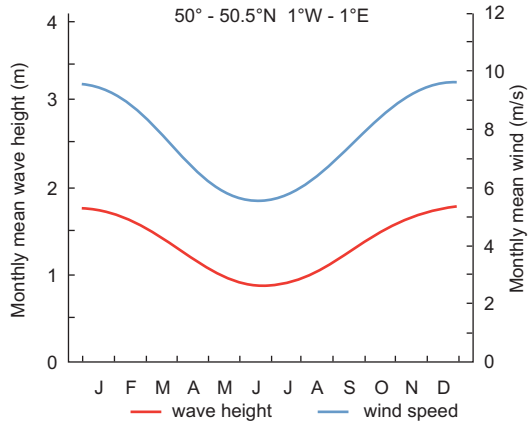


Figure 3.3. Monthly mean wave heights and wind speeds derived from ERS-2 and TOPEX-Poseidon altimeter data from 1985 onwards. Courtesy of Satellite Observing Systems Ltd.

and Jason from 1985 for an area in mid-channel to the west of Region 3. These indicate maximum wave heights around late December.

CIRCULATION

The net movement of water, the circulation, is driven by residual currents due to the tides, meteorological forcing due to winds and atmospheric pressure and mean density distribution. Within Region 3 the overall flow is from west to east, driven primarily by non-linear tides and the prevailing south-westerly winds. However, around the Isle of Wight the local circulation is complex due to the unusual tidal regime in that area. There is evidence of at least an intermittent east-west flow along the English coast through the Dover Straits and across the Channel around Cap Gris Nez. The net flow from west-east has been estimated to be on average about 0.1 Sv (1 Sv = 10^6 m^3/sec). It must be emphasized that this is an estimated average based on a mathematical model and that in reality circulation is highly variable in space and time. Nevertheless, it does indicate the likely direction of movement of a dissolved or neutrally buoyant particle such as a fish egg or larvae. Suspended sediments might also be expected to move in the same overall direction but being heavier will tend to sink and thus move less far.

SEDIMENT CONCENTRATION AND TRANSPORT

In inshore regions waves are the most important mechanism for moving particulate material about – from clay to quite large boulders, and for causing erosion of cliffs and beaches. Offshore, currents tend to be more important and, as indicated above, the heavier the particle the less distance it is likely to travel before being deposited to the seabed. Figure 3.4 (overleaf) gives details of the sediment type in the Region between Bexhill and East Wittering and shows sand inshore and gravel offshore.

Region 3 has both westerly and easterly offshore transport of sediment. Bed load divergences occur near to the tidal amphidrome point off the Solent. Nearshore transport is predominantly easterly, with some reversals in the lee of headlands. Coastal and offshore pathways are aligned where the tides and wave forces are orientated in the same direction, giving an easterly transport in the east of the Region and transport in opposite directions in the west of the Region. There are nearshore divergences at Selsey Bill, Portsmouth Harbour, The Needles and at Dungeness. The main offshore convergence is along a line from Hythe/Dungeness to Boulogne.

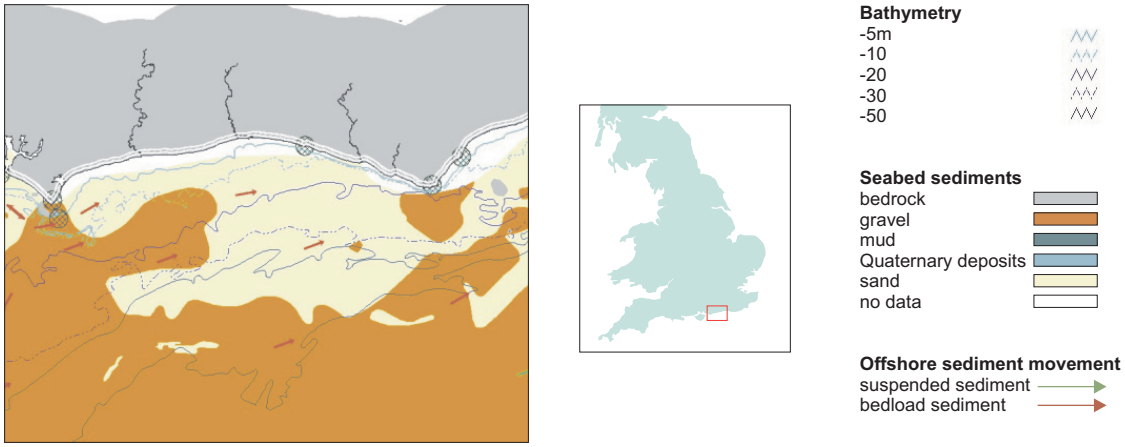


Figure 3.4. The seabed offshore of the area between Shoreham and East Wittering showing seabed type and direction of sediment transport (Ex Futurecoast report)

CHANGES IN SEA LEVEL, COAST AND SEABED

Global mean sea level has risen by about 120 m since the last ice-age around 20,000 years ago and by 1 to 2 mm per year throughout the last century. Sea level at any point in time is a combination of tidal level, surge level, mean sea level and waves. Rising sea level will tend to reduce beach width and increase coastal erosion and will also increase the risk of coastal flooding. The ice sheet that covered the British Isles was large enough to have left a legacy of post-glacial isostatic adjustment in the land mass. This effectively means that, regardless of any change in sea level due to ice melt or thermal expansion, the south of England is subsiding at around 1mm/year and in south-east England sediment consolidation adds to this a further 0.5 to 1.1 mm/year. This has significant implications for future beach erosion and coastal flooding in low lying areas of Region 3.

Within Region 3 a number of high quality beach monitoring programmes have been in place for a number of years e.g. Bournemouth and Herne Bay since 1974. These show significant beach erosion is occurring. For example at Hurst Spit the records show that beach volume fell between 1997 and 2001 from 420,000 m^3 to 350,000 m^3.

ENVIRONMENTAL QUALITY

NUTRIENTS

The microscopic plants known as phytoplankton form the base of the marine food chain. Growth of phytoplankton and the larger fixed algae is regulated by the availability of light, the nutrient forms of nitrogen and phosphorus and, to a lesser extent silicate and carbon. Excessive growth of phytoplankton and fixed algae can be triggered by an increased supply of nutrients. This phenomenon is known as eutrophication and a number of measures have been taken to reduce inputs of nitrogen and phosphorus in order either to minimise the risk of eutrophication occurring or to reduce the effect where it is observable. Common assessment procedures have been proposed by OSPAR to guide decisions on where such measures should be taken. These set out normal and elevated levels for dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP) and chlorophyll. For the English Channel, which includes Region 3, the backgrounds and elevated concentrations are defined as 9 and >15 μmol/l for DIN and 0.4 and >0.8 μmol/l for DIP. The background concentrations of DIN was exceeded in all coastal waters of Region 3 where salinity was less than 34 but inputs from land to the Channel have consistently been much lower than to other Regions around the UK and are believed to be generally similar to those in the North Atlantic (Figure 3.5).

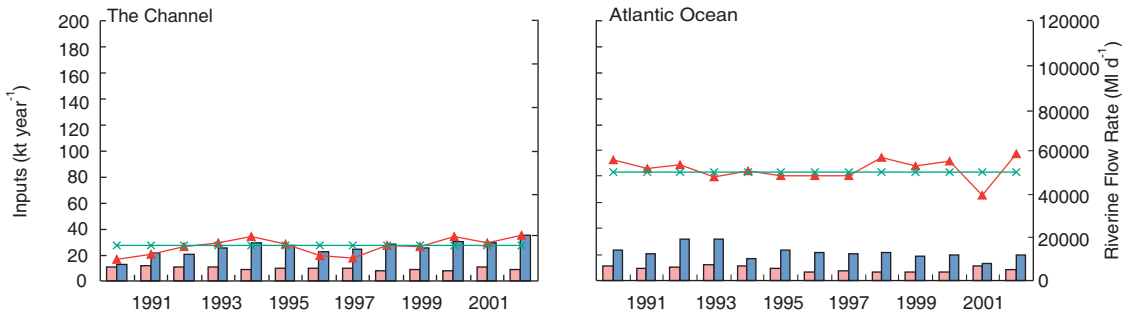


Figure 3.5. Phosphorus inputs and related riverine flow rates for The Channel and The Atlantic

Concentrations of chlorophyll do not exceed the OSPAR common assessment criterion of 10μg/l in Region 3 and although changes in phytoplankton have been observed these are believed to reflect changes that have taken place over the eastern North Atlantic rather than any local influence of nutrient inputs. However, the EC Urban Waste Water Treatment Directive also sets out standards for waste water treatment depending on the nature of the receiving water and whether or not the water body is regarded as a eutrophic problem area or one that is at risk of becoming eutrophic. Among the aspects to be considered is the growth of fixed algae. In Region 3 Chichester and Langstone Harbours are regarded as problem areas due to the growth of *Enteromorpha* and Portsmouth Harbour is regarded as a potential problem area for the same reason. A small area of Poole Harbour known as Hole's Bay is also considered to be either a problem area or a potential problem area. In these areas reductions in nutrient inputs from sewage are required and this will entail additional treatment at the sewage treatment plants.

HAZARDOUS SUBSTANCES – METALS

Within Region 3 all the concentrations of metals in sea water have been found to be below the EQS levels i.e. the concentrations defined as being likely to harm marine life. In 1997 OSPAR set background reference concentrations (BRCs) and ecotoxicological assessment criteria (EACs) for several metals in sea water but none of these are exceeded in Region 3. (It should be noted that the BRC and EAC values referred to in this report are those adopted in 1997. These have been reviewed and were recently revised but the new values were not available when the sector report on Environmental Quality was being prepared; they have not therefore been used in this review either.) Under the NMMP, concentrations of metals are monitored in fish flesh and in mussels. In all the samples taken from within the Region concentrations were found to be relatively low, for example zinc and copper were low in mussels from Southampton Water (8.6μg/kg) and in Poole Harbour one of the lowest concentrations of cadmium (102 μg/kg) was recorded in mussels. Metals are also monitored in sediments as part of the NMMP and OSPAR established both BRCs and EACs for a number of metals in sediments. Within Region 3 none of the samples collected exceed even the lower end of the ranges for either BRCs or EACs, with the exception of copper concentrations, which are considered to be slightly elevated in Southampton Water.

HAZARDOUS SUBSTANCES – CHLORINATED ORGANICS

Some chlorinated organic substances combine persistence with a tendency to bioaccumulate and toxicity. Controls have been applied to restrict the use of many such compounds and as a consequence concentrations in the marine environment have declined. The use of one such substance – hexachlorocyclohexane (HCH) was not banned until 2002 and this substance can still be detected in sea water in Region 3 where concentrations of 1-2 ng/l are found. Such concentrations are within the 0.5 – 5 ng/l EAC range established by OSPAR but, following the ban on use, are expected to fall below detectable concentrations

The sale of polychlorinated biphenyls was banned in most countries in the mid-1980s but many

of the individual compounds (they were sold as mixtures) are persistent and bioaccumulate and are toxic. They are routinely detected in environmental samples and monitoring, aimed at confirming their decline, continues. The methods used for quantification have changed over the years as techniques have been refined and although it is clear that levels have fallen since the 1980s, based on data calculated on a formulation basis (*Author's note*), it is not possible to compare more modern data with those from the past. The monitoring results nowadays are expressed in terms of concentrations of seven selected CB substances and OSPAR set an EAC range for the sum of these as 1-10 μg/kg dry wt in sediments. The most recently available NMMP data show that concentrations are relatively low and do not exceed the upper EAC concentration at any site in Region 3. Concentrations of CBs are also monitored in fish liver and in mussels. OSPAR established EACs for whole fish (1-10 μg/kg wet wt) but not in fish liver. However, concentrations of CBs in fish liver samples from Region 3 are relatively low and apart from the fact that they are detectable give no cause for concern. OSPAR has set a BRC range for CBs in mussels of 0.37 to 1.7 μg/kg wet wt for the sum of the seven selected CBs. Concentrations of 10 μg/kg wet wt were found in mussels from Southampton Water. Due to the changes in methods of quantification over the years assessment of trends in concentrations is not possible.

HAZARDOUS SUBSTANCES – POLYCYCLIC AROMATIC HYDROCARBONS (PAH)

PAHs are formed naturally e.g. as a consequence of forest fires but man's industrial activities and the burning of fossil fuels introduce considerable additional quantities to the environment. Their presence in the environment is a matter of some concern because some PAH are either known or suspected carcinogens and might therefore be expected to adversely affect marine life or even man through consumption of contaminated fish or shellfish. EACs have been set by OSPAR for 8 individual PAHs in sediments. All 8 compounds are included in the 10 PAHs routinely measured under the NMMP. Within Region 3 sediment concentrations of PAHs were not found to exceed the EAC range set by OSPAR. PAH are also monitored in mussels and within Region 3 concentrations were generally low, with samples from Poole Harbour being the lowest encountered country wide. Although the PAH data for Region 3 give little cause for concern the data do only go back to 1999 and so trend assessment would not be possible even if concentrations were higher.

ORGANIC CONTAMINANTS RECENTLY RECOGNISED AS PRESENT IN THE MARINE ENVIRONMENT

In addition to the routine surveys undertaken for substances commonly recognised as hazardous, investigations are also undertaken aimed at assessing potential new problems. These are undertaken on a pilot scale and recent studies have examined brominated flame retardants and alkyl phenols. Both studies included sites within Region 3. Alkyl phenol ethoxylates are non-ionic surfactants, the most common of which are the octyl and nonyl forms. They are widely used in both commercial and domestic applications and once in the environment they readily breakdown into alkyl phenols. Within Region 3 most of the samples of sediment were found to contain concentrations of nonyl phenols and nonyl phenol mono- and di-ethoxylates of less than the limit of detection used (1 mg/kg and 0.2 mg/kg respectively).

Bromine based flame retardants are applied to a variety of polymer products. Some 70 different chemicals are involved with a total global use of around 300,000 tonnes and, like PCBs, most products contain mixtures of compounds. The first studies in the UK focussed on polybrominated diphenyl ethers (PBDEs) but, with the exception of deca-brominated diphenyl ether, use of these compounds has been discontinued within the EU. Within Region 3 studies involving analysis of up to 15 individual BDE compounds were undertaken in 1999. These did not include samples of invertebrates. However, a sample of dab livers from off Hastings was found to contain 17 μg/kg as the sum of 15 individual BDE compounds. In view of the discontinuation of use of PBDEs within the EU future studies within the Region will focus on hexabromocyclodiene (HBCD) and tetrabromobisphenol-A (TBBP-A).

RADIOACTIVITY

Discharges of radioactive materials into Region 3 include a range of natural sources such as rocks and industrial sources. Small amounts of radioactivity also arise from nuclear power stations and from hospitals. All such discharges

are subject to formal authorisation procedures and are monitored accordingly. None of the discharges from such establishments give rise to any issues of concern in relation to public exposure or possible effects on public health or on biota.

MICROBIOLOGY

Three EU Directives require monitoring of the microbiological quality of the marine environment. The Bathing Waters Directive (for which new, tighter standards are in the process of being agreed) lays down mandatory standards that require 95% of samples of sea water from identified bathing waters to contain less than 10,000 total coliforms and less than 2000 faecal coliforms per 100 ml. All 489 identified bathing waters in England and Wales were monitored in 2003 under the terms of the Directive. The results showed 98.8% complied with the mandatory standards. Within Region 3 all the designated bathing waters passed the mandatory standard in 2003. This represents an improvement since 1990 and is a reflection of the considerable improvements that have been achieved in sewage treatment and disposal since that date.

The Shellfish Hygiene Directive sets out standards for *E. coli* and faecal coliforms in shellfish flesh. The standards define whether shellfish can be sold directly for human consumption (class A), after passage through an approved purification system (class B) or must be relayed for an extended period in either a class A or B site. Within Region 3 there are a number of shellfish production sites, all of which are located in the western part of the Region from Weymouth Bay to Chichester Harbour. Most are in harbour areas subject to sewage inputs making it difficult to achieve class A status and in fact of the 63 designated production sites in Region 3 none achieved class A status in 2003. However, 57 achieved class B status representing an improvement on the 21 out of 40 achieving this status or better in 1999, in turn reflecting improved sewage treatment and disposal arrangements introduced during that period.

The Shellfish Waters Directive sets guideline standards for contaminant concentrations in shellfish growing waters. These guidelines are intended to ensure that water quality is suitable for good shellfish growth and include one for faecal coliforms in shellfish flesh. This guideline standard is expressed in different terms to that used in the Shellfish Hygiene Directive but is broadly similar in effect to that which defines class A water quality. Due to anomalies in the way in which the two Directives were implemented, not all shellfish production waters are currently designated under the Shellfish Waters Directive and vice versa. The Government has however suggested that all shellfish growing waters designated under the Shellfish Waters Directive should be of at least class B standard under the Shellfish Hygiene Directive. Of the 119 designated waters in England and Wales between 1999 and 2002, 10% of those that failed the 300 faecal coliforms/100ml standard were located in Region 3. This indicates little or no improvement relative to earlier years.

OIL AND OIL SPILLS

All the sea area around the British Isles is included in the European Waters Special Area established by IMO in 1999. This means that there should be no discharge from a vessel of oil or oily water within the Region. No accidental spills have been reported in the Region in recent years but there have been several reports of oil slicks believed to be of vessel origin. Most of these were in the eastern Channel around the Isle of Wight or in Weymouth Bay where the number of ships passing through the area makes it very difficult to establish the origin of the illegal discharge. OSPAR has defined an EcoQO which states that no more than 10% of the common guillemots found dead or dying on beaches should be oiled. However, no formal surveys have been conducted in the Region to establish whether this EcoQO is being met. Small amounts of oil are extracted on land around Poole Harbour and at Kimmeridge to the east of Weymouth and a number of natural seeps of oil occur around the base of the cliffs in this general area.

NAVIGATION DREDGING AND AGGREGATE EXTRACTION

With several small ports and harbours in the Region as well as the major ports in the Portsmouth and Southampton areas, dredging to maintain or improve water depths is an on-going activity. In 2001, just over three million tonnes of dredged material were removed from harbours and approach channels and deposited at eleven licensed disposal sites (Swanage Bay, Needles, Hurst Fort, Nab Tower, Brighton/Rottingdean,

Shoreham, Newhaven, Eastbourne and Dover as well as two sites inside Chichester and Portsmouth Harbours for small amounts). The vast majority of this material arose from routine maintenance dredging operations. There were plans for a major expansion of container handling facilities in the Southampton area but following objections at a Public Inquiry over the disruption to bird life and marine species the Government decided against the plan. Disposal of dredged material is subject to an assessment procedure designed to minimise the impact of the disposal operation and the deposited material. A first requirement is assessment of alternative means of disposal and although the total quantities used in this way e.g. for recovering eroding salt marsh areas or beach replenishment have increased, the proportion of total arisings is still only about 1%. However, as a result of these procedures the quantities of contaminants disposed of in dredged material have been reduced. Intermittent monitoring of the disposal areas is yielding a body of data which can be used to improve understanding of effects and minimise future impacts.

Much of the seabed offshore in Region 3 is composed of coarse sands and gravel. It is part of national policy to exploit these deposits as a contribution towards the needs of the building industry for construction aggregates. It is also recognised that these offshore deposits are in many cases the only practicable source of material for beach recharge operations. Extraction of sand or gravel from offshore deposits is nevertheless only permitted after careful consultation with interested parties such as the fishing industry, nature conservation bodies and coastal defence interests. The majority of the current sand and gravel extraction takes place in Region 2 (southern North Sea) and Figure 2.7 (see Chapter 2) shows the location of the sites where extraction is currently licensed. Between 1993 and 2003 just over 25% of the UK total or 57.2 million tonnes of sand and gravel were removed from the seabed of Region 3. Following discovery of further deposits in Region 3 it is anticipated that this proportion might rise between 2001 and 2016 to 52% or 120 million tonnes. Not all the marine aggregate extracted from UK waters is used to meet domestic construction requirements and in 2003 about 6.1 million tonnes, or about 30% of the total extracted, was exported.

As part of the policy for marine aggregate extraction the Government's objective is that there should be no significant harm to the environment or fisheries and no unacceptable effects on other users of the sea. In order to achieve this, the industry is to be required *inter alia* to adopt practices that minimise the effects and to monitor effects during and after dredging. Only as information from such studies is collected together and analysed will it be possible to assess whether the declared objectives have been met or to set appropriate restrictions to ensure they are in the future.

CONSTRUCTION

Apart from the impact of urban development on the coastline of Region 3 major industrial and port developments have taken place over the years particularly around Southampton and Portsmouth. Although now largely disused, Portland Harbour to the east of Portland Bill was a major development involving the construction of a large breakwater to protect the area. Portsmouth continues to be a major naval base and important ferry terminal. Groynes and other forms of sea defences also modify much of the coastal region. To date however there have been no major new proposals for development apart from the proposed container terminal at Dibden Bay on Southampton Water, and this will not now proceed. The move towards renewable energy sources for electricity generation has not so far led to any proposals within the Region.

MARICULTURE

Apart from the cultivation of some bivalve shellfish species mariculture is not at present an activity undertaken on any scale within Region 3.

CONTAMINANT SPECIFIC BIOLOGICAL EFFECTS

In general marine organisms cope with different levels of exposure to metals by converting toxic forms into less toxic bound forms which can be stored and subsequently excreted. One such mechanism is the induction of metallothionein (MT). This is a natural response particularly to mercury, copper, cadmium and zinc and can provide an indication of exposure, though not the health of the organism concerned. Surveys of MT in dabs from offshore sites showed high variability, no correlation between males and females from the same sites and little apparent link with existing data on metal concentrations in

livers. The MT content of mussels from a small number of estuarine sites were compared with those found in mussels from Brancaster on the North Norfolk coast (Region 2). There was no correlation with MT levels in flounder livers from the same sites. However, MT levels in mussels from a site near Southampton were elevated compared to the Brancaster control and almost twice as high as those from the Tees estuary (Region 1).

The normal endocrine function in fish can be disrupted by exposure to certain organic chemicals and this can result in feminisation of male fish. In extreme cases this can result in the presence of eggs at various stages of development in the male gonad. No such occurrences have been encountered in fish from Region 3. Lower exposure levels can be assessed by vitellogenin (VTG) assay and this has been used to assess exposure of flounders from a number of estuarine sites since 1996 but no studies have yet been conducted in the English Channel.

Exposure to certain CBs has been found to alter the rate of synthesis of a group of enzymes in fish liver. The extent of exposure can thus be assessed by measuring enzyme activity and reliable methods have been developed for one such enzyme known as EROD. Studies have been undertaken using this technique with flounder and dab but only at 2 sites in Region 3, Southampton Water and Rye Bay. Rye Bay was selected as a control site and low levels of exposure were detected in both flounder and dab. In male flounder from Southampton Water the level was around 17 pM/min/mg protein, compared to 134 in dab from the Rye Bay control site. This indicates slightly higher levels of exposure in Southampton Water because dab are less sensitive by a factor of about 10. Another method for assessing PAH exposure is to measure PAH metabolites in the bile of fish and using this technique exposure of flounder in Southampton Water was almost a quarter of that found at the most exposed sites, which were in the Thames and Tyne estuaries in Regions 2 and 1 respectively. A more general approach to assessing the well-being of fish is pathological examination of fish livers. The presence of liver nodules has been assessed in dab from Rye Bay for a number of years and appears to be on the decline.

NON-SPECIFIC BIOLOGICAL EFFECTS

Measurement of a range of fish disease conditions is now an accepted integrative tool for measuring the overall health of fish populations. Surveys are carried out using dab and flounder according to carefully defined and internationally agreed protocols. As with the more contaminant specific tests, Rye Bay serves as a control site and for all the diseases studied, fish from this site exhibit low prevalence.

The oyster embryo bioassay has been used over a number of years as a means of assessing general water quality. Embryos of the oyster *Crassostrea gigas* are exposed to water samples for 24 hours and their success in developing to 'D' hinge larvae provides a measure of the water quality.The studies have shown that poor water quality is only encountered in estuarine areas. Between 1999 and 2001 water samples from sites in Poole Harbour and Southampton Water were tested on several occasions. None of the samples produced a response greater than 10% and most samples produced responses significantly less than that, although Southampton Water was only surveyed in 2000. It is worth noting that these results contrast with responses obtained some ten years earlier when observed responses were typically between 50 and 100%.

Sediment bioassay techniques have recently been developed to allow an assessment of sediment quality in estuaries. Routine deployment is still at an early stage and the tests have only been in use for a short time and at a few sites. One of these is Southampton Water where sediments were sampled at 21 sites one of which caused 100% mortality in *Corophium volutator* (a small crustacean).

LITTER

The sector report on Environmental Quality gives only a very limited amount of information on the regional prevalence of litter based on a single survey by the Marine Conservation Society (MCS) in 2003. Equally there is no information on the regional effects of litter in the sector report on Habitats and Species litter. Consequently it is not appropriate to go into detail in this chapter. However, a brief summary of the overall incidence, scale and significance of the litter

issue is provided in the final chapter of this Integrated Assessment. Region 3 was found to have the second highest density of beach litter in the 2003 MCS Beachwatch survey. The most significant source of litter was considered to be beach visitors, with almost 33% of all litter found attributed to this source. Region 3 also had the second highest percentage of sewage related debris (6%) found in any of the seven regions surveyed.

HABITATS AND SPECIES

FISH ASSEMBLAGES

In Region 3 the waters are mainly less than 50m deep and in many respects the Region is similar to the southern North Sea (Region 2) and many species of fish e.g. plaice (*Pleuronectes platessa*), migrate between the two regions. In the Dover Straits and south of the Isle of Wight, the seabed tends to be rockier than other parts of the eastern English Channel and has greater tidal streams. These sites, which are dominated by sessile filter feeding invertebrates, have a high abundance of small gadoids including poor cod (*Trisopterus minutus*) and bib (*T. luscus*). In the mid-Channel along the southern edge of the Region water depths are somewhat greater (ca 70 m) with a coarser gravel or shell seabed and here the fish assemblage is dominated by thickback sole (*Michrochirus variegatus*) and red gurnard (*Aspitrigla cuculus*). Inshore the dominant species are plaice, dab (*Limanda limanda*), sole (*Solea solea*) and solenette (*Buglossidium luteum*) and species such as the lesser weever (*Echiichthys vipera*) and common dragonet (*Callionymus lyra*). Sea horses (*Hippocampus* spp.) a species of conservation interest, are occasionally found in the Region but are more frequently recorded along the northern coast of France to the south of the Region.

COMMERCIAL STOCKS AND LANDINGS

For the purposes of assessing the status of commercially exploited stocks the eastern English Channel is grouped with the North Sea for cod, whiting and herring but stocks of plaice and sole are assessed separately. The majority of the local fishing activity in Region 3 is however by small, often beach launched, fishing boats working the inshore waters. Landings from these waters have declined along with those in the more offshore waters. There is an active fishery for both edible crabs and lobsters on the coarser gravel grounds and inshore along the more rocky stretches of coast in the west of the Region. These shellfish are believed to be exploited within sustainable limits.

The status of the main commercially exploited fish stocks in Region 3 is assessed annually by the International Council for the Exploration of the Sea (ICES) and since 1999 the advice has been expressed in terms of the precautionary approach. Prior to that date concerns had nevertheless repeatedly been expressed over the scale of fishing effort and the level of fishing mortality of species such as cod. In 2004 the ICES advice on cod in Region 3 was that, in common with the situation in the North Sea (Regions 1 & 2), the stock was suffering reduced reproductive capacity and that provision should be made for a recovery plan with zero catch, until there was strong evidence of recovery. The status of the whiting stock in the Region was regarded as uncertain and the advice was that fishing mortality should be kept below a precautionary fishing mortality reference point. The sole stock is regarded as being harvested sustainably. The stock of plaice was considered to be at increased risk of suffering reduced reproductive capacity and a precautionary limit was advised.

(In 2004 ICES defined "at risk of being harvested unsustainably" as referring to stocks where the fishing mortality is above the precautionary reference point (F_{pa}). This is equivalent to the previous terminology "harvested outside safe biological limits". The term "full reproductive capacity " describes a stock where the spawning biomass is above the precautionary refernce point (B_{pa}). This is equivalent to the previous terminology "inside safe biological limits". A more detailed explanation of the new terminology can be found in the sector report on Fish and Fisheries.)

IMPACT OF FISHING

The environmental impacts of fishing include those on abundance, size and genetic diversity of target species and effects on non-target species. Non-target species are almost inevitably caught alongside target species and suffer the same effects but because trawled gear also disturbs the seabed, benthic species abundance and diversity may also be reduced. Fishing effort is not however evenly distributed (see Figure 3.6) although it is higher to the east of the Isle of Wight than to the south. In the areas to the east of Beachy

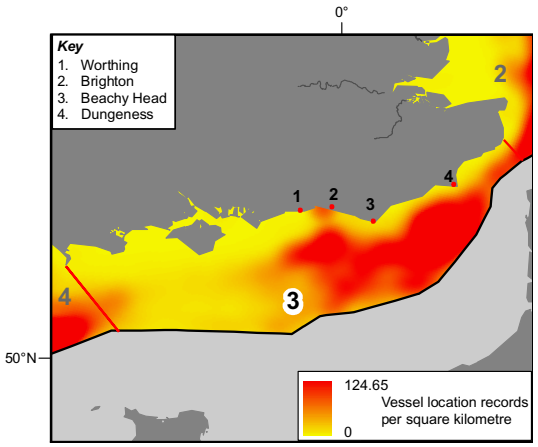


Figure 3.6. UK beam and scallop trawler density in 2002. Vessel positions filtered by speed (between five and eight knots) to remove steaming

Head and Dungeness and south of Worthing and Brighton the seabed is fairly coarse gravel and the larger bottom dwelling invertebrates are likely to suffer reduced production and diversity as a result of fishing disturbance. In areas of stable sediment, benthic diversity is high and will be reduced as a result of fishing activities compared to unfished grounds. It has been suggested that the densities of sensitive (e.g. fragile) species and opportunistic species (e.g. those that can exploit the ecosystem gap) should be used as EcoQOs. ICES is currently examining how this might be applied in practice.

Neither the sector report on Fisheries nor that on Habitats and Species draw particular attention to the adverse effects of fishing on seabirds in Region 3, although this is an issue of concern in other regions where seabird numbers are larger. Reduction in the size of fish through selective removal of larger, older mature individuals is another issue of concern, particularly of the slower growing less fecund species such as sharks and rays. The common skate and angel shark are believed no longer to occur in the Region, thus representing a reduction in fish diversity.

PLANKTON

There have been few systematic studies of the free floating microscopic plant life (phytoplankton) or animal life (zooplankton) which feed on them and together form the base of the marine food web. The one exception to this is the surveys undertaken using the continuous plankton recorder (CPR). One of the routes operated by the CPR runs out into the North Atlantic from the Isle of Wight i.e. runs through Region 3. The CPR collects both phytoplankton and zooplankton on a silk filter system that progressively winds on as the CPR is towed behind a ship. Although identification of all individual phytoplankton species is not possible, the greenness or Phytoplankton Colour Index gives a measure of phytoplankton biomass/chlorophyll that matches well with satellite measurements of chlorophyll. A range of zooplankton species is identified and these data yield biomass, abundance and diversity data and allow determination of baseline conditions for planktonic species.

Around 1987 the colour index showed a major change. Up to that time it had shown an increasing trend and a merging of spring and autumn bloom periods. Thereafter there was a step change in chlorophyll levels throughout the year, especially during spring and summer. Serious concerns were expressed that this might be due to eutrophication i.e. excessive growth linked to over abundance of nutrients, particularly nitrogen and phosphorus. However, it was apparent that the same phenomenon was affecting the whole North-east Atlantic out to about 20°W, making input of nutrients from land an unlikely explanation. It was also noticeable that the spring bloom was occurring earlier, suggesting a climate related change. This is an important conclusion because, at least so far as the plankton are concerned it means the seas around the UK are relatively unaffected by nutrients or hazardous chemicals that might affect phytoplankton. Since then it has also become apparent that over the last 40 years or so there has been a northward movement of around 10° latitude in the presence of warmer water plankton species (and fish species), as well as a complementary reduction in the diversity of colder water species.

Detailed analysis of the zooplankton species shows there have been a number of major shifts. For example there has been a steady reduction in the overall number of copepod species. Figure 3.7 (overleaf) shows the scale of this reduction averaged over an area of the English Channel that corresponds to Region 3 since 1945. Part of this is due to a marked reduction in the abundance of the colder water species *Calanus finmarchicus*, *Para-pseudocalanus* spp, *Oithona* spp. and *Pseudocalanus* adults. This change

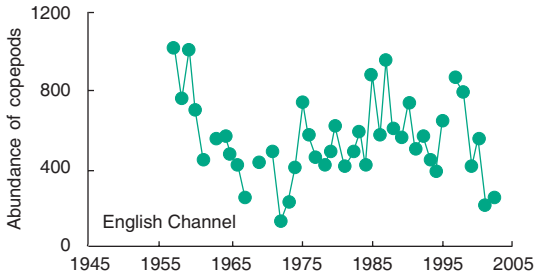


Figure 3.7. Plots of annual mean Total traverse copepods averaged for the English Channel

has implications for species such as salmon and especially cod in UK waters. Cod is under threat due to fishing pressure and is reliant on the presence of zooplankton species such as *C. finmarchicus* at critical stages in its breeding cycle. The observed changes are unlikely to assist its recovery.

BENTHOS

During recent years the JNCC has sought to establish exactly what is known about benthos in UK waters through collation of information on benthos surveys that have been conducted and by collation of data from those surveys. During the past 30 years the conservation agencies have commissioned many surveys to support the selection and designation of marine protected areas (Special Areas of Conservation (SACs)). There have been two large UK-wide systematic surveys: the Inter-tidal Survey of Great Britain and Ireland and the Marine Nature Conservation Review. Whilst it is now clear that baseline data are available for much of the UK's coastal seas there are significant gaps. For example in Region 3 there are comparatively few records for the coastal waters to the east of the Region although there is reasonable coverage for the western part of the Region. Not all the survey data are readily available and many of the available records do not cover all the benthic species phyla. This compounds the difficulty of establishing a baseline. Many of the records relate to one-off surveys and many individuals have been involved, thus further compounding the problem. Finally, as yet there are no agreed objectives, targets or measures to permit assessment of the status of benthic communities.

The NMMP does include collection and assessment of benthos from selected coastal and estuarine stations around the UK. All the stations are intended to be in areas where the seabed is soft to allow comparisons from station to station. In practice they do differ somewhat as does the degree of disturbance of the sediments by storms or tidal currents or by fishing gear. Within Region 3, where the offshore seabed is mainly coarse, there are no coastal sites in the NMMP but two estuarine sites are sampled in Poole Harbour. An assessment has recently been made of the abundance and diversity of benthic species at all NMMP sites (*MEMG, 2004*) and scores were allocated according to an experimental version of a Biotic Index (AMBI). Under this scheme, as it currently stands, a score of zero is regarded as indicating a totally normal healthy regime whereas a maximum score of seven indicates one which is heavily stressed or polluted. The two sites in Poole Harbour were allocated scores of 3.74 and 5.22. However, in terms of numbers of individual animals found, these two sites registered very high numbers (>10,000/0.1 m^2). This does in fact fit with what might be expected, given that the area is enclosed and known to be subject to contamination from a number of land based sources and is regarded as a potential eutrophication problem area due to the scale of nutrient inputs. The NMMP records do not yet cover a long enough time period to permit assessment of changes over time.

SEABIRDS

Seabird numbers and breeding success are assessed annually throughout the British Isles by the Seabird Monitoring Programme (SMP), which began in 1986 and is co-ordinated by the JNCC's Seabird Colony team. Since 1989 the results of the SMP have been published in an annual report. This is entitled "Seabird numbers and breeding success in Britain and Ireland" and is produced by JNCC in collaboration with RSPB and the Shetland Oil Terminal Environment Advisory Group (SOTEAG). While the SMP conducts annual monitoring of a sample of the seabird population in the UK, complete censuses of all seabirds in the UK have been conducted to obtain total population estimates, which provide a baseline against which subsequent monitoring can be compared. The most recent UK population estimates were obtained in 1998-2002 during

Seabird 2000 a JNCC-led census of breeding seabirds in the UK and Republic of Ireland.

Twenty-five species of seabird are known to breed in the UK and total numbers have increased from around 4.4 million in 1969-70 to 6.7 million in 1998-2002. Not all species have experienced the same success and there are considerable variations between species year to year and between breeding sites. For example, since 1969/70, when no Mediterranean gulls were recorded, numbers have increased from one breeding pair in 1985/86 to 110 in 1998-2002. Most of these birds breed in southern England and the change probably reflects the general northward migration noted with plankton and fish species. Not all the effects of climate change are necessarily favourable and rising sea levels in the Region may reduce the availability of ground nesting sites and increased storminess can cause large scale "wrecks" of seabirds, with a single severe storm being known to wash whole colonies from cliffs.

The EC Birds Directive requires Special Protection Areas (SPAs) to be designated according to their qualifying interest in one or more seabird species and/or their seabird assemblages (i.e. more than 20,000 adults). Five SPAs have been designated within Region 3. Fishing can affect seabird populations both adversely e.g. diving species may be caught in nets or on long-lines and through over-fishing of prey species at critical periods. They may also be affected in a positive way through provision of an extra food resource in discarded by-catch and offal. No particular plus or minus effects are recorded in the sector report on Habitats and Species relative specifically to Region 3.

SEALS

Two species of seal are found in UK waters, the grey seal (*Halichoerus grypus*) and the common or harbour seal (*Phoca vitulina*). Neither species is resident in Region 3.

CETACEANS

A co-ordinated approach to the recording of cetacean sitings in UK waters has only recently been established. An atlas of cetacean distribution was produced in 2003 amalgamating three separate databases into a single Joint Cetacean Database (JCD). This gives distribution and abundance data on all 28 species of cetacean recorded in UK waters in the latter half of the last century. The JCD combines two long-term data sets, one comprising effort related sightings collected since 1973 and the other linked to a seabird survey that records cetacean sightings on an effort related basis. These data sets are linked to a single snapshot survey undertaken in June/July 1994. A number of smaller scale data sets have still to be linked into the JCD. Of the 28 species recorded in UK waters only about ten are commonly recorded in UK waters and the available data only allow populations to be estimated for a few of these and then only on a very approximate basis. No population figures or even data on occurrence are given in the sector report on Habitats and Species that are directly applicable to Region 3, although it is noted that about 85 common bottlenose dolphins are present regularly in the Channel including off North-west France.

HABITATS

The sector report on Habitats and Species describes the various measures that are available, have been and are being taken to protect habitats around UK coasts. It also reviews a range of key habitat types and indicates areas where important examples of each can be found and the threats they currently face or may face in the future. Sites of Special Scientific Interest (SSSIs) have been established for a wide variety of reasons and the conservation agencies are currently in the process of assessing their status and will report in 2005. English Nature have produced a first report and their conclusions to date show a relatively good picture with 74% of the sandy and muddy shores SSSI habitats, which account for 23% of all SSSI land in England, in a favourable or recovering condition and 87% of the 3,000 hectares of rocky shore (including cliffs) SSSI habitat considered to be in a favourable condition. There are no specific details in the report as to how these areas in Region 3 are graded, although a figure is included which suggests that the SSSIs in the Region, most of which are on the mainland north of the Isle of Wight, are meeting their objectives.

There are at present only three Marine Nature Reserves in the UK none of which is in Region 3, but under the initial round of designations of Special Areas of Conservation (SAC), as required by the EC Habitats Directive, two areas have been designated as SACs in Region 3, the South Wight and the Solent Maritime SACs. The quality

status of these two areas will be assessed by the end of 2006.

The 1992 Convention on Biological Diversity came into force at the end of 1993 and in the UK a Biodiversity Strategy Group has identified 14 habitat types for which Biodiversity Action Plans are required. For the majority (61%) of these habitats and 35% of the species, the conservation trend is currently unknown but the locations of the more important examples have been established. Within Region 3 there are several such habitats. For example mudflats are well represented in Southampton Water and the Solent and in Chichester, Langstone, Poole and Portsmouth Harbours. Southampton Water contains two significant areas of sheltered muddy gravel habitat and there are several areas of littoral and sub-littoral chalk, which on the Isle of Wight and Dorset coast is vertically bedded in contrast to the more normal horizontal bedding. Seagrass beds are found in the Solent between the Isle of Wight and the mainland. Sub-littoral sands and gravels are also common in Region 3, particularly on the mainland coast to the east of the Isle of Wight. The threats posed to the various habitats by climate change and activities such as coastal development, fishing and aggregate extraction are understood in a theoretical sense but assessment of the scale of any such effects has yet to be undertaken in a quantified sense.

KEY POINTS AND CONCLUSIONS

In common with much of the rest of England the land bordering Region 3 has seen an increase in temperature during the last 100 years. This has been accompanied by an increase in storminess in the period October to March and a tendency to drier summers, particularly in recent years. Sea surface temperatures in the Region have risen by about 0.6 and 0.7°C in the last 100 years but the available data on salinity indicate no long-term change. Despite the increase in storminess there does not appear to have been any increase in wave heights in the Region but waves are an important mechanism underlying erosion of soft cliff regions in Dorset and elsewhere and in transporting sand and shingle along the coast. Sea level relative to the coast has been rising globally by between 1 and 2 mm/yr throughout the last century and in Region 3 this rise is compounded by the fact that the land mass is sinking by between 0.5 and 1.1 mm/yr. This enhances the risk of coastal flooding and erosion of beach areas and at various points along the coastline beach loss is a major problem.

Environmental quality in the Region, as judged by concentrations of the more commonly recognised contaminants, is generally good. In inshore areas where salinity is less than 34 winter concentrations of DIN and DIP exceed those regarded as background but chlorophyll levels are less than the 10 μg/l level considered to indicate excessive growth of phytoplankton and possible eutrophication. Although changes in phytoplankton and zooplankton have been observed these are not thought to be due to inputs of nutrients. In a number of enclosed areas such as Chichester, Langstone and Portsmouth Harbours excessive growth of *Enteromorpha* (a seaweed) is thought to be due to nutrient inputs from sewage and/or agricultural run-off and remedial measures are required under the terms of EU legislation. Monitoring data on concentrations of metals in sea water, sediments and biota all indicate little cause for concern, with most recorded concentrations below values set as EQSs, BRCs and EACs. The only significant exception to this is copper concentrations in sediments from Southampton Water which are considered to be slightly elevated relative to the concentrations regarded as background.

Monitoring data relating to a number of well studied organic contaminants such as HCH, CBs and PAHs indicate concentrations of these contaminants are within the ranges considered normal and below those regarded as likely to cause biological effects. This is borne out by the results of a variety of biological effects studies although sediments from Southampton Water were found to cause 100% mortality of the small crustacean used as the test species. The reasons for this are unknown as of the contaminants studied only the concentrations of copper were regarded as at all unusual.

Oil production occurs on a small scale around Poole Harbour and at Kimmeridge on the Dorset coast and there are a number of natural oil seeps around the base of the cliffs in this area. As in other regions there continue to be reports of oil slicks which are believed to be of vessel origin. These are mostly around the Isle of Wight and in Weymouth Bay but their significance in terms of their causing serious ecological damage or beach pollution seems to be minimal. Litter, particularly on beaches, does give rise to aesthetic concern

but its impact on biota has not been quantified. Radioactivity is not an issue of concern in relation to Region 3.

Microbiological quality of areas designated as bathing waters has improved substantially in recent years and in 2003 no waters in the Region failed the current mandatory standards set by the EU. Improvements in the microbiological quality of shellfish harvesting areas have also been achieved. However, with many of the main harvesting areas in enclosed waters subject to sewage inputs few achieve class A status which would allow harvesting directly for consumption. There has however, been no improvement in the microbiological quality of areas designated as shellfish growing waters under another EC Directive aimed at improving the quality of such waters.

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. Following rejection of the ABP expansion plans at Dibden Bay no major port developments are planned in the Region. However, 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.

Dredging of a different nature takes place further offshore in order to exploit seabed deposits of sand and gravel for use by the construction industry. Additional reserves have been identified in recent years within the Region and it is anticipated that the level of exploitation might rise to about 120 million tonnes between 2002 and 2016. The total area involved is however small relative to the area of the whole of the Region and all extraction will be subject to controls intended to minimise impact on other user interests.

In terms of variety of habitats Region 3 has a good range of representative types. There is a substantial number of SSSIs and several SACs. In addition a number of sites have been identified as important in the context of the Convention on Biological Diversity as providing good examples of habitat types such as mudflats, littoral and sub-littoral chalk, sub-littoral sands and gravels and seagrass beds. There is no suggestion that chemical contamination has affected fish stocks in the Region. The fish assemblages broadly reflect the nature of the benthos, which on the whole has a high diversity of filter feeding invertebrates. However, the commercially exploited species of fish are considered to be heavily exploited with the cod stock suffering reduced reproductive capacity and ICES is advising zero catch and a recovery plan. Similarly the advice concerning whiting and plaice catches involved setting of precautionary limits. Crab and lobster catches were considered to be sustainable at current rates. Some fish species are much less common in the Region than was the case historically and the common skate and angel shark are no longer believed to occur in the Region.

Marine mammals appear to be poorly represented in Region 3. Neither of the species of seal found elsewhere in UK waters is resident in the eastern English Channel. The sector report on Habitats and Species gives no details of cetacean sightings or numbers in the Region except that up to about 85 common bottlenose dolphins are present in the Channel including north-west France. Five SPAs have been designated in the Region under the terms of the EC Birds Directive due to their importance for one or more species or the fact that more than 20,000 seabirds breed there. There appears to be no particular cause for concern over man's adverse impact on seabirds through fishing or general disturbance, in the Region although rising sea level may affect the availability of ground nesting sites. Mediterranean gulls have started to breed in the area with a total of over 80 breeding pairs being recorded along the adjacent coastline in 1998-2002 (none in 1969/70).

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

INTRODUCTION

Region 4 comprises the western English Channel, Celtic Seas and South-west Approaches. Figure 4.1 shows the location of the Region in relation to its immediate neighbours, Region 3 (eastern English Channel) and Region 5 (Irish Sea) and the location of the main places mentioned in this chapter. The landward boundary extends from Portland Bill round the south-west peninsula of England and includes the Bristol Channel and Severn Estuary and the entire south coast of Wales to the southern side of the entrance to Milford Haven. The southerly seaward boundary

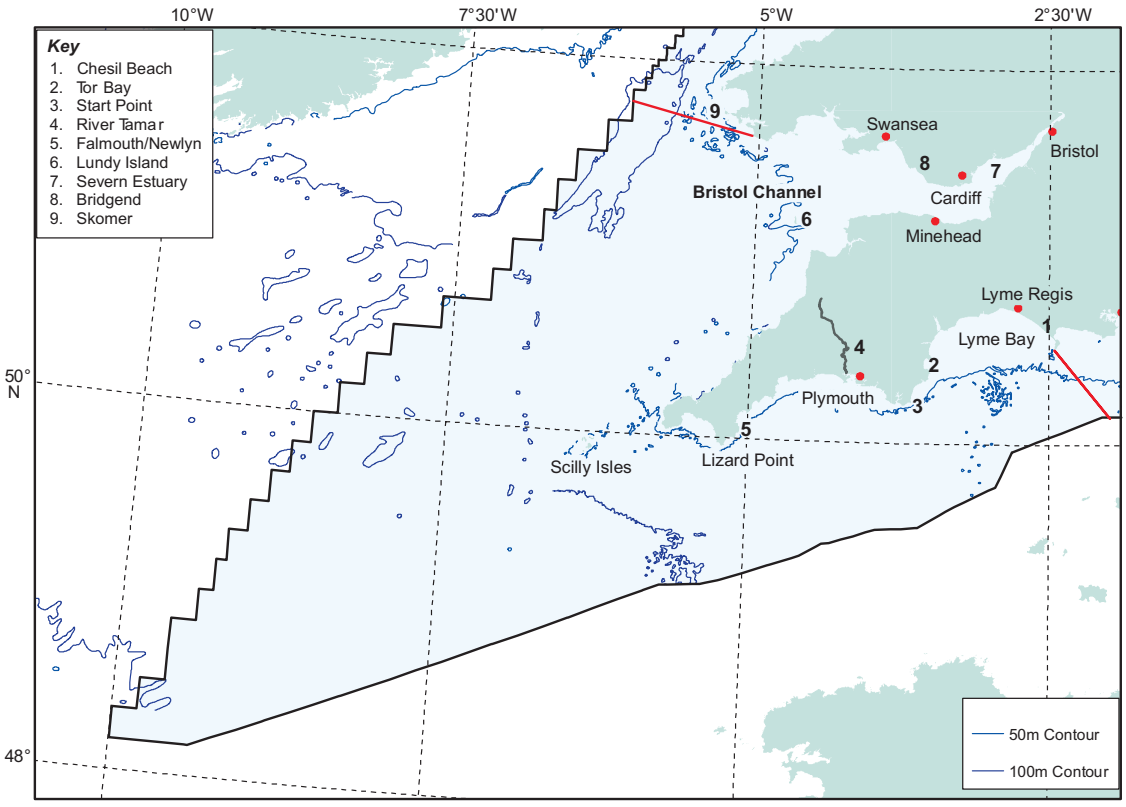


Figure 4.1. Map of Region 4. Bathymetric contour copyright UKHO

is the median line between France and England and the westerly seaward boundary is the median line between Ireland and England. Water depths in the Bristol Channel and Lyme Bay are generally less that 50 m. The northern boundary roughly coincides with the Celtic Sea Front marking the boundary between oceanic water and the coastally influenced waters of the Irish Sea. In most of the rest of the area in the English Channel and outside the Bristol Channel the water depth is between 50 and 100 m, with that in the St George's Channel and the outer part of the Region shelving to about 1000 m. The seabed is mainly composed of sand and gravel with rocky outcrops. There is significant urban development around Torbay and Plymouth on the south coast and at Bristol, Cardiff and Swansea along the Bristol Channel. The main industrial development is at Bristol and along the south Wales coast. Elsewhere tourism, fishing and agriculture are the main sources of employment in the Region. The biggest single river is the Severn, which enters the top end of the Bristol Channel, but land run-off from within the Region enters via a number of rivers along the south-west peninsula and south Wales coast. The whole region is exposed to the prevailing westerly winds and waves coming in from the Atlantic but some shelter is afforded by the Lizard and Start Point on the south coast of England and in the upper reaches of the Bristol Channel. The Bristol Channel experiences some of the highest tides and tidal currents in the UK and these, together with the funnel shape of the Channel and Severn estuary, result in the Severn estuary bore as the tide starts to flood up the estuary.

PHYSICAL ENVIRONMENT

WEATHER AND CLIMATE

Ocean circulation, and to a large extent continental shelf and coastal circulation, are driven by 3 main weather parameters, wind speed and direction, air/sea heat exchange and evaporation/precipitation. The influence of all three features is controlled or modified by the North Atlantic Oscillation (NAO) as this causes changes in strength and direction of the westerly wind flow over the North Atlantic – for a brief description of the NAO see Chapter 1. Circulation in Region 4, especially in the Bristol Channel, is also heavily influenced by the tides. If the prevailing westerly winds are stronger they tend to bring warmer moister air and thus heavier rainfall. The two year period ending March 2001 was the wettest in England and Wales since records began in 1766. The warmest years since records began in 1659 occurred in the 1990s, with the whole decade being the warmest on record with five of the warmest years occurring in that period.

The NAO has experienced its most extreme change since the 1860s from about 1960 to the present day with the winter (December to March) index showing an upward trend until at least the start of the current century. There have been similar changes in the past but the rise in values from the 1960s to the 1990s appears to be unusually large. There have been more winter (October to March) storms in the last 50 years, although the magnitude of the storms is similar to that at the start of the 20th Century. These changes are consistent with changes in the NAO leading to a southerly movement of the Atlantic storm track.

SEA TEMPERATURE

Between 1910 and about 1940 global sea surface temperature (SST) rose and then remained steady until about 1970 when it began to rise again. At the continental shelf edge around the western boundary of the Region, SST warmed between 0.12 and 0.29°C during the 20th century and around the UK coastline on average by around 0.5°C. The rise at the Plymouth Marine Laboratory (PML) station L4 off Plymouth was even larger but the records only extend back to the mid 1970s and, as the data in Table 4.1 show, the changes, except at Swansea, are much more in line with, or even less than, that observed at the shelf edge.

Table 4.1. Trends in sea surface temperature

	Nominal position	Data Span	Trend (°C/decade)
E1	50.0°N 04.5°W	1921-1987	- 0.13
Sevenstones LV	50.0°N 06.0°W	1881-1986	+ 0.04
St Gowan LV	51.5°N 05.0°W	1953-1987	- 0.17
Swansea	51.5°N 04.0°W	1976-1997	+ 0.58

SALINITY

Observations of salinity in the eastern North Atlantic (55-60°N and 15-25°W have been collected and averaged by the ICES Hydrographer for the period 1950 to 2002. There is little evidence of any overall change in the winter sea surface salinity anomaly and an indication of a slight decrease in the summer sea surface salinity during that period. There was a marked reduction in the mid-1970s due to the Great Salinity Anomaly – see Chapter 7 for a brief explanation, but during 2002, salinity was higher than the long-term average in most areas of the North Atlantic and reached the highest levels observed in over a decade. Within Region 4 salinity has been measured routinely at a station off Plymouth from the early 1900s to the early 1980s (Figure 4.2) and although the mean salinity over that period shows marked variations year to year there is little evidence of any overall trend in sea surface salinity.

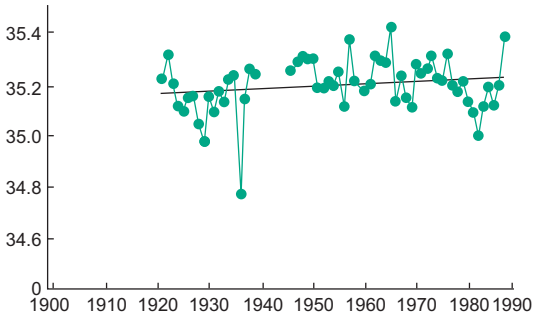


Figure 4.2. Mean sea surface salinity at MBA station E1, English Channel Courtesy of the MBA

WAVES

Waves are strongly related to wind conditions, particularly their strength and persistence and the height of offshore waves also depends on the distance and length of time over which the wind has acted upon the sea surface. In Region 4 waves approaching the coastline could have been generated not only locally but even in the distant South Atlantic. Coastal waves are influenced by local water depth and by the nature of the seabed. The measurement of waves is a relatively new development with only crude instruments available until about 1955. Since the late 1970s most recording in the field has been undertaken by wave following buoys using accelerometers and these instruments give valuable ground truth data for the more comprehensive data collected by altimeters mounted on satellites. Of the various time series of data available several apply directly to Region 4. Between 1962 and 1985 wave height increased from an average of about 2 m to an average of about 3 m at the Sevenstones LV off Land's End and an upward trend in the annual mean value of significant wave height (Hs) of about 1.5% per year occurred between the two periods 1950-54 and 1980-84 at ocean weather stations Charlie, Juliet and at the Sevenstones LV. Off the English and Welsh coasts the highest Hs (2.0-3.0 m) are experienced along the south-west Wales and western Cornwall coasts. Highest waves are experienced in the winter months between late December and January. A study of the influence of the NAO on wave heights suggests that they are indeed sensitive to the NAO (e.g. in Lyme Bay 13% of the variance of 0.69m change in the 100 year Hs per unit NAO change).

CIRCULATION

The circulation, or net movement of water, is driven by residual currents due to the tides, meteorological forcing due to winds and atmospheric pressure and mean density distribution. Within Region 4 circulation is complex. In the western English Channel it is from west to east driven by non-linear tides, the predominantly south-westerly winds and density currents due to freshwater run-off. Mean circulation in the Celtic Sea is generally weak, most of the Celtic Sea experiences strong thermal stratification in the summer. This results in a seasonal Celtic Sea front with strong anti-clockwise jet currents associated with bottom fronts around a cold saline pool. The northward flowing jet on the eastern side of St George's Channel transports water rapidly from the centre of the Bristol Channel into the Irish Sea (Region 5). Within the Bristol Channel there is an overall weak easterly residual flow along both the northern and southern coasts. Closed eddies are established around the many headlands in periods of high run-off and the outflow from the Bristol Channel is mainly at depth along its central axis. This results in an overall flushing time i.e. the average time for water to pass through the area, of between 150 and 300 days.

SEDIMENT CONCENTRATION AND TRANSPORT

Brief details of the nature of the seabed are given in the Habitats and Species section of this chapter. Sediment transport is important because it is the means by which much of the evolution of the foreshore and coastline is determined after initial action of wave energy. Region 4 features a particularly dramatic example of this at the eastern end of the Region on the south coast of England where Chesil Beach and the spit of land joining Portland Bill to the mainland have developed, with fine shingle giving way to coarse gravel from west to east. On the south Dorset coast the cliffs are mainly soft and eroding, but west of Lyme Regis the coastline is more rocky and suspended sediment loads are relatively low. On the northern coast, again the land is mainly rocky from Lands End to around Minehead and Bridgewater Bay in the Bristol Channel. However, fine sand or mud are frequently stirred up by the strong tidal currents and wave action in the upper reaches of the Channel and Severn estuary.

In the extreme western part of the English Channel sediment transport is westerly, in contrast to the mainly easterly transport in Region 3 (eastern English Channel). The Celtic Sea has a variable offshore transport of sediments. Nearshore sediment transport is predominantly northerly on the north-south orientated coasts. Off the northern coasts of Devon and Cornwall, coastal and offshore transport pathways run in opposite directions because tidal and wave forces are orientated in different directions. Sand moves westwards into the Celtic Sea in the outer and central Bristol Channel. In the Bristol Channel the main nearshore divergence of sediment are in Barnstaple Bay along a line from Lavernock Point to Sand Bay and in Carmarthen Bay. Onshore/offshore exchange occurs in the central area of the Bristol Channel and concentrations of suspended sediments tend to be high in this area.

CHANGES IN SEA LEVEL, COAST AND SEABED

Since the last ice age about 20,000 years ago global mean sea level has risen by about 120 m and has continued to rise by about 1-2 mm per year throughout the last century. Sea level records from Newlyn show short-term variations in amplitude and those of tidal constituents but no long-term trend. Similarly there is no evidence of a trend in sea level surges at Newlyn since the 1920s. Relative mean sea level, due to the combined effects of absolute Mean Sea Level (MSL) and land movement, is increasing around the UK coast. However, although there was an increase in the rate of rise towards the second half of the 19th Century, overall sea level rose less rapidly between 1921 and 1990. In Region 4 sea level rise e.g. due to thermal expansion and/or ice melt has to be combined with the effect of land subsidence due to post glacial land adjustment following the retreat of the last ice sheet. In south-west England and Wales this amounts to a total of approximately 1.4 mm/year.

POL has carried out Peak over Threshold (POT) analyses of sea levels at Newlyn between 1915 and 2001. The threshold was chosen to ensure that the lowest level expected to be exceeded on average five times/year in any 20 year period was greater than the threshold. They were then analysed to give the sea level thresholds exceeded by, on average, one to events/year – POT1 to POT 5 and, as Figure 4.3, shows there has been a clear upward trend in the 20 year running averages.

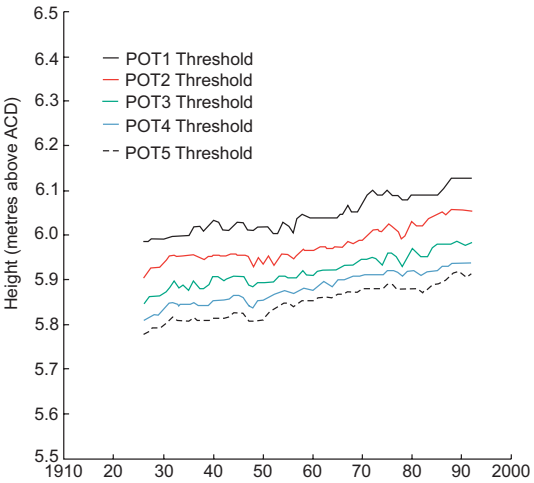


Figure 4.3. Peak over Threshold (POT) trends at Newlyn. Courtesy of David Blackman, POL

ENVIRONMENTAL QUALITY

NUTRIENTS

The marine food chain is based upon microscopic plants known collectively as phytoplankton which in turn are consumed by tiny animals – zooplankton. Phytoplankton growth is regulated by light and the availability of nutrient forms of nitrogen and phosphorus and, to a lesser extent carbon and silicate. Excessive growth of phytoplankton or fixed plants in response to increased availability of nutrients is known as eutrophication and a number of measures have been taken in recent years to avoid problems that can be associated with this phenomenon. Common assessment procedures have been proposed by OSPAR, which are intended to guide decisions on where restrictions on inputs are likely to be necessary. These set normal and elevated levels for dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) and chlorophyll. For the English Channel these are lower than those for the North Sea (Regions 1 and 2) and the Irish Sea (Region 5). These differences recognise the fact that the North Sea and Irish Sea have always been subject to natural run-off from land whereas Region 4 is mainly oceanic water. The levels set are 9 to >15 μmol/l for DIN and 0.4 to 0.8μmol/l for DIP and chlorophyll should be less than 50% higher than the offshore or historical background, regarded typically as 10 μg/l.

In Region 4 concentrations of DIN, DIP and chlorophyll are all normally below the common assessment criteria, even in the more enclosed Bristol Channel – see Figure 4.4.

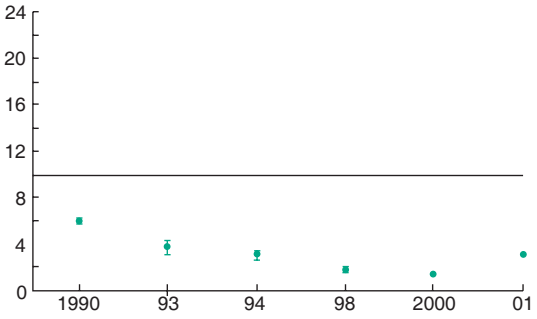


Figure 4.4. Coastal (Salinity =<34) Chorophyll concentrations for Bristol Channel

This reflects the fact that inputs of nutrients to the Region from land based sources are low and there is active mixing from waves and tidal movement. Thus for the Region as a whole nutrients do not present a cause for concern. Excessive growth of macroalgae, particularly *Enteromorpha*, is used to indicate eutrophication in inshore and intertidal areas and for this reason two small estuaries in Region 4, the Taw (N Devon) and Tawe (S Wales) have been identified as problem areas and the Loughor Estuary (S Wales) has been identified as a potential problem area.

HAZARDOUS SUBSTANCES – METALS

Within Region 4 all concentrations of metals in sea water are reported to be below the EQS values i.e. those defined as being unlikely to harm aquatic life. OSPAR established background reference concentrations (BRCs) and ecotoxicological assessment criteria (EACs) for metals in sea water, sediments and marine species. (It should be noted that the BRC and EAC values referred to in this review are those adopted by OSPAR in 1997. These levels have been reviewed and were recently revised but the new values were not available when the sector report on Environmental Quality was being prepared; they have not therefore been used in this review either.) In Region 4 concentrations of mercury, lead, copper and zinc in sea water were all below both BRC and EAC levels. The concentration of cadmium in sea water in the Severn estuary was however about 0.09 μg/l i.e. below the maximum of the EAC range of 0.01-01 μg/l, it was also about four times higher than the upper BRC (range 0.008-0.025μg/l). Concentrations of cadmium were much higher in this area in the past (up to 0.4 μg/l in 1995), due to past metal smelting activity and the lower concentrations therefore represent a marked improvement. EACs have also been established for metals in sediments and concentrations of lead were found to be above the EAC in both the Tamar and Severn estuaries. The BRCs for sediments are expressed as a ratio of the metal to aluminium concentrations in the fine fraction of sediments, as a means of establishing whether the concentrations are natural or have been influenced by anthropogenic activity. In the Tamar estuary the BRC was exceeded for both lead and copper, as it was in the Severn estuary for lead, and although the BRC for mercury was not exceeded in the Tamar estuary it was among the highest recorded. The Tamar estuary receives

run-off from a heavily mineralized catchment area which was extensively mined in the past and is still subject to some run-off from old mine workings. As previously mentioned the contamination of sediments in the Severn estuary is attributable to past smelting activity.

Concentrations of metals are also monitored in the muscle and liver tissue of fish and mussels. None of the concentrations of metals found in the muscle or liver of fish sampled in Region 4 were high compared to the levels found in other regions. There are no BRCs or EACs for metals in fish except for mercury in fish flesh and concentrations of mercury in fish from Region 4 have always been close to background. No EACs were established for metals in mussels but BRCs were agreed. One sample of mussels from the Severn estuary was found to contain the highest concentration of cadmium (1,500 μg/kg) recorded in the course of the monitoring studies but otherwise concentrations of metals in mussels from Region 4 were unremarkable, albeit in some cases, as would be expected given past industrial activity, above the BRCs.

HAZARDOUS SUBSTANCES – ORGANICS

A number of chlorinated organic substances combine persistence with a tendency to bioaccumulate and toxicity. Controls have been applied severely restricting the use of most of these compounds and as a consequence concentrations in the marine environment have declined. OSPAR set an EAC range for hexachlorocyclohexane (HCH), the use of which was not banned until 2002. HCH was used in its gamma-isomer form (lindane) as an insecticide and the EAC range for sea water is 0.5 -5 ng/l; in Region 4 the concentrations are typically between 1 and 2 ng/l, i.e. are unlikely to be harmful. Concentrations are expected to fall further following the ban on use of this compound.

Polychlorinated biphenyls (PCBs) are another group of chlorinated organics which were used in a wide range of industrial and domestic applications. Concentrations are normally expressed in terms of seven selected CB compounds (the commercially available products were mixtures) and OSPAR has set the EAC range as 1-10 μg/kg dry wt in sediments. Concentrations of CBs in sediments were found to be above the upper EAC range at two sites in south Wales, where manufacture of PCBs was undertaken in the past. Elsewhere in the Region concentrations of CBs, in common with most other regions, exceeded the lower end of the EAC range. Concentrations of CBs in samples of fish liver from Region 4 were generally low compared to values recorded elsewhere but in mussels from one site in the Severn estuary concentrations of four CBs were found to exceed 1 μg/kg. The BRC range for the sum of the seven CBs routinely monitored in mussels is 0.35 – 1.7 μg/kg and this was exceeded in samples from the Tamar as well as the site in the Severn estuary referred to above.

HAZARDOUS SUBSTANCES – POLYCYCLIC AROMATIC HYDROCARBONS (PAH)

PAHs are a matter for concern because a number of them are known or suspected carcinogens. They occur naturally in the environment e.g. as a consequence of forest fires but man's industrial activities and the burning of fossil fuels adds further quantities to the input inventory. EACs have been established by OSPAR for eight individual PAH compounds in sediments and these eight are included in the group of ten PAHs monitored under the NMMP. The sum of the upper EACs is roughly equivalent to 10,000 μg/kg for the ten PAH compounds and none of the concentrations of PAH measured in sediments in Region 4 exceeded this total. PAHs have also been measured in mussels at a limited number of sites around the UK. Total concentrations of the ten PAHs routinely measured exceeded 100μg/kg wet wt at sites in the Tamar and Severn estuaries but the concentrations did not exceed the EACs provisionally set by OSPAR and PAH concentrations need not therefore be a particular cause for concern in the Region.

ORGANIC CONTAMINANTS RECENTLY RECOGNISED AS PRESENT IN THE MARINE ENVIRONMENT

In addition to the routine surveys undertaken for substances commonly recognised as hazardous, investigations are also undertaken on potential new problems. These are usually undertaken on a pilot scale and recent studies have examined brominated flame retardants and alkyl phenols. Both studies included sites within Region 4.

Alkyl phenol ethoxylates are non-ionic surfactants, the most common of which are the octyl and nonyl forms, they are widely used in both commercial and domestic applications and once in the environment readily degrade into alkyl phenols. Within Region 4 most of the samples of sediment were found to contain concentrations of nonyl phenol and nonyl phenol mono- and di-ethoxylates of less than the limit of detection of the method used (1 mg/kg and 0.2 mg/kg respectively). Octyl phenol was found to be present in a few sediments from inshore stations along the south coast and off the south coast of Wales, but all the concentrations were low, generally less than 0.02 mg/kg.

Bromine based flame retardants are applied to a variety of polymer products. Some 70 different chemicals are involved with a total global use of around 300,000 tonnes. Like PCBs most products contain mixtures of compounds. The first studies in the UK focussed on polybrominated diphenyl ethers (PBDEs) but, with the exception of deca-brominated diphenyl ether, use of these compounds has been discontinued within the EU. Within Region 4 studies involving analysis of up to 15 individual BDE compounds were undertaken in 1999. These did not include samples of invertebrates and none of the dab or flounder liver samples were found to contain concentrations significantly above the detectable level. In view of the low concentrations found and the discontinuation of use of PBDEs within the EU future studies within the Region will focus on hexabromocyclodecane (HBCD) and tetrabromobisphenol-A (TBBP-A).

RADIOACTIVITY

Inputs of radioactive materials into the Region arise from natural sources such as rocks. Other inputs arise from nuclear power stations, naval activities, GE (Healthcare) (previously Nycomed Amersham) and from hospitals. All such discharges are subject to formal authorisation. None give rise to concerns in relation to possible effects on either public health or marine organisms.

MICROBIOLOGY

The UK is required to comply with three EC Directives that set standards for microbiological quality. All use bacterial indicators of faecal contamination but use different measurements. The Bathing Waters Directive (for which new, tighter standards are in the process of being agreed) currently requires 95% of the sea water samples collected from a identified bathing water to contain less than 10,000 total coliforms/100 ml and less than 2,000 faecal coliforms/100 ml. There are 489 identified bathing waters in England and Wales and all were monitored in 2003. Of these, 483 or 98.8% passed the mandatory standards but two of those failing were in Region 4. This does however represent a considerable improvement on the situation recorded in 1990. This is as a consequence of investment in improved sewage treatment and disposal arrangements in the Region. The extent to which continued failures are attributable to diffuse sources, including run off from land used for rearing cattle and sheep is unclear but could be a significant factor.

The Shellfish Hygiene Directive lays down standards for *E. coli* and faecal coliforms in bivalve shellfish flesh. The standards define whether shellfish can be sold directly for human consumption (class A), after passage through an approved purification system (class B) or must first be subjected to an approved heat treatment process or be relayed for an extended period in either a class A or B area. By 2003 81% of the 249 designated shellfish beds in England and Wales had achieved class B status, compared to 69% in 1999 but there has been no improvement in the small numbers achieving class A (5% down to 4%). In 2003 in Region 4 no beds were graded class A but 64 were graded class B and a further 20 sites graded class C, with four more classed as prohibited. Some improvement can be expected as further improvements in sewage discharges are brought into effect.

The Shellfish Waters Directive lays down guideline standards for a variety of contaminants and is aimed at the protection or improvement of the quality of the waters from a shellfish growth standpoint. It nevertheless includes a microbiological quality guideline standard of less than 300 faecal coliforms/100 ml of shellfish flesh and intervalvular fluid in at least 75% of the samples. This is expressed differently but is broadly similar in effect to the requirements of class A under the Shellfish Hygiene Directive. This would be difficult to achieve and the Government has set a target that all designated shellfish growing waters should achieve at least a standard equivalent to class B under the Shellfish Hygiene Directive. In England and Wales a total of 119 waters have been designated under the Shellfish Waters Directive. Of the sites that failed to meet the aspirational target 35% were in Region 4. There was no significant change between 1999 and 2002.

OIL AND OIL SPILLS

The European Waters Special Area established by IMO in 1999 includes the whole of Region 4. There should not therefore be any deliberate discharge of oil or oily water from ships within the Region. This does not preclude illegal discharges and about 20 oil slicks attributed to discharges from vessels were reported in the Region in 2001. Whilst some of these may have occurred outside Region 4 it is unlikely that they all did, especially as clusters were noted in mid-Channel and off the south coast of Cornwall.

There have been no significant accidental oil spillages in the Region since the *Sea Empress* spill on the edge of the Region the southern Irish Sea (Region 5) in February 1996 when about 72,000 tonnes of Forties crude oil were spilt. The oil affected about 200km of coastline, most of it in Region 4. About 445 tonnes of modern dispersants were used at sea to aid dispersion but most beach areas were cleaned manually and were open by Easter that year. The area is an internationally important one for wildlife and although at the time the spill did kill many seabirds, particularly scoter ducks in Carmarthen Bay, as well as other marine organisms, recovery was rapid and the effects had all but ceased to be detectable by early 1998. This contrasted with experience with the Torrey Canyon oil spill in 1967 when large quantities of toxic Mk.1 oil dispersants were used. Recovery in areas where these dispersants were used took between 10 and 15 years, whereas areas not treated with dispersants recovered in only two to three years (*MECN Research Contract Report to Defra*) i.e. at much the same rate as post *Sea Empress*.

NAVIGATION DREDGING AND AGGREGATE EXTRACTION

Dredging is a necessary activity at most ports and harbours, at least occasionally, in order to maintain water depths safe for navigation. At many large ports it is almost a routine activity and is undertaken on a year round basis. Occasionally new developments lead to increased dredging activity and this is distinguished from routine maintenance dredging and is termed capital dredging. In order to protect other user interests consultations take place before disposal sites are designated and licences to dispose of dredged material are granted. In Region 4 four licensed disposal sites were used in 2001, (Falmouth, Rame Head, Bolt Head and Lantic Bay) off the south coasts of Devon and Cornwall and one on the north coast of Cornwall. The remaining 13 licensed sites in the Region were all used in 2001 and are located in the Bristol Channel (Milford Haven, Swansea Bay, Cardiff (2), Newport, Portishead, Portbury/Bristol Docks (3), Avonmouth, Watchet and a small site in the Neath estuary. Two of the sites account for two-thirds of the 3.1 million tonnes of dredged material disposed of in 2001 in the Region.

The quantities of contaminants disposed of with dredged material are being reduced, partly because, due to reduced inputs of contaminants the level of contamination is decreasing but also because of tighter controls on the concentrations of contaminants permitted on dredged material that is allowed to be disposed of at sea. There is also pressure to make beneficial use of dredged material e.g. for recovery of eroding salt marsh areas, but although the quantity used in this way is increasing it still only accounts for less than 1% of total arisings. Monitoring of dredge disposal sites is undertaken on an intermittent basis and the development of indicators of the impact of dredged material disposal is progressing slowly. A basic requirement of any such indicator is that it must allow for site specific variations in natural conditions and human influences.

There is no dredging for aggregates in the English Channel or Western Approaches but some aggregate dredging does take place in the Bristol Channel mainly along the south coast of Wales. Between 1993 and 2003 the amounts dredged in these areas varied between abut 1.5 and 2.3 million tonnes per year and this accounted for only about 9% of the total extracted around England and Wales. A smaller proportion is forecasted for the period 2001 to 2016 representing a decrease to about 9 million tonnes or about 4% of the anticipated demand.

Dredging of maerl (calcareous algae) takes place in the Fal estuary under a Crown Estate Commission licence that was first issued in 1978. The licence, which is issued contrary to English Nature wishes, authorises extraction of up to 30,000 tonnes/yr of dead maerl and does not permit removal of live maerl from the St Mawes Bank.

CONSTRUCTION

There are few major developments taking place in Region 4 at present apart from barrages at Cardiff and Swansea, although under the push for development of renewable energy sources one offshore wind farm with up to 30 turbines is proposed for Scarweather Sands in Swansea Bay. There are however significant centres of population around Torbay, Plymouth, Falmouth, Bristol and along the south Wales coast at Bridgend, Cardiff and Swansea. There are also numerous smaller towns and villages, often developed around old fishing harbours and these have become centres of tourism. Although only short stretches of the coast require coastal defence works to prevent flooding most of the coast would be regarded as a modified environment even if only by agricultural use. Most of the licences granted for construction in Region 4 during the last few years have related to small scale harbour improvements or to the installation of new sewage outfalls. Whilst the impact of each of these proposed developments is considered carefully in order to minimise the impact on other user interest the greatest concerns currently arise over the siting of wind farms. The potential impacts of these developments are reasonably well understood e.g. possible changes to hydrodynamic and sedimentary processes, possible impact on fisheries and navigation and on marine species such as seabirds, cetaceans and fish as well as migrating birds. However, the actual effects at any one site are unknown and each development must be carefully assessed. Research and monitoring to establish actual effects will be crucial if decisions about further developments are to be properly informed by practical experience and research and monitoring findings.

MARICULTURE

Apart from cultivation of some bivalve shellfish species mariculture is not at present an activity undertaken on any scale in Region 4.

CONTAMINANT SPECIFIC BIOLOGICAL EFFECTS

A number of contaminant specific effects feature in the NMMP, for example the impact of endocrine disrupters in the feminisation of male fish. This can be assessed by measuring plasma vitellogenin (VTG) presence in male fish. Certain PAH and some CBs induce the synthesis of a group of enzymes by fish liver and the extent of exposure can be assessed by measuring the activity of one such enzyme known as EROD. The formation of DNA adducts and of foci of cellular abnormalities (FCA) may also be promoted by exposure to PAH compounds. Where such effects have been looked for in Region 4 they have either been undetectable or have occurred at very low levels.

One effect that was detectable in Region 4 is that caused by tributyl tin (TBT), which was used in anti-fouling paints. The effect is known as imposex and the surveys use dog whelks, the females of which, when exposed to TBT, develop male characteristics. Two indices are used, relative penis size index (RPSI) and the vas deferens sequence index (VDSI). In Region 4 the most recent survey (1997) only included the northern coastline of the south-west peninsula of England and the south Wales coast. Exposure to TBT was evident at most sites but at all of them VDSI was considered low i.e. VDSI <4, the level above which reproduction is effectively prevented. RPSI values were also low.

Studies of exposure to metals using metallothionein as an indicator of the extent of exposure have been undertaken in a number of areas around the UK but to date the pilot scale studies reported on in other chapters do not appear to have included sites in Region 4.

NON-SPECIFIC BIOLOGICAL EFFECTS

An integrative tool for assessing the overall health of fish populations is the measurement of a range of fish disease conditions. Surveys have been conducted for a number of years using dab and flounder. These surveys use carefully developed, internationally agreed protocols aimed at creating a time series of comparable data. The majority of the surveys have been conducted in Regions other than Region 4 but the data available for this Region suggest low prevalence of all the diseases routinely looked for.

The oyster embryo bioassay has been used over a number of years as a means of assessing general water quality. Embryos of the oyster *Crassostrea gigas* are exposed to water samples for 24 hours and their success in developing to 'D' hinge larvae provides a measure of water quality. The studies have shown that poor water quality is only encountered in estuarine areas. Between 1999

and 2001 water samples from sites in the Tamar and Severn estuaries were tested on several occasions. Low responses were observed in all cases, with the highest being just over 10% in the Severn estuary in March 2000. This contrasts with the situation typically observed in estuaries some ten years earlier when many of the results indicated serious deterioration in water quality (i.e a response of greater than 30%) with many showing between 50 and 100% responses.

The newly developed bioassays for assessing sediment quality have been trialled in a number of areas where there was particular reason to expect effects might be observed. No such sites for these preliminary investigations were identified in Region 4.

LITTER

The sector report on Environmental Quality includes only very limited information of the regional prevalence of litter based on a single survey conducted by the Marine Conservation Society (MCS) in 2003. Equally there is no information on the regional effects of litter in the sector report on Habitats and Species. Consequently it is not appropriate to go into any detail in this chapter. However, a brief summary of the litter issue is provided in the final chapter of this Integrated Assessment. In the 2003 Beachwatch survey conducted by MC. Region 4 had the highest density of beach litter at double (4 items/m surveyed) the average for the rest of the UK. The most significant sources of litter in the Region were judged to be beach visitors (responsible for almost 35% of all litter found) and fishing debris (21%).

HABITATS AND SPECIES

FISH ASSEMBLAGES

The fish found in Region 4 include several south-western species and because it is open to the Atlantic Ocean, warm temperate and sub-tropical pelagic fish species have always been encountered occasionally. In recent years the frequency of occurrence of several southerly species has increased. Such species include John Dory (*Zeus faber*) and boar fish (*Capros aper*) (Figure 4.5)

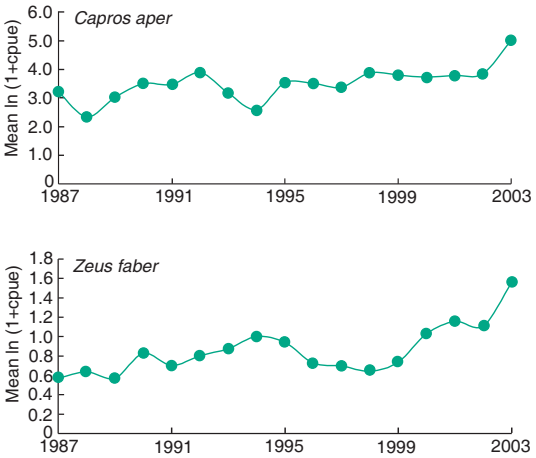


Figure 4.5. Relative abundance of boarfish (top) and John dory (bottom) in the Celtic Sea (1987-2003). CEFAS research vessel surveys

However, the abundance of some southerly species has decreased during the second half of the 20th Century. For example red seabream (*Pagellus bogareveo*) were typically common in the western English Channel and Celtic Sea but few were recorded in the 1980s and 1990s.

The western English Channel is generally deeper than the eastern English Channel (Region 3) with the Hurd Deep exceeding 100 m. Much of the seafloor is relatively coarse and shelves steeply away from the coast. Species such as anglerfish (*Lophius piscatorius*) and cuckoo ray (*Leucoraja naevus*), which are infrequent in Region 3, are relatively common in the western English Channel. The western English Channel contains numerous wrecks and these can be locally important for species associated with reefs e.g. conger eel (*Conger conger*) and pollack (*Pollachius pollachius*). The basking shark (*Cetorhinus maximus*) is a protected species and is often found in the western Channel associated with fronts that occur in the summer months. There are however few recent records of angel shark (*Squatina squatina*) which was historically abundant in Start Bay.

The fishes found in the Bristol Channel are generally the same as those found in the western English Channel but there are a few differences. For example large numbers of small-eyed ray

(*Raja microocellata*) are present in this part of Region 4 and the area off Trevose Head in north Cornwall is an important teleost spawning ground. The extensive sandy area between Pembrokeshire and the Gower on the south coast of Wales is an important nursery area for bass (*Dicentrarchus labrus*) and several species of flatfish and ray. Species of conservation interest include shad (*Alosa* spp.) and lampreys, which migrate up some of the rivers feeding into the Bristol Channel.

In the more westerly Celtic Sea the fish assemblages are similar to those of the western English Channel although offshore species become more abundant as depth increases. Such species include hake (*Merluccius merluccius*), megrim (*Lepidorhombus whiffiagonis*), long-rough dab (*Hippoglossoides platessoides*) and blue whiting (*Micromesistius pouttassou*) and boarfish. Pelagic sharks such as the blue shark (*Prionace glauca*) and porbeagle (*Lamna nasus*) occur in this part of the Region and seasonally in the western English Channel and outer Bristol Channel. The basking shark and another species of conservation interest the common skate (*Dipturus batis*) are also found in this part of the Region.

COMMERCIAL STOCKS AND LANDINGS

Region 4 is a biogeographically intermediate area between the typical Boreal fauna of the North Sea (Regions 1 and 2) and the more southerly Mauritanian fish species. Cod continues to be an important commercial species in the western English Channel and in the Bristol Channel but is increasingly replaced by hake as the main target species, especially in the more westerly parts of the Region. As water depth increase, megrim and anglerfish become more important, compared to the plaice and sole mixed fisheries of the western English Channel and Bristol Channel. The main pelagic species caught in the Region are mackerel, horse mackerel and herring. Most of the fishing effort in the Celtic Sea part of the Region is in mixed demersal fisheries targeting hake but catching variable quantities of cod, whiting, anglerfish, megrim, sole and plaice. In the Bristol Channel there are seasonal fisheries for sole and plaice. There are some important grounds for *Nephrops* in parts of the Celtic Sea. In the western English Channel the seabed tends to be coarse and the main shellfisheries are for scallop and, closer to the shore, edible crab, lobster and crawfish. In recent years fisheries for velvet swimming crab, spider crab and cuttlefish have all increased, primarily for export to France and Spain.

Figure 4.6 shows the trends in landings for the main exploited fish species caught in Region 4 and shows that although landings have fluctuated year by year they have not fallen so rapidly as in some other Regions. Stocks are

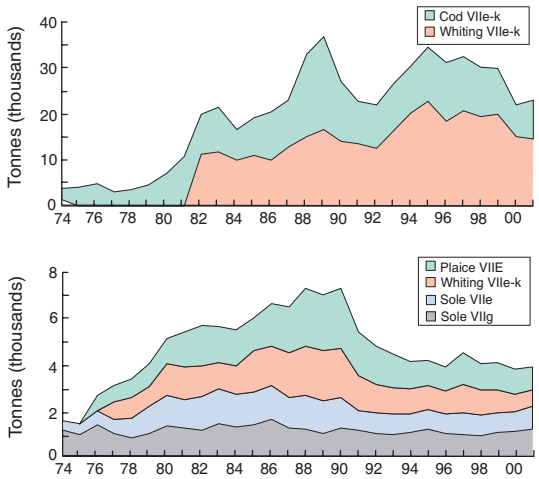


Figure 4.6a. Landings of roundfish and flatfish from the Celtic Sea and western channel. Species shown are: cod, whiting, plaice and sole

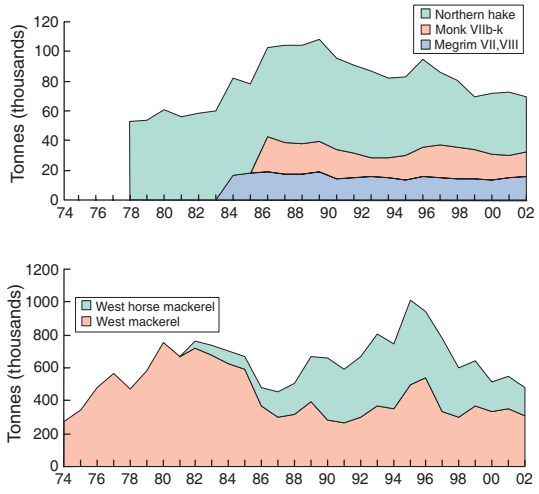


Figure 4.6b. Landing of widely distributed stocks from the Celtic Sea and western channel. Species shown are: hake, megrim, western mackerel and horse mackerel

assessed annually by the International Council for the Exploration of the Sea (ICES) and since 1999 their advice has been offered on the basis of the precautionary approach. Many demersal stocks are considered to be being fished at rates outside precautionary limits.

The northern hake stock is subject to a management recovery plan due to the low stock size, high fishing pressure and poor recruitment. Celtic Sea cod is at increased risk of reduced reproductive capacity. Stocks of anglerfish, megrim and sole in area VIIg and f and of whiting in areas VIIe-k were considered to be at full reproductive capacity. Up to 85% of the North-east Atlantic mackerel stock is found largely in Region 4 and in recent years the stock has declined below the biomass reference point (Bpa) and is considered to be at increased risk of reduced reproductive capacity. The fishing mortality is unsustainable in the longer term and needs to be reduced. The status of the horse mackerel stock is uncertain but is expected to decline and *Nephrops* stocks are all thought to be exploited at sustainable levels.

(In 2004 ICES defined "at risk of being harvested unsustainably" as referring to stocks where the fishing mortality is above the precautionary reference point (Fpa). This is equivalent to the previous terminology "harvested outside safe biological limits".The term "full reproductive capacity" describes stocks where the spawning biomass is above the precautionary reference point (Bpa). This is equivalent to the previous terminology "inside safe biological limits". A more detailed explanation of the new terminology can be found in the sector report on Fish and Fisheries, which also contains a map showing the ICES areas.)

IMPACT OF FISHING

Apart from the obvious effect on stocks of target fish, fishing can have a number of other effects. Fishermen use fishing gear designed to target the larger more valuable individuals and so the faster growing fish tend to be caught first. This means fishing can have selective genetic effects by preferentially leaving those individuals that grow more slowly or mature earlier. There is growing evidence that cod and plaice stocks have been so affected. A further possible genetic effect is that in a managed stock, fish may not breed randomly and thus sub-populations may develop and over fishing may reduce genetic diversity. The loss of common skate and angel shark has led to reduced biodiversity in Region 4.

Fisheries also take by-catches of non-target fishes and marine mammals, seabirds and benthic animals. Most of the by-catch is discarded at sea. Reducing the rate of by-catch and discarding, is generally regarded as having desirable ecosystem effects and initiatives to achieve reductions are increasingly included in EU management measures. Various measures are being tested both to accurately assess the scale of discards and to reduce them. A side benefit of reducing fishing effort on target species is likely to be reduced discards and some by-catch species may start to recover if fishing rates on the target species can be kept within sustainable limits.

The numbers of dead common dolphins found washed up on beaches in the Region has been a source of considerable concern on conservation grounds. Most of these dead animals appeared to have been drowned after having been caught in fishing gear. Measures have since been taken to assess how many dolphins are caught in fishing gear in the Region. Early studies suggest that the scale of the by-catch is variable. In 2001, 53 common dolphins were recorded from 116 trawl tows but in 2002, 8 were caught in 56 tows. Defra is continuing to fund work on the development of a dolphin exclusion grid to stop dolphins being caught and trials were conducted in both 2002 and 2003.

Gears that are trawled along the seabed, particularly beam trawls and toothed scallop dredges, have a direct impact on the seabed habitat and this leads to modification of habitat and the loss of sensitive and fragile species. Although fishing effort is not uniform and some areas of the UK shelf are fished less than once every seven years, as Figure 4.7 indicates, much of Region 4 is heavily fished. The effect of bottom disturbance is to reduce the production and diversity of larger bottom dwelling invertebrates but the effect is less on many of the smaller animals that provide food for flatfish. Scavenging animals also benefit from the carrion left on the seabed after disturbance by fishing gears. The densities of sensitive species and opportunistic species on the seabed have been proposed as the basis of EcoQOs to limit effects on benthos. These indicators are being investigated by ICES. Sensitive species in the area include the sea fan (*Eunicella verrucosa*) and fan mussel (*Atrina fragilis*)

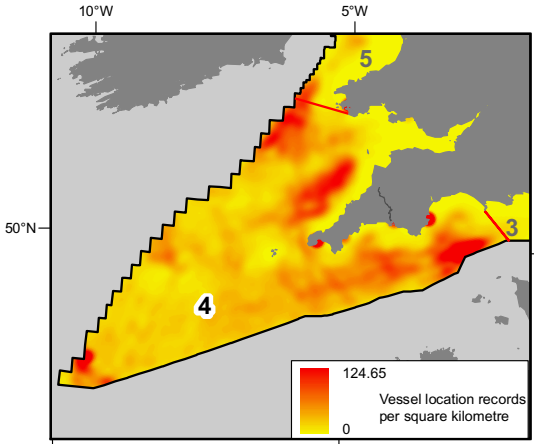


Figure 4.7. UK beam and scallop trawler density in 2002. Vessel positions filtered by speed (between five and eight knots) to remove steaming

Fishing can affect seabirds adversely by taking fish the birds require as food, especially during the breeding season when the adults are foraging for fish to feed their young. On the positive side discards can provide an additional source of food supply, although the extent to which this benefits fledgling seabirds is debateable. In Region 4 the effects of fishing on seabirds, whether positive or negative, is not an issue of particular comment in either the Fisheries or Habitats and Species sector reports, unlike the situation in several other regions where it definitely is an issue requiring attention.

PLANKTON

The microscopic free floating plants at the bottom of the marine food web are collectively termed phytoplankton. They provide food for the microscopic animals known as zooplankton which in turn feed the fish and their predators. A number of long-term records exist for plankton in the western English Channel off Plymouth in Region 4. Investigations based at the Marine Biological Association (MBA) Laboratory began in the early 1900s and have continued, with short interruptions during the war years and again from the mid 1980s, to the start of the new century. These records provide the basis of an extremely good understanding of changes in both phytoplankton and zooplankton over the years and clearly show a number of changes have occurred. Some of the changes are attributed to changes in nutrient availability due to changing hydrographic conditions and others are attributed to temperature changes (*MECN Research Contract Report to Defra*). Similar changes have occurred in the zooplankton and there is clear evidence that from the 1960s there was an increase in the abundance of *Calanus* and fish larvae and cold water species began to return until around 1979. Since 1985 the balance has switched again to warmer water species and pilchard spawning has increased. The changes were associated with severe winters in western Europe and a negative phase in the NAO (*MECN Research Contract Report to Defra*). The MBA records, as well as those collected more recently by the Plymouth Marine Laboratory (PML), relate almost entirely to station samples taken at intervals rather than continuously in either time or space. The data do however link well with satellite images that yield more complete spatial coverage.

Records obtained using the continuous plankton recorder (CPR) do not stretch back so far in time but they do provide data from repeated transects along more or less fixed routes, two of which pass through the Region out into the Atlantic. The CPR collects both phytoplankton and zooplankton and although it is not possible to identify all individual phytoplankton species, a measure of their overall biomass/abundance is provided by the Phytoplankton Colour Index. This Index correlates well with satellite measurements of chlorophyll. The records show an increase in phytoplankton productivity since about 1987. This has been accompanied by an earlier start in the spring bloom and more prolonged growth, effectively merging with the autumn bloom. The changes in phytoplankton abundance have been accompanied by changes in zooplankton abundance, species structure and diversity. The results correlate well with the longer term data sets collected over a smaller area by the MBA and PML. None of these plankton records indicate any connection between the changes observed and land based inputs of nutrients. All appear to be induced by changing hydrographic patterns and/or temperature.

BENTHOS

The largest single data set related to invertebrates in the western English Channel extends from 1959 to 1985 and was collected by staff from the MBA. In fact sampling of benthos in this area began

in the late 1800s and some of the more recent sampling was specifically targeted at stations sampled in those early years. The records show changes in the benthos have occurred that have been related to sea temperature, particularly cold waters, immigrant species and blooms of dinoflagellates. Increasingly changes have been brought about by heavy fishing gear such as beam trawls and scallop dredges. A survey conducted in 1998 was designed to test the resilience of megabenthic species and involved resurveying ten sites previously surveyed 40 years earlier. Most sites did show temporal changes in bivalve and echinoderm communities but two of the sites did not. This suggested that a few areas of seabed continue to have a similar community composition to that before the general increase in bottom fishing disturbance. The findings also highlight the patchy nature of benthic communities (*MECN Research Contract Report to Defra*).

The JNCC has a pivotal role in maintaining UK-wide data sets and, in pursuance of this remit, has sought to collect information on where benthos surveys have been conducted and to collate data from them. During the past 30 years the conservation agencies have commissioned many surveys to support selection and designation of marine protected areas (Special Areas of Conservation (SACs)). There have been two large UK-wide systematic surveys: the Inter-tidal Survey of Great Britain and Ireland and the Marine Nature Conservation Review. There have also been a number of regional surveys one of which was the South-west Britain Sub-littoral Survey. As a result of these efforts it is clear that in Region 4 a considerable body of information exists but there are nevertheless significant gaps, particularly in the more westerly areas of the Region.

Among the data gathered together were those collected on benthos under the NMMP. All the NMMP stations are intended to be of a similar soft bottom nature to allow comparison to be made of conditions between stations. This does not always work out well in practice and different stations also tend to be subject to different degrees of disturbance. Only three offshore sites are located in Region 4, one in Lyme Bay and another off the Tamar, both on the south coast of England and the third off Milford Haven at the extreme north-west edge of the Region. A further five stations, classed as estuarine are located within the Region, three in the Severn estuary and two in the Tamar estuary.

All the NMMP data have recently been assessed (*MEMG, 2004*) in terms of abundance and diversity using a Biotic Index (AMBI). Under this system, as it currently stands, a score of zero is regarded as indicateing a totally normal healthy regime whereas a maximum score of seven indicates one which is heavily stressed or polluted. The offshore site scores ranged from 0.95 in Lyme Bay to 2.42 in the Tamar and probably reflect the relative order of stress due to contamination. At the estuarine sites the scores ranged from 2.69 to 3.85 at the two stations in the Tamar estuary to between 0.03 and 5.59 in the Severn. It is not easy to interpret whether these differences reflect contamination stress or are due to disturbance or pollution or simply differences in seabed type and it is clear the AMBI index requires further development if it is going to assist in this process. However, various other types of assessment were used and these tend to confirm that the lower score does indeed represent a natural regime, albeit in this case one with a very restricted range of taxa. The NMMP data sets do not extend over a long enough period to permit an assessment of trends over time.

SEABIRDS

Seabird numbers and breeding success are assessed annually throughout the British Isles by the Seabird Monitoring Programme (SMP), which began in 1986 and is co-ordinated by the JNCC's Seabird Colony team. Since 1989 the results of the SMP have been published in an annual report. This is entitled "Seabird numbers and breeding success in Britain and Ireland" and is produced by JNCC in collaboration with RSPB and the Shetland Oil Terminal Environment Advisory Group (SOTEAG). While the SMP conducts annual monitoring of a sample of the seabird population in the UK complete censuses of all seabirds in the UK have been conducted to obtain total population estimates, which provide a baseline against which subsequent monitoring can be compared. The most recent UK population estimates were obtained in 1998-2002 during Seabird 2000, a JNCC-led census of breeding seabirds in the UK and Republic of Ireland.

Twenty-five species of seabird are known to breed in the UK and total numbers have increased from around 4.4 million in 1969-70 to 6.7 million in 1998-2002. Not all species have experienced the same success and there are considerable variations between species year to year and between breeding sites.

The EC Birds Directive requires Special Protection Areas (SPAs) to be designated according to their qualifying interest in one or more seabird species and/or their seabird assemblages (i.e. more than 20,000 breeding adults). In Region 4 Carmarthen Bay has been designated as an SPA (the only wholly marine SPA to date) on account of its over-wintering scoter duck population and the Scilly Isles have also been designated as an SPA. Two more SPAs are located just outside the Region off Milford Haven. The scoter duck population in Carmarthen Bay did suffer considerable mortality in the aftermath of the *Sea Empress* oil spill but recovered rapidly and now appears to have returned to pre-spill numbers

The seabird section of the sector report on Habitats and Species does not make any particular mention of the effect of fishing on seabirds in Region 4 but it is an issue of concern in some other regions.

SEALS

There are two species of seal resident in UK waters but only one, the grey seal (*Halichoerus grypus*) is found in any numbers in Region 4. Two main sites are favoured, Lundy Island and the Scilly Isles. (There is another breeding site on Skomer and this is referred to in Chapter 5.) The two sites in Region 4 provide the isolated conditions the seals prefer for their breeding cycle. At these sites breeding starts earlier than elsewhere in the British Isles with pups normally being born between August and October. The pups are weaned after about 21 days and mating occurs towards the need of that period. The pups stay at the breeding colony for up to two more weeks but then depart to feed at sea. Once the female has left her pup there is no further parental care. Both the breeding colony sites in Region 4 (plus the one on Skomer) have been included in the list of sites designated for this reason under the EC Habitats Directive as Special Areas of Conservation (SAC). In fact the grey seal is not considered to be under any form of threat in the UK but it is so regarded in other parts of the EU and the UK, which has a disproportionate part of the global population of these species, is obliged to designate representative breeding colonies where they meet the Directive's requirements.

Overall numbers of seals are counted annually to assess total numbers and breeding success. The resulting data will be used in assessment of EcoQOs for seals. Currently there is only one such EcoQO and this is expressed in terms of population trends and utilisation of breeding sites. The available evidence suggests that the population of grey seals in the UK as a whole is beginning to stabilise. Overall numbers increased year on year between 1984 and 1996 but pup production decreased for the first time in 1997 and again in 2002. The epidemics of phocine distemper virus (PDV) that occurred in 1988 and 2002 affected grey seals much less than common seals and the population of grey seals in Region 4 was barely affected by either outbreak.

CETACEANS

Cetacean distribution has recently been mapped in atlas form as part of a more co-ordinated approach to the recording of cetacean sightings. The atlas combined data from three major sources and, although a few small data sets from miscellaneous other sources have still to be incorporated, this Joint Cetacean Database (JCD) provides the best overall picture currently available. Twenty-eight species of cetacean have been recorded in UK waters but of these only ten are commonly recorded in UK waters. Nevertheless, the information available does show that the number of species is comparable with other areas at similar latitudes and does represent a diverse assemblage of this group.

Population estimates have only been made for a few cetacean species in UK waters and in most cases relate only to certain areas and are subject to considerable uncertainty. Four line transect surveys were carried out in Region 4 in the early 1990s and produced population estimates for *Lagenorhynchus* dolphins in the Celtic Sea, for short-beaked common dolphin (*Dolphinus dolphinus*) – between 23,000 and 249,000,and for the common bottlenose dolphin (*Tursiops truncatus*) in parts of the Celtic Sea and the English Channel. There are no data on population trends for any of these species. However, the by-catch of dolphins in the English Channel is a cause of concern and various measures are being tried to assess the true scale of the problem and to find a solution (see the Impact of Fishing section of this chapter for further details).

HABITATS

The sector report on Habitats and Species describes the various measures that are available, have been and are being taken to protect habitats

and species around UK coasts. It reviews a range of key habitats and indicates areas where important examples of each are to be found and the threats they currently face, or may face in the future. A large number of Sites of Special Scientific Interest (SSSIs) have been established in the Region for a wide range of reasons at various times under a number of legislative frameworks. The status of SSSIs throughout the UK is currently unknown and there is no agreed list of features to be reported on but the end of the first reporting period for SSSIs is March 2005. English Nature is charged with ensuring that all SSSIs are in a favourable condition by 2010 and action has started to identify what needs to be done to achieve this goal.

Only three Marine Nature Reserves have so far been designated in the UK. These are Strangford Lough and Skomer, both in Region 5, although Skomer is very close to Region 4, and Lundy Island in the Bristol Channel i.e. in the Region. Lundy Island is important for a number of reasons. All five British shallow water corals are to be found there, as are a number of slow growing south-western species of soft coral, the sea fan and a variety of erect branching sponges. The southern kelp and a number of other seaweeds are at or close to their (current) northern limit of distribution. The first statutory No Take Zone (NTZ) to be confirmed by the Government was established in January 2003 as a 3.3 km^2 area on the east of Lundy Island MNR. A 3-5 year programme of monitoring will compare the status of the seabed within the NTZ with surrounding areas, to evaluate its effectiveness in protecting seabed habitats. Preliminary results are said to be promising with, for example, more and larger lobsters in the NTZ than in the surrounding areas after only 18 months.

Under the terms of the 1992 Convention on Biological Diversity the UK has identified 14 marine habitat types for which Biodiversity Action Plans (BAPs) have been drafted. Of these habitat types, mudflats, sheltered muddy gravels, seagrass beds and sub-littoral sands and gravels are all well represented by sites in the Region. In addition *Sabellaria alveolata* reefs are located in Lyme Bay and in the Bristol Channel and maerl beds occur in Falmouth Bay. Extraction of dead maerl from the Fal estuary is authorised under a CEC licence that was first issued in 1978.There are a number of saline lagoons along the south Wales coast.

KEY POINTS AND CONCLUSIONS

Air temperatures over the land have risen by about 0.5°C in the last 100 years with the 1990s being the warmest decade on record since records began in the mid 17th Century. However, in Region 4 the rise in sea water temperature has been somewhat cyclical and less notable, with the increase at the shelf edge being between 0.12 and 0.29°C and the records for most coastal stations in the Region indicating similar or slightly smaller increases. Records relating to a station off Plymouth suggest there have been marked variations in salinity since the start of the twentieth century but no overall trend; although further to the west the records, as collated by the ICES Hydrographer, show a slight decrease in the period 1950 – 2002. There has been an increase in storminess during the last 100 years though not an increase in average storm intensity. However, records from the Sevenstones LV off Land's End, plus weather ship and satellite altimetry data, suggest that wave heights have increased from about 2 m to about 3 m between 1962 and 1985. This may have as much to do with conditions in the Atlantic Ocean as with local storminess because waves reaching this area may have been generated well outside the Region.

Along the south coast of England suspended solids concentrations are generally low. To the east of Lyme Regis the soft cliffs of the Dorset coast are subject to erosion and Chesil Beach has been formed as a result of wave action and long-shore transport of shingle and stones. 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. However, due to the generally harder rock of the coastline coastal erosion is not a particular problem, nor does sea level rise yet present serious problems as most of the coastline is not particularly low lying, even though in terms of subsidence solely as a consequence of post-glacial adjustment, the south-west experiences the highest rate of subsidence.

In terms of contaminant concentrations the picture regarding environmental quality is somewhat mixed. With the exception of a few small estuarine areas where sewage inputs and/or agricultural run-off introduce nutrients and cause excessive growth of the macroalgae *Enteromorpha*, inputs of nutrients do not pose

a problem. Concentrations of DIN, DIP and chlorophyll are all below the guidance levels above which some form of remedial measures might be indicated. Changes in plankton composition have been recorded but these are believed to reflect changes over a much wider area, probably brought about by climate change and a general northwards shift in species, rather than nutrient inputs. Past metal ore mining in the catchment area north of Plymouth and metal ore smelting in South Wales and near Bristol are the undoubted causes of concentrations of a number of metals being above those set as BRCs. However, in most cases they are below those considered likely to cause biological effects. One notable exception was encountered with a sample of mussels from the Severn estuary which had a particularly high concentration of cadmium.

Detectable concentrations can be found of most of the traditionally studied organic contaminants. Concentrations are however generally below the EACs, except for CBs near the site on the south Wales coast where PCBs were manufactured in the past. PAH concentrations were found to be highest in the Severn and Tamar estuaries but the concentrations did not exceed the EACs and gave no particular cause for concern. This tends to be supported by the limited amount of data available from biological effects studies in the Region. In some cases effects were observed but always at a low level. A survey of the impact of TBT on dog whelks was conducted along the west coast of the UK in 1997 and although clear evidence of exposure was found the scale of effect was below that which would cause ecological harm.

The microbiological quality of coastal waters in Region 4 is perhaps the recognised contamination issue that requires most attention. Despite substantial investment in sewage treatment schemes and improved effluent discharge arrangements, two bathing waters failed to achieve the EU mandatory standards in 2003. There have been some improvements in the number of shellfish harvesting areas achieving class B status but no increase in the number of areas achieving class A. There was no improvement in the number of shellfish growing waters meeting the UK's aspirational microbiological quality target set under the terms of the Shellfish Waters Directive as representing good growing conditions for shellfish - 35% of the shellfish growing waters that failed to meet this minimum target in 2002 were situated in Region 4.

There continue to be reports of oil slicks in the Region that are attributed to discharges from vessels but whether all the discharges occur within the Region is unclear given the direction of prevailing winds and the fact that outside the Region discharges would not be illegal. There have been two major oil spills that affected the Region in the past but in both cases recovery is now regarded as complete. The first (*Torrey Canyon*) spill in 1967 involved large scale use of early generation oil dispersants, which caused widespread ecological damage, from which recovery took up to 15 years. The more recent *Sea Empress* spillage in 1996 saw more controlled use of lower toxicity dispersants and recovery was more or less complete within two years.

Few stretches of the coast have been affected by coastal defence works. There are however numerous small harbours around the south-west peninsula and major centres of population with associated ports at Plymouth, Falmouth, Bristol, Swansea and Cardiff. Dredging to maintain these ports is an on-going activity, but careful selection of the sites at which disposal is authorised, limits the effects on other marine interests. Some dredging for aggregates does take place in the Bristol Channel but the quantity extracted is small compared to the UK total (ca. 9% or 20 million tonnes between 1993 and 2003). Barrages are currently under construction at both Cardiff and Swansea and the installation of up to 30 wind turbines is proposed on Scarweather Sands in Swansea Bay. As with all other construction projects the aim will be to ensure any developments cause the minimum of adverse effects on other uses of the marine environment.

Region 4 contains a wide variety of habitat types ranging from deep water in the extreme west through rocky cliffs and saline lagoons to sandy or muddy beaches and salt marsh areas in the coastal parts of the Region. The seabed in the Bristol Channel and Severn estuary is quite mobile due to the strong tidal currents and the range of species encountered in the Region reflects this diversity of habitat types. In terms of contaminant effects the Region can be regarded as healthy and the species mix typical of what might be expected given the nature of the physical environment. A wide variety of fish species is found in the Region with, increasingly, more species previously regarded as rare visitors from warmer waters to the south. Some species e.g. common skate considered to be rare or

absent from other regions as a consequence of fishing mortality can still be found in Region 4. However, most of the commercially exploited fish stocks are considered to be being fished outside precautionary limits and reduced effort and/or recovery plans have been advised accordingly. Most shellfish stocks appear to be at acceptable levels of exploitation.

The impact of fishing on other species as a consequence of by-catch or incidental damage to habitats as a consequence of using heavy trawl gear is perhaps of less concern in scale of effect terms in Region 4 than elsewhere, although the actual types of effect remain the same. One exception to this is the by-catch mortality caused to common dolphins and development of a dolphin exclusion grid is an option being trialled and the UK government has declared a ban on pair trawling by UK registered vessels, although the major causes of the problems are not believed to be UK vessels (*Author's Note*).

A variety of records exist of plankton species composition within the Region, particularly for the area south of Plymouth. All show there have been substantial changes over the years, both in species present and the timing of blooms. However, the changes are believed to be linked to similar changes observed over a wide area of the north-east Atlantic and are probably climatically induced. Good records also exist for the western English Channel on benthos and these also show changes attributed to immigrant species and changes in water temperature, as well as the effect of seabed disturbance by trawl gear at some, but not all, stations studied.

The range of cetacean species found in the Region is considered to be normal for the latitudinal range encountered and estimates have been made of populations of at least three species in the Region, though as yet no population trend data have been collected. Only the grey seal is found in any numbers in the Region but there are breeding colonies on the Scilly Isles, Lundy Island and one just outside the Region on Skomer in Region 5. Lundy Island is particularly important in habitat terms and is one of only three Marine Nature Reserves thus far designated in the UK. It has important examples of a variety of species and is also the location of the first statutorily designated No Take Zone in the UK. This was defined in 2003 and covers an area of 3.3 km^2 east of the island; early results indicate the measure is proving successful with more and larger lobsters being found in the area than around it. The Scilly Isles are designated as an SAC because of their importance for grey seals, and as an SPA due to their significance in seabird habitat terms. Carmarthen Bay is currently the only wholly marine SPA in the UK and was designated as such because of its importance as an over-wintering area for scoter ducks.

Region 5:
Irish Sea

INTRODUCTION

This Region comprises the Irish Sea and North Channel and is bounded to the north by a line drawn from Fair Head in Northern Ireland to the southern tip of Kintyre in Scotland and to the south by a line drawn from Milford Haven to Dungarven Bay in Ireland, with the west coasts of Wales, north-west England and southern Scotland forming the easterly boundary and the median line between UK and Ireland the western boundary. The boundaries of this Region were chosen so as to coincide with those defined by the Irish Sea Pilot Project undertaken by JNCC.

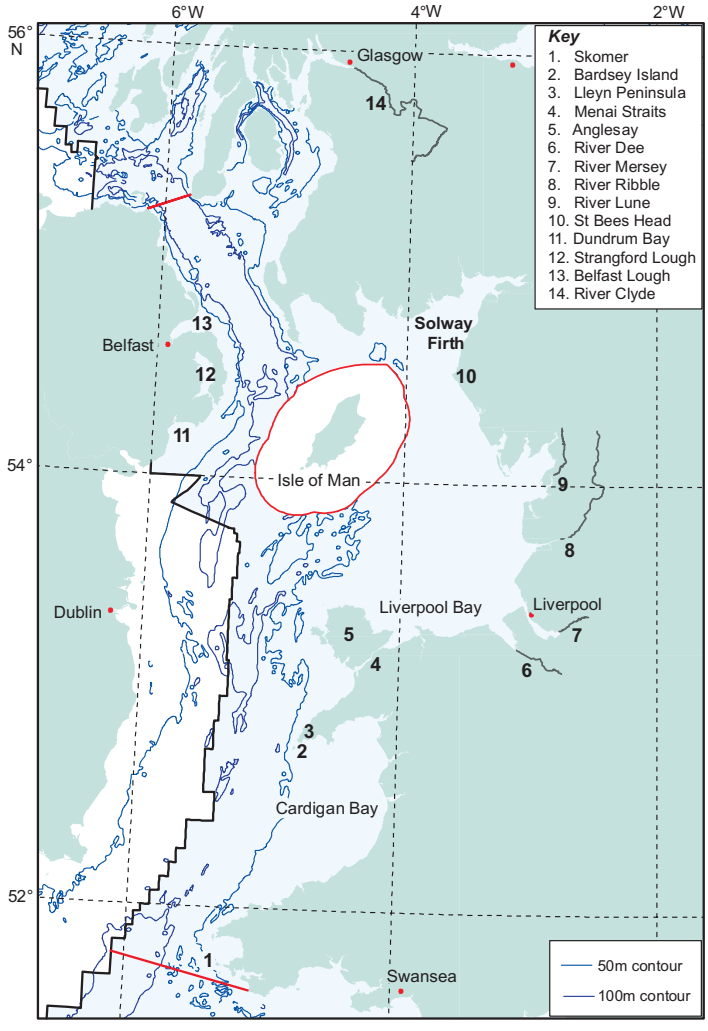


Figure 5.1. Map of Region 5. Bathymetric contour data copyright UKHO

Figure 5.1 shows the position of the Region in relation to its two immediate neighbours Regions 4 (Western English Channel, Celtic Seas and South-west Approaches) and Region 6 (Minches and West Scotland) and the locations of the major places mentioned in this chapter. Bottom water temperatures vary between 1 and 13˚C and stratification occurs seasonally in the deeper areas. The Region is sheltered from the worst influences of oceanic storms. However, storm surges can be funnelled through the area causing unusually high sea levels, especially when coincident with periods of spring tides. The Region has a wide variety of habitats ranging from rocky coasts, particularly around Wales, to extensive areas of sand and mudflats in Morecambe Bay, and the Solway Firth. The Welsh and Scottish coasts have numerous small rivers and coastal towns but are not densely populated, whereas the English coast features a number of major estuary systems and there are major centres of population around Merseyside, Belfast Lough and the Clyde estuary. The Strathclyde region is an important area for mariculture particularly for shellfish.

PHYSICAL ENVIRONMENT

WEATHER AND CLIMATE

On an oceanic scale wind speed and direction, air/sea heat exchange and evaporation/precipitation are the major factors driving ocean circulation. The influence of all three factors is controlled or modified by the North Atlantic Oscillation (NAO). At the level of a regional sea these same factors affect waves and associated currents, storm surges etc, either directly or through the effect they have had in the Atlantic. Stronger or more frequent westerly winds over the North Atlantic will drive more Atlantic water into UK waters and bring more rain and warmer air. In turn this will result in lower temperatures in coastal waters and enhance density driven coastal flows and contaminant run-off, whereas the warmer air will raise temperatures, especially in the shallower waters around the UK such as those in the Irish Sea.

There are good long-term temperature records for Central England Temperature (CET). This is an area roughly bounded by Bristol, Manchester and London and the records go back to 1659. These records show that five of the six warmest years occurred during the 1990s and that the mean CET increased during the 20th Century by about 0.5°C. This scale of rise is supported by data for a land station in Northern Ireland, which indicates a similar rise between 1873-1902 and 1961-1990. Within the Irish Sea the Met Office has a station at Aberporth. Judging by wind data collected at Bidston Observatory on Merseyside wind direction and strength is very variable on a year by year basis but the main direction is westerly with occasional strong winds from a south-easterly direction (Figure 5.2). Note the marked differences between the two winters, which are attributable to the marked difference in NAO.

Rainfall is equally variable. The Met Office records go back to 1766. These records show the 24 months ending March 2001 were the wettest on record in England and Wales and the 12 months ending March 2001 the wettest 12 months. Records for Northern Ireland show that summers during the last three decades of the twentieth century were drier than the previous 70 years but total rainfall has not changed markedly, meaning the winters have become wetter.

Changes in the NAO can be linked directly with much, though not all, of the warming that is clearly detectable over the UK and with the wave climate west of Britain and thus that of the Irish Sea. When the NAO is positive storm activity tends to be pushed north-east wards from Newfoundland into northern Europe, with more intense and frequent storms around Iceland and in the Norwegian Sea. There is evidence from work at the Hadley Centre that the average number of storms over the UK has increased over the last 50 years but decreased over Iceland. This would be consistent with a southerly movement of the Atlantic storm track. However, the records also suggest that storms are no more frequent now than they were at the beginning of the last century.

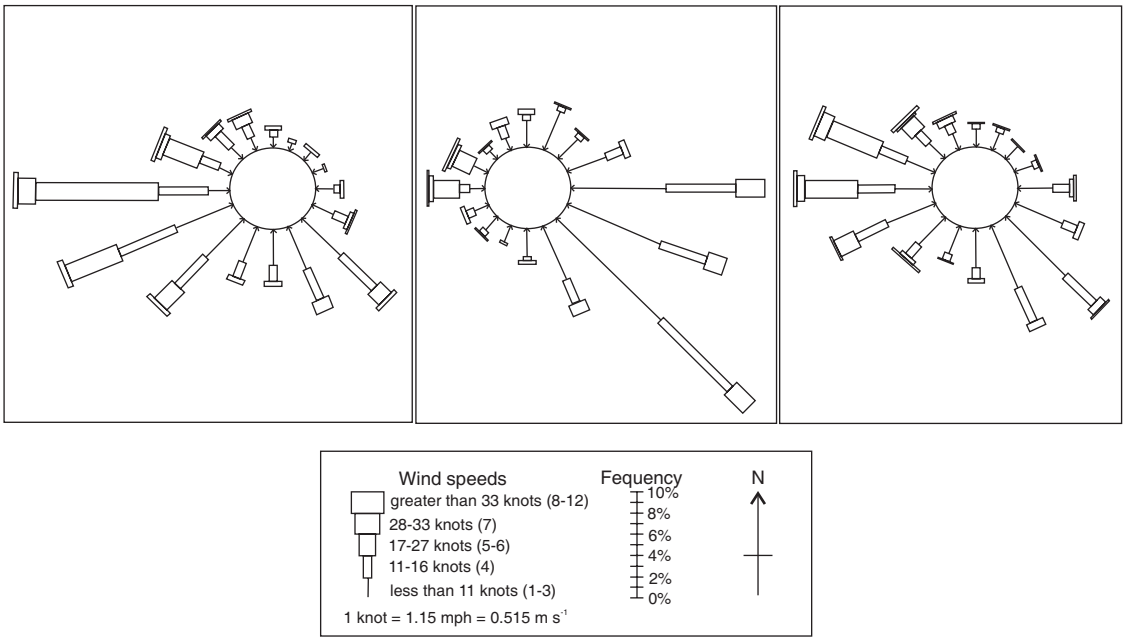


Figure 5.2. Bidston wind roses for extreme Index years and full data series Frequency, force and direction of the wind at Bidston Observatory, Birkenhead, for winter (December to February). Left is winter 1994/5, centre is winter 1995/6, right is full data series, 1992-2003. Courtesy of POL and Andy Tabor

SEA TEMPERATURE

As would be expected from the evidence of a warming trend in air temperature over land and on the coast, sea surface temperatures (SST) in and around the Irish Sea generally, have shown an increase in temperature over the years. Thus for example between 1950 and 2002, based on data held by ICES, winter SST in the Irish Sea increased by about 0.5°C, although there was an apparent cooling in summer SST since the 1980s (Figure 5.3).

Data from Port Erin also show an increase in temperature over the last 70 –100 years of about 0.6°C. Similar patterns are shown by data from coastal stations in Northern Ireland, and in the Mersey and Ribble estuaries. An even larger rise >1°C over the last 40 years has been reported locally for the Menai Straits) but it should be noted that the time series started in 1962/63 which were very cold years (*Ref MECN Research Contract Report to Defra*).

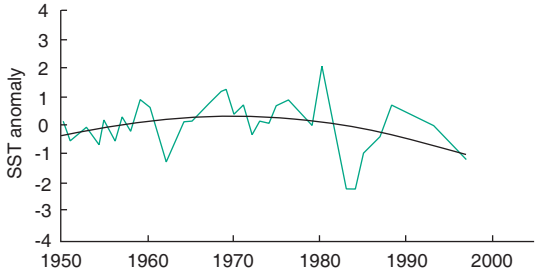


Figure 5.3. Summer (July to September) SST Anomaly, 1950-2002, Irish Sea (53-55°N, 6-4°W)Time series produced by averaging the summer data sets by year. Anomalies produced by subtracting the mean calculated for the whole period. Long-term trend based on a second order polynomial. Courtesy of the ICES Oceanographic Data Centre

SALINITY

Most of the Irish Sea waters can be regarded as fully mixed so that sea surface data can be regarded as reasonably representative of the whole water column. An exception is the seasonal summer stratification that develops in the north-west of the Region. Data held by ICES for sea surface salinity in the Irish Sea show an apparent decrease during the period 1950-2002 in both summer and in winter (Figure 5.4).

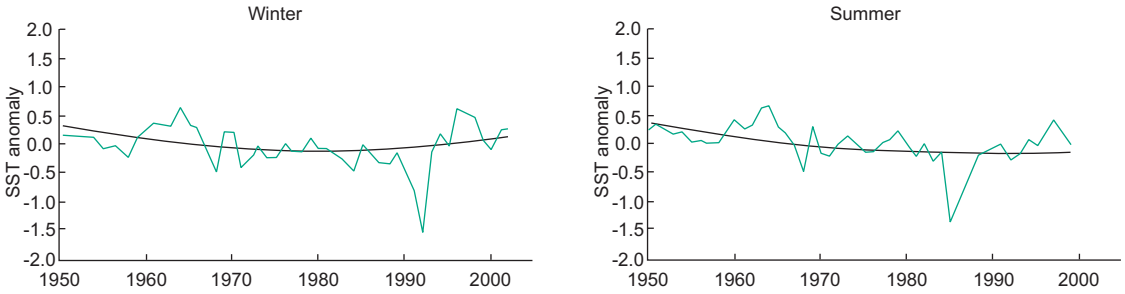


Figure 5.4. Winter (January to March) and Summer (July – September) SSS Anomaly, 1950-2002, Irish Sea (53-55°N, 6-4°W).Time series produced by averaging the winter data sets by year. Anomalies produced by subtracting the mean calculated for the whole period. Long-term trend based on a second order polynomial. Courtesy of the ICES Oceanographic Data Centre

This may in part be a reflection of there being markedly fewer observations since 1980 thus reducing confidence in any single data point; for example the data include only a single winter value in 1991 and this was unusually low and possibly unrepresentative of the overall situation. However, data collected at Port Erin between 1965 and 2002 also appear to show a similar trend in minimum, maximum and mean salinity. There is however, considerable inter-annual variation and it might be that this is linked to surface run-off which has also shown marked variability in recent years. However, although fluctuations in salinity have occurred in the Menai Straits the salinity record versus river nutrient loads do not support a simple connection (*MECN Research Contract Report to Defra*).

WAVES

Waves approaching the UK from the Atlantic may have been generated by local wind conditions, as well as those in the North-east Atlantic and the North-west Atlantic but on occasions even the South Atlantic. The maximum height of waves is important because they can affect shipping, pose a risk to offshore structures such as oil and gas platforms and to coastal defences. Coastal flooding is most often caused when high tides coincide with storm surges and unusually high waves. In the Irish Sea, as with other UK waters, the wave climate is strongly seasonal, with mean wave heights tending to peak in January but with a high likelihood of high monthly mean and extreme wave heights arising at any time throughout autumn and winter. There are no long-term records of wave heights in the Irish Sea from a single type of measuring system but wave data from ships, buoys and satellites collectively show that between the 1960s and through into the 1990s wave heights have increased in the north-east Atlantic.

CIRCULATION

Flushing time is an indication of how long it typically takes for water to move through an area and thus has some value in terms of understanding overall water movement. Clearly there will be considerable variation depending on season and year to year but for the Irish Sea the normally accepted average value is about one year. In a shallow sea area such as the Irish Sea the circulation shows considerable variability, particularly depending on wind forcing and air/sea heat exchange. Typically water flow through the Irish Sea is from south to north but this may be slowed or even locally reversed depending on wind conditions and river discharges, which may also set up gyres and inshore currents counter to the normal overall flow. In the eastern Irish Sea, density driven currents are particularly important. In this area the saline oceanic inflows and freshwater inputs from the rivers Dee, Mersey, Ribble and Lune cause horizontal and vertical density changes in Liverpool Bay. These flows are strongest in winter and spring but even then they can be overwhelmed in periods of strong winds

Most areas of the Irish Sea are continuously vertically mixed but stratification regularly occurs under calmer summer conditions in the deep basin in the western Irish Sea and in Cardigan Bay. Deep-water gyres develop with strong narrow jet stream currents, which retain material within the Region as long as stratification persists. There is evidence of considerable changes in flow conditions in the Irish Sea over the last 30 years based largely on the observed distribution

of ^{137}Cs relative to numerical models which were developed based on earlier circulation data. For example coastal flow conditions for the north-eastern Irish Sea along the Scottish coast changed post 1977 up to 1980-81 when the flow rate appeared to double but then reverted to the earlier flow pattern. Such findings emphasise the need for caution in using loose average information such as flushing times and extrapolating trends.

SEDIMENT CONCENTRATION AND TRANSPORT

Further details of seabed type can be found in the section dealing with Habitats and Species but in terms of sediment transport, satellite images show two distinct turbidity maxima in the Irish Sea, one off Anglesey and the other off Wicklow Bay (Figure 5.5).

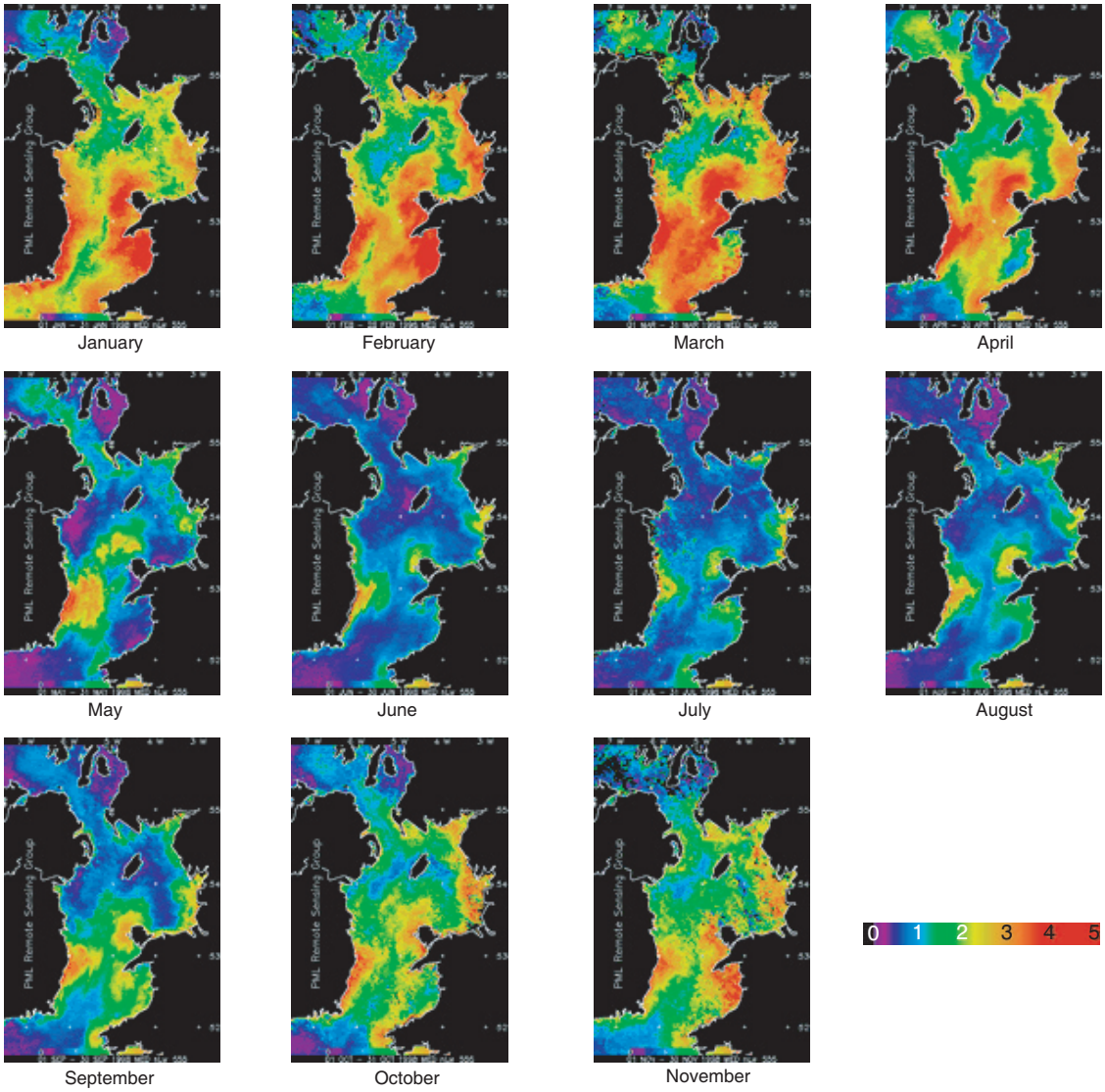


Figure 5.5. Satellite images of reflectance at 555nm during 1998, closely related to SPM concentrations. The images are NASA SeaWifs composites for the Irish Sea 1998 at a resolution of 1.1km. Courtesy of NASA and PML Remote Sensing Group

Figure 5.5 also illustrates the influence of calmer conditions in the summer months relative to winter conditions when suspended solids loads are markedly greater. These coincide with the areas of maximum tidal currents, which maintain fine sediments in suspension throughout the water column. There is a southerly and south-westerly offshore transport of sediment off the Lleyn peninsula and a northerly and north-easterly offshore transport off the north coast of the Lleyn peninsula i.e. divergence. Offshore divergence occurs from Ireland to Bardsey Island and from Northern Ireland to Scotland. Offshore convergences occur west and east/south-east of the Isle of Man, Liverpool Bay and Morecambe Bay. The nearshore sediment pathway is mainly northerly along N-S coasts and easterly along E-W coasts. Off the mid-Wales coast, the coastal and offshore pathways run in opposite directions because tidal and wind forces run in opposite directions, In terms of changes with time there is evidence that water clarity in the Menai Straits, as measured by Secchi disc, decreased from 2.3 m to 1.5 m between the mid 1960s and late 1980s. This however, does not necessarily imply increased sediment loading as the measurement reflects total suspended matter including plankton. There was no evidence from satellite reflectance imagery data, of any consistent trend in suspended sediment concentrations between 1987 and 1997 in the Irish Sea. Year to year variability was however, positively correlated with changes in wind strength, which in turn was related to north to south pressure gradients and the NAO.

CHANGES IN SEA LEVEL, COAST AND SEA BED

The implications for mean sea level of land mass movement as a result of post-glacial adjustment are small in the Irish Sea region because it lies in an area of minimum change. The Irish Sea records since 1768 for Liverpool show short-term variations of the tidal components but no long-term tends in sea level nor is there any evidence of a trend in sea level surges. There is however, a link between sea level and the NAO with a positive NAO index leading to anomalously low air pressure in the north and thus a hydrostatic increase in sea level due to the pressure change, but this appears to have only a limited impact in the Irish Sea.

The major estuaries along the Wales coastline are largely in-filled with sediment and those of the Dyfi, Mawdach and Dwyryd Rivers have major spits and dune complexes at their mouths. The development of these spits is not a recent phenomenon; they began to form as sea levels began to stabilise more than 5000 years ago. Similar in-filling by sediment is occurring in the major estuaries of north-west England such as the Dee, Mersey, Ribble and in Morecambe Bay and the Solway. The Mersey for example has seen a net loss in volume of between eight and ten percent over the 70 years to the late 1970s, although since then there has been a small increase. The most significant changes have occurred in the upper estuary and inter-tidal region.

ENVIRONMENTAL QUALITY

NUTRIENTS

In the natural environment the growth of aquatic plants is regulated by biological, chemical and physical factors. Of the physical factors temperature and light are important and of the chemical factors nitrogen and phosphorus and to a lesser extent silicate and carbon are essential for growth. Thus, if any of these is in limited supply, growth may be inhibited. Equally it may be enhanced if they are available in increased amounts, or in the case of temperature, growth may occur earlier. Excessive plant growth in response to increased supply of nutrients is termed eutrophication. Although it is not a new phenomenon and was first identified in coastal waters almost 100 years ago, in recent years eutrophication has become a cause for concern and remediation measures. Various measures have been introduced to reduce inputs and draft common assessment procedures have been proposed by OSPAR to guide priorities for action. These set normal and elevated levels for dissolved inorganic nitrogen (DIN) and phosphorus (DIP). These criteria allow for natural regional differences and for the Irish Sea are set at 12 and >18 μmol/l for DIN and 0.8 and >1.25 μmol/l for DIP respectively.

In the Irish Sea, as elsewhere in the immediate coastal area (waters with salinity <34) DIN concentrations exceeded the 18 μmol/l level and in Belfast Lough they were as high as those found around south-eastern England. Time series data for nutrients in the Irish Sea are available from the Isle of Man and Menai Straits. The Isle of Man time series shows that nitrate concentrations

rose between 1960 and 1990 but have since levelled off, albeit with considerable inter-annual variability. Phosphate concentrations also rose until 1990 but have since declined. In both cases the changes are considered to have come about in response to changes in inputs from the land (*MECN Research Contract Report to Defra*). In the Menai Straits there seems to have been a similar trend but with a greater response to land-based reduction measures in the water concentrations of both nitrogen and phosphorus (Figure 5.6) although this may also in part be due to changes in the relative oceanic water inflow through St George's Channel (*MECN Research Contract Report to Defra*).

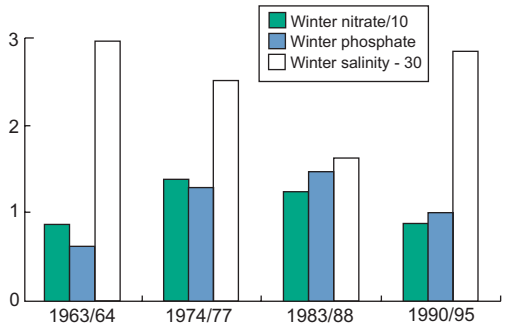


Figure 5.6. Decadal comaprison of winter nitrate, phosphate and salinity for the Menai Straits

In comparative terms in the eastern Irish Sea concentrations of nutrients are generally lower than in the southern North Sea (Region 2) but, as in that area, are clearly elevated. Algal growth in response to these elevated concentrations is detectable via elevated concentrations in chlorophyll A levels. In some local areas, most notably inner Belfast Lough, they were more than 50 per cent higher than the levels regarded as historical background offshore, although in the past three years there has been a major improvement and high concentrations of chlorophyll A are no longer observed. However, the relevant sectoral report makes no mention of increased blooms in the Irish Sea as a whole or of the occurrence of any algal species considered to be associated with eutrophication. Also in the general context of chlorophyll concentrations it should be noted that a reduction in primary production as measured by chlorophyll has been reported off the Isle of Man (*MECN Research Contract Report to Defra*).

HAZARDOUS SUBSTANCES – METALS

Within the Irish Sea all concentrations of metals in sea water are reported to be below the EQS values i.e. those defined as not likely to harm aquatic life. However, concentrations of mercury in water from the Mersey and of cadmium in sediments from the same area exceed the Background Reference Concentration (BRC) values set by OSPAR in 1997 i.e. they are above the concentrations regarded as typical of the more remote areas of the OSPAR region. Concentrations of mercury in water from the Mersey and for lead in sediments from that area and off the Isle of Man, Belfast Lough and the Clyde also exceeded the levels adopted by OSPAR as Ecotoxicological Assessment Criteria (EACs). (It should be noted that the BRC and EAC values referred to in this review are those adopted by OSPAR in 1997. These values have been reviewed and were recently revised but the new values were not available when the sector report on Environmental Quality was being prepared; they have not therefore been used in this review either.) Concentrations of copper and zinc in mussels used as indicators of relative levels of contamination in the immediate coastal zone were generally below the accepted BRCs but concentrations of mercury in fish from Liverpool and Morecambe Bays exceeded the BRC. However, the concentrations reported in 2002 were lower in both areas than those found in1993-1995 and this probably reflects a continuing trend in response to controls on previous industrial discharges from chlor-alkali plants that affected these areas up to the mid 1970s (*Author's note*).

HAZARDOUS SUBSTANCES – CHLORINATED ORGANICS

Certain chlorinated organic compounds have been found to combine persistence and a tendency to bioaccumulate with toxicity. As a consequence controls have been applied severely restricting the use of many of these substances with resultant declines in the concentrations found in the marine environment. However, concern still centres on hexachlorocyclohexane (HCH) which in its gamma isomer form was used as an insecticide (its use was banned in EU countries in 2002). Inputs from the UK declined in response to earlier restrictions and fell by between 60 and 80 percent between 1990 and 2001. Within OSPAR, EACs were set for HCH but investigations under the NMMP found all concentrations in water

samples from the Irish Sea to be below these and concentrations are expected to fall further following the total ban in 2002. PCBs are another class of chlorinated organic compounds and until manufacture ceased in the early 1970s and sales in the UK were banned in 1986 concentrations are usually expressed in terms of seven selected CB compounds (commercial formulations were sold as mixtures) and OSPAR has set the EAC range as 1-10 μg/kg dry wt. in sediments. The NMMP data up to 2002 show that within the Irish Sea area concentrations in sediments exceeded the upper level in the Clyde and Mersey estuaries, with one sample from the Mersey containing more than five times that level. Concentrations of CBs are also measured in fish liver and mussels under the NMMP. Concentrations in fish liver from the Mersey estuary and Liverpool Bay were among the highest recorded for the UK as a whole although concentrations in fish livers from the Solway were the lowest. Data for earlier years were collected on a different basis and so no trends can be established, although the 1993-95 data also show concentrations to be high in fish livers from Morecambe Bay. There are no BRCs or EACs for CBs in fish liver but both BRCs and EACs were set for mussels. Concentrations exceeded the EAC in both the Mersey and Clyde estuaries.

HAZARDOUS SUBSTANCES – POLYCYCLIC AROMATIC HYDROCARBONS (PAH)

PAHs are produced naturally e.g. in forest fires and from urban and industrial sources, including the burning of fossil fuels. EACs have been established for eight individual compounds in sediments and these plus two more feature in the NMMP. The sum of the ten compounds exceeded the sum of the eight compounds for which EACs were set at three sites in the Irish Sea area – Morecambe Bay, the Mersey estuary and the Bann estuary in Northern Ireland. From this it is concluded that effects may occur in sediment dwelling animals, including induction of neoplastic liver disease in fish. Concentrations of PAH are also measured under the NMMP in mussels from 20 site around the UK. The highest concentrations were found in mussels from the Clyde estuary (682 μg/kg wet wt) but were still below the sum of the upper EACs. All the summed concentrations found were below the OSPAR EACs, suggesting that they did not pose a threat to either mussels or human consumers.

ORGANIC CONTAMINANTS RECENTLY RECOGNISED AS BEING PRESENT IN THE MARINE ENVIRONMENT

In addition to the routine surveys undertaken for substances commonly recognised as hazardous, investigations are also undertaken aimed at assessing potential new problems. These are usually undertaken on a pilot scale and recent studies have examined brominated flame retardants and alkyl phenols. Both studies included sites within Region 5.

Alkylphenol ethoxylates are non-ionic surfactants of which the most common are the octyl and nonyl forms. They are widely used in both commercial and domestic applications and once in the environment readily break down into alkyl phenols. Within Region 5 most of the samples of sediments were found to contain concentrations of nonyl phenol and nonyl phenol mono- and di-ethoxylates of less than the limit of detection of the method used (1mg/kg and 0.2mg/kg respectively). Octyl phenol was detectable in samples of sediment collected at a number of coastal sites within the Region, particularly in Liverpool Bay. However, the concentrations were low and none exceeded 0.06 mg/kg.

Bromine based flame retardents are applied to a variety of polymer products. Some 70 different chemicals are involved, with a total global usage of around 300,000 tonnes. Like PCBs most products contain mixtures of compounds. The first studies in the UK focussed on polybrominated diphenyl ethers (PBDEs) but, with the exception of deca-brominated diphenyl ether, use of these compounds has been discontinued within the EU. Studies are therefore now being directed towards hexabromocyclodecane (HCBD) and tetrabromobisphenol-A (TBBP-A). Within Region 5 studies involving analysis of up to 15 individual BDE compounds were undertaken in 1999. These did not include samples of invertebrates. However, the highest concentration of PBDEs found in the livers from samples of dabs was found in a sample collected off Anglesey (330 μg/kg as the sum of 15 individual BDE compounds). Following cessation of use of most of these compounds within the EU concentrations of PBDEs are expected to decline.

RADIOACTIVITY

The largest single input of artificial radionuclides around the UK arises from Sellafield on the Cumbrian coast in Region 5. Other minor sources arise from various nuclear powered electricity generating plants and hospitals. 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 1,000 times lower than peak discharge levels. An exception is ^{99}Tc discharges which rose in 1994 following commissioning of the Enhanced Actinide Removal Plant (EARP). The increase in 1994 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. The peak discharge rate was reached in 1995 and ^{99}Tc has subsequently been detected in sea water and in lobsters, seaweeds and other marine biota in the northern sector of the Region. Authorised annual discharge limits were reduced by slightly more than half from 200 to 90 TBq in January 2000 and the intention is to reduce the authorisation limit to 10 TBq by 2006.

Concentrations of ^{137}Cs in sea water are now only a small percentage of those prevailing in the 1970s. The highest concentrations of radionuclides in sediments occur 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. 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.

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. All authorised releases of radioactive materials are subject to regular monitoring and assessment of exposure. In all cases individual doses experienced by the public are well within the internationally agreed dose limits. Radiation exposure of marine organisms in the north-eastern Irish Sea is unlikely to cause adverse effects at the population level. This applies even to historical dose rates that are likely to have been at least ten times greater than present day levels.

MICROBIOLOGY

Monitoring is undertaken around the UK in response to three EC Directives, each of which defines acceptable limits for bacterial indicators of faecal contamination. In compliance with the Bathing Waters Directive (for which new, tighter standards are in the process of being agreed) monitoring was conducted in 2003 for 565 bathing waters identified by the UK, of which 556 (98.4%) passed the current mandatory standards compared to 78.1% in 1990. Whilst this represents a considerable improvement and reflects the major investments made in better sewage disposal, four of the failing beaches were in Region 5, two in the Clyde area one on the Welsh coast and one on the Lancashire coast. A significant factor in the continued failure of bathing waters in this Region is thought to be diffuse sources, in particular run off from land used for rearing cattle and sheep.

The Shellfish Hygiene Directive sets differing standards for *E. coli* and faecal coli in shellfish flesh (rather than water) according to whether the shellfish can be sold directly (class A) after passage through an approved purification process (class B) or after a lengthy period of relaying in either a class A or B area (class C). Between 1999 and 2003 there has been an increase in the number of shellfish growing waters achieving class B status rather than class C (87% in England and Wales as opposed to 69% in 1999). Again this largely reflects improved sewage disposal arrangements. Unfortunately out of a total of 88 sites within England and Wales in Region 5, 17 were still graded class C with a further seven graded as prohibited i.e. no harvesting allowed. None of the sites in Northern Ireland fell below Class B and in Scotland comparisons over a period are not possible because the system used was changed. However, 21 sites were classified in 2003 and of these five were graded class A, seven class A/B seasonal, seven class B and two class C.

The Shellfish Waters Directive is intended to protect and improve conditions for growing shellfish. The standards are defined differently to those for the Shellfish Hygiene Directive but are broadly similar in effect to the conditions for class A. Although the areas designated under the two Directives do not currently all coincide the government's declared aspiration is that broadly they should and that all waters designated under

the Shellfish Waters Directive should reach at least the class B standard of the Shellfish Hygiene Directive. In the Irish Sea there is some way to go before this objective is reached as overall 51% of the designated waters that failed to meet that standard in the period 1999 to 2002 were located in Region 5. Northern Ireland has designated nine areas under the terms of this Directive with monitoring undertaken at 31 sites. None of these failed in 2000 but two failed in 2001. Within Region 5 Scotland has designated nine shellfish waters under the terms of this Directive. Several sites have consistently failed to comply with the guideline standards for faecal coliforms but improvements to local discharges now underway in response to requirements under the Urban Waste Waters Treatment Directive are expected to result in better compliance. However, a number of failures remain unexplained and may be as result of diffuse or agricultural sources.

OIL AND OIL SPILLS

The entire area around the UK is within the European Waters Special Area established by IMO in 1999. As such, all deliberate discharge of oil or oily water mixtures from ships is prohibited. Illegal discharges do still take place and in 2001 around 15 oil slicks were attributed to vessels in Region 5. Most of these were in the eastern Irish Sea between North Wales and the Isle of Man or in the North Channel. No oil spills as a result of shipping accidents have occurred in the Region since the *Sea Empress* spill in early 1996. Most of the impact of that spill was experienced in Region 4 (see Chapter 4 for more details). However some oil did affect the important Marine Nature Reserve around Skomer and some rare species in the outer reaches of Milford Haven. However, even at these sites the effects had in most respects ceased to be detectable by early 1998 i.e. within 2 years of the event. The use of oil based muds in drilling operations was never a major feature in the Irish Sea and old cuttings heaps are not regarded as a significant source of oil in the Region. An ecological quality objective (EcoQO) has been defined by OSPAR, which states that the number of oiled common guillemots found dead or dying on beaches should be less than 10% of the total. To date no systematic surveys have been undertaken in the Region to establish the extent of compliance with this EcoQO.

NAVIGATION DREDGING AND AGGREGATE EXTRACTION

Dredging is an essential activity if harbours and their approach channels are to be maintained or improved. Although in total terms minor fluctuations arise in the quantities of material dredged and relocated each year the overall quantities reflect the fact that most major ports undertake dredging more or less continuously. There are more substantial differences in capital dredging activities and in 2002 five port developments were underway in the Irish Sea area. In 2001 almost 6.2 million tonnes of dredged material were disposed of at 15 disposal sites in the Irish Sea region. This was about two million tonnes more than in any other Region. Very few disposal sites are monitored regularly but the overall aim is to limit the impact of the operation on the biota and seabed profile in the area and monitoring is undertaken at intervals at most sites.

Work is underway to establish indicators of effects but as yet none have been agreed. Limits have however been set at national level for acceptable levels of contaminants in dredged material allowed to be relocated at sea and concentrations have decreased over the years. When the defined acceptable levels are exceeded alternative methods of disposal must be found.

Dredging of natural sand and gravel (aggregate) deposits is an important aspect of UK national policy. The material taken within Region 5 is mostly sand from off the North Wales coast and amounted to 3.8 million tonnes between 1993 and 2003 - less than 2% of the UK total. The quantity may rise slightly to about 4 million tonnes between 2001 and 2016 but this still represents only about 2% of the projected total. There is no doubt that removal of aggregates from the seabed affects the local benthic ecosystem but feed-back from monitoring of these effects allows controls to be set such that recovery is possible in the short to medium term. It is therefore increasingly possible to achieve one of the defined objectives of allowing extraction viz. that the impact is minimised. Similarly, techniques for monitoring the positions of the dredging vessels mean it is possible to detect and thus limit out of area dredging operations. Aggregate extraction

is only permitted after an Environmental Impact Assessment and extensive consultation with other user interests.

CONSTRUCTION

About a third of the UK population lives within 10 km of the coast. Inevitably therefore much construction has already taken place in the form of sea defences, ports and harbours and urban development generally. Within the Irish Sea no major coastal construction projects are planned at present except for the development of a number of wind farms as part of the Government's strategy to decrease carbon dioxide emissions. Five hundred wind turbines are proposed for construction in the Irish Sea region; all of them in the area between North Wales and the Solway Firth. Various concerns arise as to the possible impacts of such developments on other activities e.g. fishing and over changes to the physical environment through modification of sediment transport and deposition, and effects on fish and birds, and sea mammals e.g. through interfering with migration routes. As yet construction has been completed at only one site in the Irish Sea at North Hoyle off the North Wales coast, so no results of monitoring the extent of such effects are available. It is however intended to feed the results of such monitoring into the design and approval process for future rounds of offshore renewable energy projects.

MARICULTURE

The majority of the fish and shellfish farms in the UK are located around Scotland in Regions 1, 6 and 7, but there is some mariculture activity in Region 5 in the Strathclyde area. Most of the activity is focused on farming of shellfish species although there is some farming of fish as well. Because the activity is mainly centred on shellfish, which derive their food from the wild plankton naturally present rather than feed pellets, issues such as accumulation of food residues and medicines are much less of concern than in Regions 1, 6 and 7. However, the industry in Region 5 is regulated to the same standards that are applied in other Regions around Scotland with the overall aim of encouraging increased production whilst at the same time minimising impact on other interests.

CONTAMINANT SPECIFIC BIOLOGICAL EFFECTS

In general marine organisms cope with different levels of exposure to metals by converting toxic forms into less toxic bound forms which can be stored and subsequently excreted. One such mechanism is the induction of metallothionein (MT). This is a natural response particularly to mercury, copper, cadmium and zinc and can provide an indication of exposure, though not of the health of the organism concerned. Surveys of MT in dabs from offshore sites showed high variability, no correlation between males and females from the same sites, and little apparent link with existing data on metal concentrations in livers. The MT content of mussels from a small number of estuarine sites was compared to that found in mussels from Brancaster on the North Norfolk coast (Region 2). There was no correlation with MT levels in the livers of flounders from the same estuaries. However, MT levels in mussels from sites in the Mersey and Clyde estuaries were elevated compared to those in the Brancaster control. Levels of MT in the sample from the Mersey were similar to those found in mussels from the Tees (Region 1) but MT levels in mussels from the Clyde were higher again being similar to those found in a sample from the Thames (Region 2)

Certain organic chemicals can disrupt normal endocrine function and in fish this can result in feminisation of male fish. This is readily detectable by vitellogenin (VTG) assay and in extreme cases by the presence in the male gonads of eggs in various stages of development. Such a condition has been recorded in flounders from the Mersey. However, although flounders from the Mersey were found to exhibit the highest VTG levels in a survey of estuaries undertaken in 1995, levels were subsequently lower in most years thereafter and in February 2001 the level had declined by more than a thousand-fold.

TBT was used in antifouling paints applied to pleasure craft, and commercial shipping including fishing vessels, but its use has been discontinued following discovery of the fact that it causes widespread adverse effects on marine organisms. One such effect is imposex

in dog whelks. This term is used to describe the development in female dog whelks of male characteristics. Two indices of exposure are used, relative penis size index (RPSI)and the vas deferens sequence index (VDSI). A survey was undertaken along the west coast of England, Wales, Scotland and Northern Ireland to establish the level of exposure to TBT following cessation of use. The results showed that TBT is still present in the environment but at no sites in Region 5 was the level of exposure sufficiently high to inhibit reproduction.

A measure of exposure to PAH (and to certain CBs) can be obtained by assessing the rate of synthesis of a group enzymes by fish liver, one of which is known as EROD. High levels of EROD activity have been found in dab from various sites in the Irish Sea e.g. in males caught off Morecambe, St Bee's Head and in outer Cardigan Bay and in flounders caught in Liverpool Bay. Insufficient data exist to allow any form of trend analysis but high levels of EROD activity might be expected to be associated with various pathological changes in fish livers.

Fish liver pathology examination is therefore one of a range of techniques used to assess the well-being of flat fish. The studies form part of the NMMP and the presence of foci of cellular alterations (FCA) is one test where clear regional differences seem to be apparent. FCA prevalence was highest in the Mersey (18.4%) but lowest (0%) in Belfast Lough and in the Clyde FCA prevalence was double (4%) that found at the control site in Rye Bay (Region 3). For most liver pathologies no trends are apparent but higher numbers of liver nodules were recorded in dab from Liverpool Bay and Cardigan Bay in 2002 than in 2000 and 1995 respectively.

NON-SPECIFIC BIOLOGICAL EFFECTS

Measurement of fish disease conditions in individual fish is recognised as an integrative tool for monitoring the overall health of fish populations and surveys using dab and flounder have been conducted in a number of areas for several years. Some areas of the Irish Sea consistently show higher levels of disease than fish from a reference site in the English Channel and in Cardigan Bay there has been an increase in several disease conditions in dab (Figure 5.7).

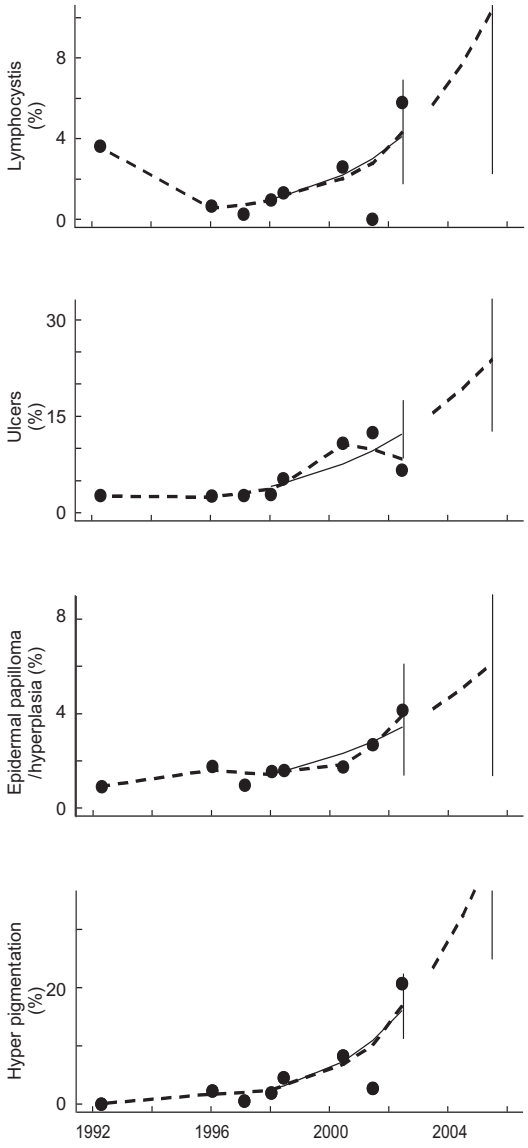


Figure 5.7. Trend in disease levels in dab in Cardigan Bay

The oyster embryo bioassay has been used over a number of years as a means of assessing general water quality. Embryos of the oyster *Crassostrea gigas* are exposed to water samples for 24 hours and their success in developing to 'D' hinge larvae provides a measure of the water quality. The studies have shown that poor water quality is only encountered in estuarine areas. Between 1999 and 2001 water samples from sites in the Mersey (two sites) and Ribble

estuaries and from Morecambe Bay and off St Bees Head were tested on several occasions. At none of the five sites sampled was any significant toxicity revealed. Ten years earlier responses of between 50 and 100% were regarded as typical for estuarine sites suggesting there has been a significant improvement in water quality over this period. A survey was conducted on three occasions between May and August 1999 along a 30 km transect in the Clyde estuary. Samples were collected at several depths to reflect the stratified nature of the estuary. No response was observed in either the survey in May or early August. However, on the third survey in mid-August, significant toxicity (i.e. a response of greater than 20%) was observed at 6m depth at the Kelvin confluence and at both 2 and 6m depth at Rothersay Dock. These results highlight both spatial and temporal variability and perhaps indicate the need for some caution in drawing conclusions as to trends in water quality based on relatively few samples.

Two sediment bioassays have been developed and are now routinely deployed to assess sediment quality in four estuaries of which the Mersey is one. Nineteen sites are sampled and the results show there are differing effects along the estuary suggesting different levels of exposure to harmful substances. However, such observations have only been made for a short period and no change can yet be assessed.

LITTER

The sector report on Environmental Quality gives only very limited information on the regional prevalence of litter based on a single survey conducted by the Marine Conservation Society (MCS) in 2003. Equally the sector report on Habitats and Species contains no information on the regional effects of litter. Consequently it is inappropriate to go into any detail in this chapter. However, a brief summary of the overall incidence, scale and significance is provided in the final chapter of this Integrated Assessment. Region 5 had a higher density of beach litter at 2.9 items/m surveyed than the UK average (2 items/m). The most significant sources of litter in the Region were judged to be beach visitors (over 32%) and sewage related debris (almost 22%). The average amount of sewage related debris found in Region 5 was in fact higher than anywhere else in the UK, but this was largely on account of extremely high levels on a single beach.

HABITATS AND SPECIES

FISH ASSEMBLAGES

There are several distinct fish assemblages in the Irish Sea with their distributions related mainly to the depth and seabed type. The inshore waters of the eastern Irish Sea have mainly a sandy bottom. In these areas, in addition to the exploited flat fish species such as sole (*Solea solea*) and plaice (*Pleuronectes platessa*), species such as tub gurnard (*Trigla lucerna*), lesser weever (*Echiicthys vipera*), common dragonet (*Callionymus lyra*) and sand gobies (*Pomatoschistus* spp.) are all abundant. The offshore grounds are coarser and spotted ray (*Raja montagui*), cuckoo ray (*Leucoraja naevus*), lesser spotted dogfish (*Scyliorhinus canicula*), red gurnard (*Aspitrigla cuculus*) and thickback sole (*Microchirus variegatus*) dominate. In the *Nephrops* grounds the sea bed is more muddy and species such as witch (*Glyptocephalus cynoglossus*) and Fries's goby (*Lesuerigobius friesii*) are found only in these areas. Some species do seem to have become much less common, for example white skate (*Rostroraja alba*) is no longer caught and common skate (*Dipturus batis*) is only rarely caught – typically in the North Channel. The rocky grounds around Anglesey and the Lleyn peninsula are important areas for greater spotted dogfish (*Scyliorhinus stellaris*). In the deeper waters to the west of the Region small numbers of long-rough dab (*Hippoglossoides plattessoides*), Norway pout (*Trisopterus esmarki*) and boarfish (*Capros aper*) may be found.

COMMERCIAL STOCKS AND LANDINGS

Landings of pelagic species (mainly herring and mackerel) from the Irish Sea have fallen from about 20,000 t in the 1970s to less than 6,000 t for the last 20 years. The herring stock has increased in recent years from the low levels seen in the early 1990s. The Clyde herring stock in the north of the Region is however, considered to be at a low level. The main demersal fisheries are for *Nephrops*, which yield by-catches of whiting, cod, haddock and plaice with considerable discards of whiting and plaice. The *Nephrops* stock is considered to be fully exploited but there is concern over the high level of whiting discards – about 60% of the whiting caught in this fishery are discarded. The haddock stock shows considerable fluctuations with time, with periods of strong recruitment in the

1960s, 1979s and again in the 1990s. At present the stock seems to be fairly stable at about half the 1996/99 peak of around 5,000t. Plaice and sole stocks have been fairly stable recently but are below the peak levels of the 1980s. There is a seasonal beam trawl fishery for sole in spring and this yielded a by-catch of plaice but the fact that sole stocks are declining has reduced pressure by beam trawlers. Cod and whiting stocks are both severely depleted and cod reached its lowest recorded stock in 2001 (Figure 5.8).

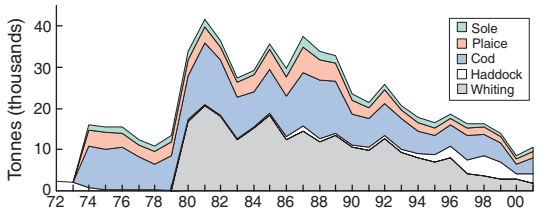


Figure 5.8. Landings of demersal species from the Irish Sea. Species shown are sole, plaice, cod, haddock and whiting

Shellfisheries are also important in the Irish Sea with an important fishery for scallops off the Isle of Man and for queen scallops in the central Irish Sea. Mussels are harvested in the Menai Straits and there are extensive fisheries for edible crabs and lobster along most of the rocky coast of Wales. The International Council for the Exploration of the Sea (ICES) assesses the status of fish stocks annually and advise on acceptable levels of exploitation consistent with preserving or improving existing stock levels. In 2004, ICES reported that in Region 5 only the *Nephrops*, and plaice stocks were considered to be harvested sustainably, while sole was harvested outside precautionary limits. The herring stock has increased in recent years from low levels in the early 1990s. Cod is under a recovery plan. The haddock fishery appears to follow occasional periods of strong recruitment leading to good fisheries. The stock is currently relatively stable.

(In 2004 ICES defined "at risk of being harvested unsustainably" as referring to stocks where the fishing mortality is above the precautionary reference point (F_{pa}). This is equivalent to the previous terminology "harvested outside safe biological limits". The term "full reproductive capacity" describes stocks where the spawning biomass is above the precautionary reference point (B_{pa}) This is equivalent to the previous terminology "inside safe biological limits".).

IMPACT OF FISHING

In addition to the target species, which they are intended to catch, fishing gears can catch non-target species such as marine mammals, seabirds and benthic animals as well as non-target fish species and undersized individuals of the target species. Small fast-growing short-lived productive species such as dab and gurnard are largely unaffected but long-lived slow-growing species such as spurdog, common skate and thornback ray can be severely affected. Many such species in the Irish Sea are now thought to be reduced to less than 10% of their unfished abundance and common skate and angel shark are now rarely if ever seen in the Irish Sea. There are no consistently collected data on by-catches of either seabirds or mammals in the Irish Sea but the sector report on Habitats and Species does not flag either potential impact of fishing as a problem in the Region.

In addition to by-catches of other free-swimming species, trawl fishing disturbs the seabed and hence animals living on the seabed and in the upper parts of the sediment. There are no area-wide quantitative data for the scale of these effects but some of the research investigations were undertaken in the Region. These showed that trawling reduces productivity and diversity of the larger invertebrate species but has less of an effect on smaller bottom dwelling species that provide food for flatfish. Scavenging animals also benefit from the dead and dying animals left on the disturbed seabed. No indicators yet exist to allow assessment of such impacts but EcoQOs involving densities of fragile species and appropriate species are under consideration. OSPAR has proposed an EcoQO directed at the presence and extent of threatened and declining species but the details of how this will be applied have still to be fully tested. Species to which it would apply in the Irish Sea are likely to include the basking shark (*Cetorhincus maximus*) and the common skate.

PLANKTON

Numerous measurements of plankton abundance and species diversity have been made in Region 5 including routine monitoring for toxic phytoplankton species that has been undertaken by FRS on behalf of the FSA since 1996. However, with the exception of the continuous plankton recorder (CPR), few observations have been

undertaken consistently at any one place. The CPR survey data for the Irish Sea date from 1970 and two transects are operated, one across the Irish Sea and the other from approximately the latitude of north Anglesey in a south south-west direction along the western boundary of Region 5. The results show that there has been a shift, starting in about 1986, from a cold temperate ecosystem to a warmer dynamic one. They also suggest that, at least so far as the plankton are concerned, the Region is relatively unaffected either by anthropogenic inputs of contaminants or by eutrophication.

The colour index for the Irish Sea, which broadly corresponds to overall phytoplankton abundance, fits reasonably well with satellite derived data for chlorophyll, and shows a move to generally higher levels from 1989 onwards. This fits well with a similar rise post 1988 in the Celtic Sea (Region 4). This change is significantly correlated with a change in SST and Northern Hemisphere Temperature (NHT). The change in phytoplankton colour is also reflected in changes in the relative abundance of two species of copepod, *Calanus finmarchicus*, which is characteristic of colder waters from the north and *Calanus helgolandicus*, which is more typical of warmer southern waters. The relative abundances of these two species are believed to reflect not only temperature change but also the relative movement of warmer or colder water masses. The changes seen in the Irish Sea closely follow those seen in the Celtic Sea which in turn are broadly similar to those observed in the North Sea (Regions 1 and 2), albeit less marked. Analysis of copepod indicator assemblages show much the same thing (see Figure 1.15 in Chapter 1), with warm water clearly influencing the shelf waters west of the British Isles and north of Scotland into the North Sea and having some influence within the Irish Sea.

BENTHOS

During the last few years considerable effort has been applied to mapping and collecting the data on all sampling of benthos undertaken over the last 100 years. In the past 30 years the conservation agencies have commissioned many surveys to support the selection and designation of marine protected areas (i.e. Special Areas of Conservation SACs)). There have been two large UK-wide systematic surveys: the Inter-tidal Survey of Great Britain and Ireland and the Marine Nature Conservation Review. Effort is now being applied to analysing all the available data and to identifying changes and the extent to which causes can be attributed. It is however already apparent that although there are sufficient data available to establish baseline conditions in much of the coastal waters of the Irish Sea region, data suitable for assessing temporal changes are only available at a few locations. Furthermore, it is not possible to assess benthic status, as although considerable effort has been put into defining objectives there are as yet no agreed objectives, targets or measures against which to form judgements. The sector report on Habitats and Species does however conclude that fishing activity impacts heavily on benthic communities.

An assessment has recently been made of the data collected under the NMMP over recent years (*MEMG, 2004*). The data from all 47 coastal stations and 31 estuarine sites were collated and the abundance and diversity of the benthic species found at each site was assessed against an experimental version of a Biotic Index (AMBI). In its current form this allows a score to be allocated for each site, zero is then regarded as representing a normal healthy regime and a maximum score of seven indicating one which is heavily stresses or polluted. Of the 16 coastal sites in Region 5 the highest scores (2.52 and 2.19) were allocated to two stations in Dundrum Bay (Northern Ireland), one in Cardigan Bay (2.34) and one in the Clyde off Cumbrae (2.41). The lowest scores were allocated to stations off the Ribble (0.25), Outer Belfast Lough (0.47), in Morecambe Bay (0.65), off St Bees Head on the Cumbria coast (0.73) and off the outer Mersey (0.77), south-east of the Isle of Man (0.85) and in the outer Clyde estuary at Irvine Bay (0.90). All the NMMP stations are intended to be similar soft bottom substrates but in practice this is not always the case and some of the apparently stressed scores are likely to be the result of disturbance or mobile sediments. Because data were available for Belfast Lough over a 5-year period an assessment of change was made. High

faunal abundance in 1997/98 was attributed to large numbers of annelid worms and amphipod crustaceans, probably associated with high nutrient input. However, there was a step by step improvement in the benthos between 1997 and 2002, which was directly correlated with the massive reduction in nutrient inputs

SEABIRDS

Seabird numbers and breeding success are assessed annually throughout the British Isles by the Seabird Monitoring Programme (SMP), which began in 1986 and is co-ordinated by the JNCC's Seabird Colony team. Since 1989 the results of the SMP have been published in an annual report. This is entitled "Seabird numbers and breeding success in Britain and Ireland" and is produced by JNCC in collaboration with RSPB and the Shetland Oil Terminal Environment Advisory Group (SOTEAG). While the SMP conducts annual monitoring of a sample of the seabird population in the UK complete censuses of all seabirds in the UK have been conducted to obtain total population estimates, which provide a baseline against which subsequent monitoring can be compared. The most recent UK population estimates were obtained in 1998-2002 during Seabird 2000 a JNCC-led census of breeding seabirds in the UK and Republic of Ireland.

Twenty-five species of seabird are known to breed in the UK and total numbers have increased from around 4.4 million in 1969-70 to 6.7 million in 1998-2002. Not all species have experienced the same success and there are considerable variations between species year to year and between breeding sites. For example in Region 5 numbers of Roseate Terns have declined by 94% over the past 30 years due to gradual emigration across the Irish Sea to colonies in the east coast of Ireland.

The Region holds 45% of the world population of Manx shearwaters on just five islands. Skomer is one of a number of SPAs around the Irish Sea that qualify for that status due to the presence of one or more seabird species or their seabird assemblages. Although food availability is known to affect seabirds, especially their success in rearing young and failures due to this are noted for some regions in the Habitats and Species sector report, there are no references to this being a problem in the Irish Sea. Nor, apart from a mention of the impact of the *Sea Empress* oil spill, which in fact turned out to be transient, does oil pollution appear to cause serious lasting problems for seabirds in the Region.

SEALS

Grey seals (*Halichoerus grypus*) prefer low lying haul out sites, where they can rest, have their pups and raise them till weaned and mate. They therefore tend to favour sites which are remote from human populations. Common or harbour seals (*Phoca vitulina*) also need haul out sites but they are less dependent on areas well away from human disturbance. Their pups can swim within hours of birth and mating takes place in the water. There are major breeding sites for grey seals in the Irish Sea area at Bardsey Island (off Anglesey) and Skomer in the extreme south of the Region, with smaller numbers at various other locations on the Welsh coast. These sites together however, only account for about 2% of the total UK population. The majority of the common seals found around the UK are found in other Regions but in the Irish Sea common seals are found in the Firth of Clyde and Strangford Lough.

Populations of both grey and common seals have increased steadily since the early 1980s but are now showing signs of beginning to stabilise. Both species were affected by outbreaks of phocine distemper virus (PDV) in 1980 and 2002 although the common seal suffered much higher mortality rates. Numbers had recovered by the time of the 2002 outbreak, which did not seriously affect seals in the Irish Sea. There are EcoQOs for seals but they are expressed simply in terms of numbers and utilisation of breeding sites, thus allowing relative numbers to be followed. There is no suggestion that numbers of either species are at risk in the Irish Sea. However, the EC Habitats Directive includes both species on Annex II because they are regarded as rare or threatened elsewhere in Europe. Consequently member states are required to designate sites for their protection. A number of sites where seals are found have therefore been designated as SACs in Region 5 at least in part because the site in question is important for one or other species of seal or in one case (Skomer) because of its importance specifically for grey seals.

CETACEANS

Although 28 species of cetacean have been recorded as being seen in the waters around the UK, population estimates only exist in the Irish Sea area for common bottlenose dolphins in Cardigan Bay where between 130 and 350 animals are believed to be resident. Although not yet formally designated as an SAC the presence of this population of the dolphin population in Cardigan Bay means there are proposals so to do.

HABITATS

The sector report on Habitats and Species reviews the various forms of designation available to identify and protect vulnerable or important habitats in coastal areas and sub-tidal areas. Information is also provided on the presence of various forms of habitat identified under obligations to the Convention on Biological Diversity. The Irish Sea is shown to be an important area in nature conservation terms with most types of habitat represented, some of them relatively rare. There is currently an active programme of SAC monitoring around Wales that will increase the possibilities of detecting changes in the Region.

The Irish Sea has two of the three MNRs so far designated by the UK, Skomer Island and Strangford Lough and almost 70% of the Welsh coast has SAC status under the EC Habitats Directive. The Skomer MNR, which includes part of the Marloes peninsula, is the site of a number of special projects several of which have potential as indicators of environmental change. e.g. the monitoring of the population of the yellow trumpet anemone (*Parazooanthus axinellae*). The South Wales Sea Fisheries Committee prohibited the collection of scallops within the MNR area in 1990 and population density is now estimated to be about 4 times that recorded in 1984. In terms of habitat type there are important and extensive areas of mud flats in Morecambe Bay, Solway Firth and Strangford Lough. The Lleyn Peninsula features a number of sea grass beds, which are relatively uncommon around UK coasts. Other relatively rare features, which are well represented in the Irish Sea relative to other Regions, are tidal rapids and *Modiolus* beds in Pen Llyn a'r Sarnan SAC and Strangford Lough and *Sabellaria alveolata*, which is considered to be at the northern limit of its range in Britain, occurs around much of Cardigan Bay and on the Cumbria coast. Maerl beds are another unusual type of habitat around the UK but the beds around Skomer, Strangford Lough and the southern Lleyn peninsula and Clyde estuary represent a significant proportion of the total number found in England and Wales.

It is clear that there is good information on what habitats are where and a good understanding of how each type might be threatened but repeat survey data that would allow an assessment of changes are as yet in short supply. In a few cases changes have been noted but for the most part it has proved difficult to attribute causes. There have been changes in the extent of the *Sabellaria* beds in the last 20 years particularly in the Dee Estuary, where it has decreased, but there are new beds in Morecambe Bay where it had been absent for some 30 years. One example where a cause has been attributed is damage to the maerl beds in the Clyde estuary by scallop dredging.

An important initiative in respect of the development of a nature conservation strategy that *inter alia* would detect and interpret trends was the Irish Sea Pilot Project. This sought to gather together geophysical, hydrographical, nature conservation ecological and human use data for a single sector of the UK with a view to mapping the various forms of data using GIS techniques. It was found that biological information for the intertidal and near coast was satisfactory but data were sparse for most offshore areas to the extent that good decision making would be constrained. The project therefore tested a concept known as Marine landscapes, which uses hydrographical and geophysical data to identify habitat type in the absence of biological data. This proved to be successful and within the area 18 different coastal and seabed landscape types were distinguished, with a further 4 water column types.

KEY POINTS AND CONCLUSIONS

Of the regions featured in this Integrated Assessment the Irish Sea is the most enclosed. It has an overall average flushing time of about one year. It is nevertheless subject to the same overall changes that influence other regions. Air temperatures over the land have increased by about 0.5°C during the last century and the 1990s were the warmest decade on record. During the last 3 decades of the 20th Century summers in Northern Ireland were drier than normal but as

overall rainfall has not changed winters have tended to become wetter. These changes over land have been reflected in sea temperatures with rises of between 0.5°C and greater than 1°C being recorded at various stations in the Region and around its margins. The available data on salinity measurements indicate that overall there has been an apparent decrease since 1950 in both summer and winter and whilst this does fit with increased winter rainfall, some of the annual data points used represent only one observation and may not be typical of either conditions for the whole of that year or the area.

Although largely enclosed the Region is exposed to waves coming in from the Atlantic from the south-west and there is evidence that wave heights increased between the 1960s and 1990s. Most of the waters of the Region are continuously vertically mixed but in the deeper waters to the west of the Region stratification occurs in the summer months resulting in gyres and inshore currents that run counter to the normal overall flow from south to north. Strong tidal currents and the generally soft sandy or muddy seabed, particularly in the northern half of the Region mean that suspended solids loads are relatively high and there is a general tendency for estuaries on the west coast of England and Wales to infill; in the Mersey estuary this is believed to amount to up to 10% loss in estuary volume during the last 70 years. The high suspended solids load tends to reduce light penetration and has significance for overall productivity in the Region.

In environmental quality terms the Region can broadly be divided into two halves, one south and the other north of an east west line from Anglesey to Ireland. South of this line contaminant concentrations are generally low and the scale of biological effects associated with contamination by the commonly recognised chemicals is minimal. North of the line the tendency to gyre circulation driven by density currents in Liverpool Bay and elsewhere, tends to retain material within the area. It is into this area that the major centres of population and industry drain and contamination is more apparent as a result. Winter DIN concentrations exceed the top of the range regarded as normal for the Region, although there is evidence that concentrations have stabilised or begun to fall since about 1990 when input reduction measures were introduced. Chlorophyll levels did exceed those considered to represent background at a number of locations in the Region but even in inner Belfast Lough the concentrations are no longer considered high enough to indicate potential eutrophication. 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.

Concentrations of a number of metals in water, sediments and biota tend to be above BRC or EAC values in areas like the Mersey, Clyde and Belfast Lough and clearly indicate anthropogenic sources. However, concentrations are lower now than was the case in the past, thus indicating the effectiveness of controls on inputs that were applied in the latter decades of the last century. Concentrations of the traditionally studied organic contaminants such as the chlorinated pesticides, CBs and PAHs have all decreased in environmental samples collected in the northern part of the Region. HCH concentrations in water samples are now below those regarded as likely to cause ecological effects. However concentrations of CBs remain elevated in areas like the Mersey and Clyde estuaries and may be high enough to cause biological effects. A similar pattern of elevated concentrations is shown by the monitoring data for PAH. The fact that biological effects might be caused is borne out by the results of a variety of biological effects studies, thus confirming the need for continuing controls, although much of the currently observable effects are likely to be due to historical inputs. A survey to assess the current levels of TBT was conducted along the whole of the UK west coast. The results showed that TBT contamination is still widespread but that within Region 5 the scale of effect on dog whelks is unlikely to affect reproduction.

With the nuclear fuel reprocessing plant at Sellafield on the Cumbria coast concerns over the discharge of radioactive materials and their possible effects on people and the environment have long been a matter of contention. However, inputs of all radionuclides except ^{99}Tc are now much lower than they were in the 1970s. ^{99}Tc inputs peaked in 1995 but have since been reduced and are scheduled to fall further in 2006. Levels of ^{137}Cs in water in the Region are now only a small percentage of those prevailing in the 1970s and the sediments of the mud patch close to Sellafield are now the main source. Exposure levels to the most exposed members of the public are well within present internationally agreed

acceptable dose limits. Exposure levels to the most exposed biota are considered to be below those that might cause effects at population level and would not have done so even when the exposure levels were higher – about ten times present levels

The microbiological quality of bathing waters in Region 5 has improved substantially since 1990. In 2003 five beaches in the Region failed the current mandatory standards set by the relevant EC Directive standard, two of which were in Scotland. 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. Failure of at least one if not both of the sites that failed in Scotland was attributed to diffuse rather than point sources, specifically contamination arising from cattle and sheep. Some improvements in the microbiological quality of shellfish harvesting waters have also been achieved through better sewage treatment although several continue to be graded as class C thus precluding practical harvesting for human consumption. The position in relation to compliance with goals set to meet the shellfish growing waters Directive also remains unsatisfactory with 51% of all designated waters that failed to meet the desired standard in 2002 being located in the Region. Litter also continues to present an aesthetic problem on beaches and may also have an effect on marine species that may ingest particles or become entangled in larger items of debris. However, the actual scale of any such effects remains unclear.

Most of the oil slicks attributed to discharges from vessels were reported in the northern half of the Region either east of the Isle of Man or in the North Channel but there have been no reports of any serious bird mortalities or other ecological effects in recent years and the impact of these discharges in beach pollution terms is unclear. 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 concerns.

Much of the coastline in the southern half of the Region is relatively undeveloped but Liverpool Bay, Morecambe Bay, Belfast Lough and the Clyde estuary are all areas with substantial urban and industrial developments, either directly on the coast or with catchment areas draining into them. In 2002 five major port developments were in progress and these added to the quantities of dredged material that arose in connection with port and harbour maintenance operations. 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 but this only amounted to 3.8 million tonnes between 1993 and 2003. It is forecast to remain fairly static between 2001 and 2016 but will continue to represent about 2% of the total extracted from UK waters. Construction of coastal defences has taken place particularly along some of the lower lying areas of the North Wales coast where coastal flooding has occurred in the past. The major construction projects currently scheduled to take place in the area are associated with the development of offshore wind farms, with up to 500 or more wind turbines proposed to be installed between the North Wales coast and the Solway Firth. Minimising the impact these will have on other marine interests will present a major challenge.

The nature of the seabed in the Region varies considerably from south to north and from east to west and the different substrates present different habitats for fish species and benthic animals alike. So far as commercially exploited fish species are concerned fishing pressure has rendered species such as the common skate and white skate rare or totally absent from the Region and catches of most other species have declined. Stocks of most fish species, except plaice, sole and *Nephrops* are considered by ICES to be being harvested outside precautionary limits. Apart from the impact on target species there are side effects of fishing that affect other species. These include mortality due to by-catch, damage to benthic species and habitats by trawl gear and removal (or provision) of food species utilised by seabirds. All of these effects do occur in the Region but, perhaps due to the relatively low levels of fish stocks, the major concerns in relation to fishing in the Irish Sea appear to relate to the viability of the fish stocks themselves rather than effects on other species.

In a more general habitat context there is clear of evidence of changes having taken place in the phytoplankton and zooplankton. Phytoplankton abundance appears to have increased since the late 1980s and there have been structural changes in the zooplankton species mix. Whilst these

could be related to changes in nutrient inputs the timings are not consistent and they are believed to be associated with similar changes over a wide area of the north-east Atlantic that are probably climatically induced. The benthic species found in the Region match what would be expected given the nature of the seabed. However, effects of bottom trawling are apparent in some areas, as are the effects of organic enrichment in Belfast Lough where large populations of annelid worms and amphipod crustaceans have been noted. This effect does however seem to have been reduced in recent years following reductions in the input of organic matter with the cessation of disposal of sewage sludge and nutrient inputs. A similar effect of increased benthic biomass but reduced diversity was noted at the Garroch Head sewage sludge disposal ground in the Clyde whilst disposal was taking place. It is expected that recovery has since occurred and a survey to confirm this is planned for 2005 (*Author's Note*).

The numbers and range of species of both seabirds and cetaceans encountered in and around the Irish Sea is considered normal for the latitude and types of habitat available in the Region. The few recent changes noted in the background information available on habitats and species for this Region appear to be related to natural rather than direct anthropogenic pressures. Two of the three MNRs designated by the UK are located in Region 5 - Skomer in the south-east of the Region and Strangford Lough in the north-west. In addition almost 70% of the Welsh coast has been accorded SAC status under the terms of the EC Habitats Directive. There are extensive areas of mudflats in the Dee estuary, Morecambe Bay and the Solway Firth. Other examples of important habitat types found in the Region include beds of horse mussels in the Pen Llyn a'r Sarnan SAC and tidal rapids in the Menai Straits and *Sabellaria* beds in the Dee estuary and Morecambe Bay. The Region holds 45% of the world population of Manx shearwaters on just five islands.

Region 6:
Minches and West Scotland

INTRODUCTION

Figure 6.1 below shows details of the location of Region 6 in relation to the neighbouring Regions 5 (Irish Sea) and 7 (Scottish Continental Shelf) and the locations of the main places mentioned in this chapter. The landward boundary of Region 6 on the eastern side of the area is a rocky, indented fjord-like coast with the rocky east coast of the Outer Hebrides forming the western boundary. To the south lie the coast of Northern Ireland and the Irish Sea (Region 5) with the boundary between the two Regions being defined as a line drawn from Fair Head in Northern Ireland across the North Channel to the southern tip of Kintyre. The northern boundary between Region

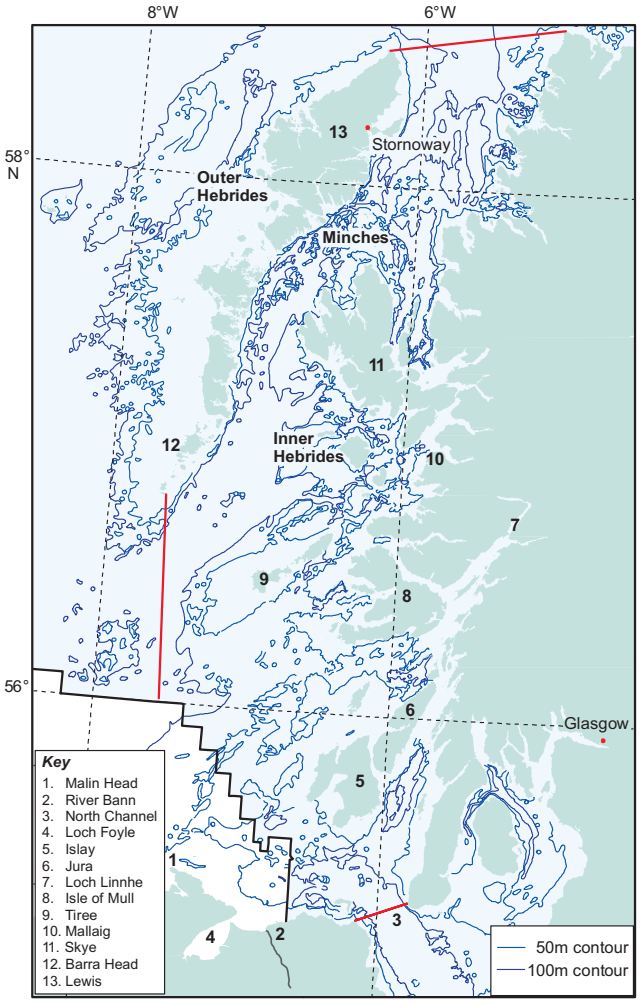


Figure 6.1. Map of Region 6. Bathymetric contour data copyright UKHO

6 and Region 7 (Scottish Continental Shelf) links the Butt of Lewis to the northern tip of Scotland. In the northern part of the Region the Minches form a channel (water depth >100 m) between the Outer Hebrides and Inner Hebrides/Scottish mainland. There are few large areas of shallow water, most lochs are deep and water depths generally exceed 50 m. The southern part of the Region is exposed to westerly and south-westerly winds coming in from the Atlantic but the Outer Hebrides offer some shelter to the northern part of the Region from the Atlantic swell and storms. Bottom water temperatures are fairly constant, typically 8 to 10˚C. Most of the area is rural but with numerous small communities and towns, mostly situated on the inner shores or at the head of the long firths and lochs. There are many islands in the Region most of which have only small resident populations. The economy of the Region depends on tourism, fishing and increasingly, on mariculture activities initially centred on salmon but now including other fish species and bivalve shellfish such as mussels, oysters and scallops.

PHYSICAL ENVIRONMENT

WEATHER AND CLIMATE

Oceanic circulation is driven mainly by three parameters, wind speed and direction, air/sea heat exchange and evaporation/precipitation. These same parameters affect the distribution of temperature and salinity on the more local scale of areas such as Region 6. For example stronger and more frequent westerly or south-westerly winds over the North Atlantic will drive a greater influx of Atlantic water into the Region and through the Tiree Passage and the Minches. They will also bring higher rainfall and warmer air temperatures. Higher rainfall will result in lower salinity in coastal waters and will enhance density driven coastal water flow. Storms are accompanied by increased wave heights and possibly surges, which in turn enhance mixing and can increase coastal erosion.

A major factor influencing North Atlantic circulation and weather is the North Atlantic Oscillation (NAO) – for a brief description of this see chapter 1. From about 1960 the NAO has experienced its biggest changes since the 1860s with the winter Index (December to March) showing an upward trend, following an extreme negative phase in the early 1960s. There is evidence that such changes are not unique but the scale of recent changes does seem to be particularly large. In the UK positive winter indices result in wet winters and unsettled cooler than normal summers, whereas negative winter indices are usually associated with colder winters and warmer summers.

Global surface temperature has increased by about 0.6°C since the late 19th century and the Earth appears to have been warmer since the 1960s than at any time in the previous 1,800 years. Three terrestrial measures of temperature change have been produced for Northern Ireland and Scotland, a Northern Ireland Index, a Scottish Mainland Index and a Scottish Islands Index base on Stornoway (on Lewis in the Outer Hebrides) and Lerwick in Shetland. A comparison of 30 year means of annual temperature between 1873 and 1902 and 1961-1990 for all three indices demonstrated a clear warming trend of between 0.11°C and 0.39°C. An analysis of rainfall records in Northern Ireland from 1931 – 2000 indicated there were no statistically significant trends in either annual or winter rainfall. However, summers in Northern Ireland have generally been drier during the past three decades, with 1976, 1983 and 1995 being particularly dry. This has led to an increasing trend in the balance between winter and summer rainfall i.e. relatively drier summers and wetter winters

SEA TEMPERATURE

Changes in sea surface temperature influence the distribution of marine organisms with increase tending to move the boundary between warm temperate and boreal species further north. Satellite derived data suggest there has been a

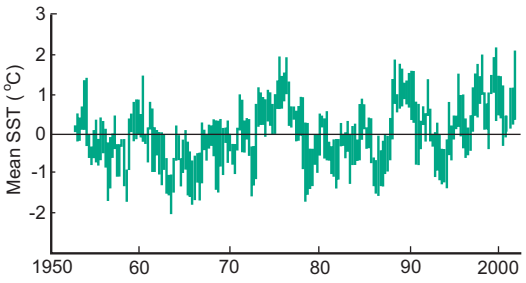


Figure 6.2. Monthly mean SST at MillportThe large change during the year due to seasonal changes has been removed by subtracting the long-term monthly averages. Courtesy of FRS (Source of data: Millport Marine Biological Station)

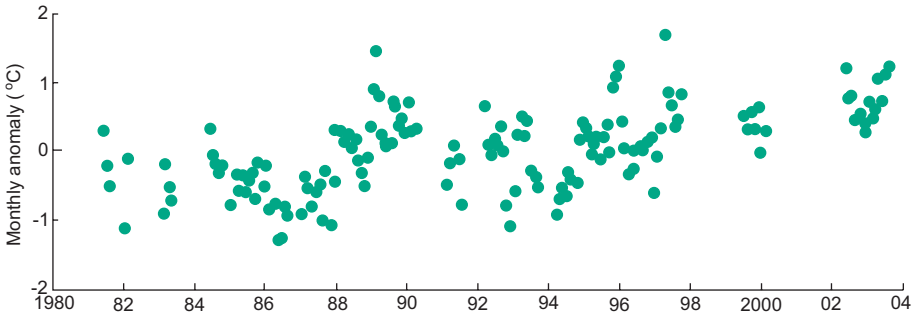


Figure 6.3. Monthly temperature anomalies in the Tiree Passage. Courtesy of Colin Griffiths, DML

warming trend over most of the North Atlantic since 1981 of between 0.2 and 1°C/decade, but the area most influenced by the Irish Sea water passing north through the North Channel has averaged 0.6°C/decade – (see Figure 5.2 in Chapter 5). Two time series of data exist for Region 6, one collected by the Millport Marine Biological Station going back to 1953 (Figure 6.2) and the other collected by the Dunstaffnage Marine Laboratory (DML) for the Tiree Passage (Figure 6.3).

The Millport record shows that monthly mean temperature has been increasing steadily but the Tiree Passage data show a more complex picture. The Tiree Passage is a SW-NE orientated strait between the Isle of Mull to the south-east and the Isles of Croll and Tiree to the north-west. The water column is normally well mixed or weakly stratified at the measuring site. The dominant variance in the record is due to the seasonal cycle but after adjustment for this seasonality the temperature anomalies are very similar to those seen in the North Atlantic water in the Scottish Coastal Current

SALINITY

Conductivity, from which salinity can be derived, has been measured intermittently since 1985 by DML at their mooring in the Tiree Passage. Unfortunately these data were not available for the MPC sector report and the temporal trend in salinity for Region 6 can only be inferred from what is known about trends in the water masses feeding into the Minches. This would suggest that salinity has remained fairly steady, or perhaps decreased slightly since the 1950s, as this is the trend observed in both the Irish Sea and North-east Atlantic, which are the sources of the two main water masses flowing into and through the Region.

WAVES

The height of waves approaching the UK coastline depends upon the strength of the wind and the distance and length of time over which the wind has acted on the sea surface. Region 6 is quite exposed, particularly in the south of the Region and the largest waves approaching Region 6 are likely to have been generated in the north-west Atlantic or as a result of local storm activity. As waves approach the coast their height may be increased as the water depth decreases. In British waters the west coast of Ireland and the Outer Hebrides experience the highest mean wave heights (long-term mean significant wave height Hs 3.0 m). Waves in the Minches will not be as large as these due to the shelter afforded by the Outer Hebrides, they are nevertheless still influenced by the winter wave climate of the NE Atlantic, which in turn is influenced by the NAO. Figure 6.4 shows wave heights at Malin Head on the north coast of Ireland and in the Sea of Hebrides versus the NAO Index and clearly shows the close relationship and strong influence of the NAO.

The accurate measurement of waves has only become possible in recent years and there do not appear to be any reliable records of wave heights in Region 6 prior to the early 1990s when satellite altimetry data began to be available.

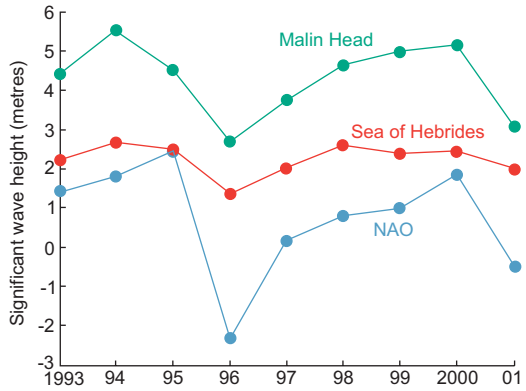


Figure 6.4. Wave height versus NAO Index at Malin Head and Sea of Hebrides. Courtesy of David Woolf, SOC

However, records from the NE Atlantic collected from a combination of records from ships and buoys since the 1960s and from satellites since the early 1990s suggest that the mean winter wave height has increased significantly with a value of about 0.03 m/yr increase in the winter mean significant wave height (Hs).

CIRCULATION

Circulation is the term used to describe the net movement of a water body. At any point in time it is the result of residual currents from a combination of those arising from tides, meteorological forcing and density distribution. Circulation is never constant but is variable in both space and time, especially short-tem or even seasonal and inter-annual time scales. Despite this variability it is useful to understand the general circulation pattern in an area as this indicates where water passing through has come from and where it is most likely to be moving to. Partly as a consequence of the tracer provided by the discharge of radioactive material from Sellafield on the Cumbrian coast in Region 5, the circulation in Region 6 is fairly well understood. Water flows northwards through the North Channel out of the Irish Sea and mixes with fresher water from the Clyde Sea and Firth of Lorne. From there it continues north as the Scottish Coastal Current (SCC). The flow of Irish Sea water through the North Channel tends to be in pulses depending on the wind, with the strongest flow northwards along the eastern side and a weaker surface return flow along the Irish coast. An average outflow of 0.075 Sv (1 Sv $=10^6$ m^3/sec) was measured in the North Channel between July 1993 and July 1994.

The SCC continues its northward journey into the Tiree Passage where measurements of the flow have been made since 1981. These suggest a mean volume flow of 0.067 Sv but ^{137}Cs studies indicate this water is a mixture of North Channel water and Atlantic water with a dilution ratio of about 3:1. At the entrance to the Minch the SCC divides with one branch flowing on northwards between the Outer Hebrides and Scottish mainland and the other turning south then west around Barra Head to continue northwards up the west coast of the Outer Hebrides. The flow of these two branches of the SCC is significantly influenced by wind stress and the resulting pulsed flow is associated with the passage of depressions to the north of the British Isles.

SEDIMENT CONCENTRATION AND TRANSPORT

There is very little information on sediment concentration and transport relevant to Region 6. Given the rocky nature of most of the coastline, input as a result of erosion is likely to be low. The substantial admixture of Atlantic water with Irish Sea water flowing northward from the North Channel will further tend to reduce concentrations of suspended sediments.

CHANGES IN SEA LEVEL, COAST AND SEABED

At any point in time the sea level registered at a particular place is a combination of tide level, mean sea level and waves. Mean sea level (MSL) is the height of the sea relative to the land averaged over a period long enough to remove fluctuations due to tides and waves. Around the UK MSL changes seasonally by about 10cm and there is an 18.6 year period over which the twice daily tides increase in range but up to 3.7% because of changes in the declination of the moon. The most recent maximum was in 1997 and the next minimum will be in 2006. Global MSL has risen by about 120 m since the last ice age 20,000 years ago. It continued to rise by between 1 and 2 mm/year throughout the last century. The effect of the retreat of the ice sheet from the British Isles after the last ice age can still be seen in the vertical movement of the land, with the maximum rise of about 1.6 mm /year in coastal and western

Scotland i.e. in Region 6. In Region 6 therefore the land rise effectively cancels out the average increase in MSL seen globally and the risk of coastal flooding as a consequence is less in this Region than anywhere else in the UK.

Most of the coastline in Region 6 is rocky and profiles change only slowly with time. The north coast of Northern Ireland is predominantly basalt and coastal erosion is minimal. A recent review of rates of change along much of the Scottish coastline since at least the mid-1800s concluded that there had been changes over time with erosion starting around 1900 following a period of accretion. There was then a period of slight accretion between 1920 and 1960 but this was followed by erosion again. Between 1969 and 1981 the Scottish Coastal Forum surveyed all Scottish beaches longer than 100m and concluded that of all the beach areas in Region 6, the highest rates of erosion were occurring in the Outer Hebrides with the least erosion occurring on the Highlands and Islands coastlines. The most recent study was undertaken by the Office of Science and Technology (OST) and its findings tend to confirm those of the Scottish Coastal Forum. The OST study divided the coastline into a series of coastal cells and concluded that the northern section of the coast in Region 6 as far south as Mallaig, including the islands of Mull, Islay, Jura and Skye, was stable but with eroding pocket beaches. South of Mallaig the predominant picture is one of erosion, except where the coast is rocky or protected by sea defences.

ENVIRONMENTAL QUALITY

NUTRIENTS

The marine food web is based on microscopic plants known as phytoplankton. Phytoplankton growth is regulated by light and availability of nutrient forms of nitrogen and phosphorus and, to a lesser extent, silicate and carbon. Excessive plant growth in response to an increased supply of nutrients is termed eutrophication and measures have been taken to reduce inputs of nutrients to avoid this occurring. OSPAR has proposed common assessment procedures to guide decisions on whether such measures are required. These set normal and elevated levels for dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) and a guideline that states chlorophyll concentrations should be no more than 50% higher than historical offshore background for the area concerned. The common assessment procedures criteria recognise that regional differences arise naturally and higher levels are set for the Irish Sea than the English Channel or North Sea.

The common assessment procedure criteria for DIN and DIP relate to winter concentrations and in Region 6 the concentrations of both DIN and DIP were found to be below the criteria set for Scottish waters. At a very local level mariculture activities do result in increased nutrient concentrations due to fish excretion and decomposition of unused fish food. In recent years there have been more numerous cases of shellfish being contaminated by toxins of algal origin. Blooms of toxin forming phytoplankton are considered to be a possible manifestation of eutrophication but in Region 6 the concentrations of DIN and DIP are not high enough to be regarded as the primary cause of shellfish contamination. Part of the problem is that in the past such toxins would have gone undetected because there was little exploitation of shellfish and no requirement to monitor for the toxins until the Shellfish Hygiene Directive entered into force. Now monitoring is required but there is no information on past incidence of toxin forming phytoplankton. There is also the strong possibility that the phytoplankton assemblage has changed as there appears to have been a regime shift since about 1987 (see Habitats and Species section).

HAZARDOUS SUBSTANCES – METALS

Within Region 6 all concentrations of metals in sea water are below the EQS values i.e. the concentrations defined as being unlikely to harm marine life. They are also all below the Background Reference Concentrations (BRCs) and the Ecotoxicological Assessment Criteria (EACs) i.e. the concentrations above which effects on biota might be expected to occur. These BRC and EAC values were agreed by OSPAR and were intended to guide decisions on whether input reduction measures are necessary. (It should be noted that the BRC and EAC values referred to in this review are those adopted by OSPAR in 1997. These levels have been reviewed and were recently revised but the new values were not available when the sector report on Environmental Quality was being prepared; they have not therefore been used in this review either.) BRCs and EACs were set for metals in sediments and none of the samples

collected in Region 6 were found to contain metal concentrations in excess of these values. Indeed assessment of the metal to aluminium ratios, which give an indication of whether the metal present is of natural origin or has been elevated by anthropogenic activity, suggest little or no contamination of the sediments as a result of industrial or other activity. This suggests that the influence of contamination in the Clyde Sea area and in the Irish Sea (Region 5) does not extend significantly into Region 6. Metals are also monitored in samples of mussels and flatfish as part of the NMMP but all the concentrations measured in samples from Region 6 were considered normal i.e. were below the BRCs for mercury, cadmium and lead and for other metals were comparable to the lowest values recorded elsewhere

HAZARDOUS SUBSTANCES – CHLORINATED ORGANICS

Some organic compounds, particularly those containing chlorine, combine persistence with a tendency to bioaccumulate and toxicity. Their presence in the environment is considered undesirable and controls have been applied severely restricting the use of many of these compounds. As a consequence concentrations in the marine environment have declined. OSPAR derived EACs for several of these compounds but with the exception of hexachlorocyclohexane (HCH) concentrations in water are mostly below detectable levels and no BRCs have been defined. The concentrations of HCH found in water samples taken from Region 6 were the lowest recorded in UK waters at about 0.3 ng/l.

Polychlorinated biphenyls (PCBs) were used extensively in a wide range of industrial and domestic applications. They were produced as mixtures of several compounds (CBs) and concentrations are usually expressed in terms of seven selected CBs. OSPAR set the EAC range for the sum of these as 1-10 μg/kg dry wt in sediments. Samples of sediments collected from the Minches and Northern Ireland coast in Region 6 and the North Channel (Region 5/6) all contained less than 1mg/kg dry wt total CBs, indicating low levels of contamination by CBs in the area. Concentrations of CBs are measured in fish liver and in mussels as part of the NMMP and in Region 6 all concentrations were low.

HAZARDOUS SUBSTANCES – POLYCYCLIC AROMATIC HYDROCARBONS (PAHS)

PAHs are produced naturally e.g. in forest fires but man's industrial activities and the burning of fossil fuels add to the quantities entering the environment. EACs were set by OSPAR for eight individual PAH compounds in sediments and these eight are included in the ten compounds monitored under the NMMP. The first NMMP survey was conducted in 1999 and although there have been annual surveys since then there are still too few data to assess temporal trends. Somewhat surprisingly concentrations of PAH in the northern part of Region 6, as judged by the concentrations found in sediment samples from sea lochs on the coast of north-west Scotland, although clearly not of petrogenic origin, are considered to be rather high. The situation is rather similar in the southern part of Region 6 where a sample from the Bann estuary on the coast of Northern Ireland was found to contain >10,000 μg PAH/kg dry wt of sediment in the 1999 survey. This exceeds the sum of the upper EAC values for PAH established by OSPAR and suggests that effects may be detectable in organisms living in or on the sediments in this estuary.

RADIOACTIVITY

Apart from the natural sources of radioactivity present in rocks etc there are no inputs of radioactive materials directly into the Region. Sellafield to the south, in Region 5, is the largest single source of artificial radionuclides to the marine environment in the UK. Details of past and present inputs from Sellafield, levels in the Irish Sea and their effects are provided in the appropriate section of Chapter 5. The natural pattern of circulation from the Irish Sea means that the effects of Sellafield discharges can be seen in the presence of the various radionuclides in water, biota and sediments. However, the levels in Region 6 are lower than in the past and lower than in the Irish Sea. The levels are monitored and exposure rates to humans are assessed relative to the appropriate internationally agreed standards. In all cases the individual doses experienced by the public are well within these limits. The effects of radiation exposure on marine organisms in the Region are unlikely to cause adverse effects at the population level.

MICROBIOLOGY

The UK is required to monitor the extent of microbiological contamination in certain waters around its coasts under the terms of three EC Directives. The Bathing Waters Directive (for which new, tighter standards are currently being agreed) lays down mandatory standards that require 95% of the samples of water from identified bathing waters to contain less than 10,000 total coliforms and less than 2,000 faecal coliforms per 100 ml. In 2003 monitoring was undertaken at 16 identified bathing waters in Northern Ireland that lie within Region 6, all complied with the current mandatory standards. This represented an improvement relative to 1990 when one identified bathing beach failed to meet the mandatory standard. Currently there are three identified bathing beaches in Scotland within Region 6 and all met the mandatory standards in 2003. Scotland had not identified any bathing waters in Region 6 in 1990.

The Shellfish Hygiene Directive sets standards for *E. coli* and faecal coliforms in shellfish flesh. The standards define whether the shellfish can be sold directly for human consumption (class A) or after passage through an approved purification system (class B) or must first be relayed for an extended period in either a class A or B area. Within Region 6 none of the production sites classified in Northern Ireland fell below class B. Scotland has 92 separately classified harvesting sites within Region 6 and in 2003, 31 of these were classified as class A, 55 as class A/B depending on season. Scotland operates a seasonal system of classifying its harvesting areas and contamination can occur intermittently. It is suspected that non-point sources such as farm run-off, seabirds and marine mammals may be the source of contamination.

Monitoring of microbiological quality is also required under the Shellfish Waters Directive. The intention of this Directive is to improve or protect water quality from the standpoint of ensuring good shellfish growth. The guideline standards set out in this Directive include one for faecal coliforms in shellfish flesh which, although expressed differently, is broadly similar to the requirement of class A under the Shellfish Hygiene Directive. Waters so designated under this Directive are not necessarily the same as those classified under the Shellfish Hygiene Directive or vice versa although the current policy is that they should broadly coincide. Within Region 6 monitoring is carried out under the terms of the Shellfish Waters Directive in both Northern Ireland and Scotland. Northern Ireland has designated nine areas with 31 sites under the terms of this Directive. None of these designated sites failed in 2000 or in 2001.

Within Scotland in Region 6 there are 68 designated shellfish growing waters, most of which were designated in 2002. There are therefore relatively few data with which to make comparisons over time. Several sites consistently comply with the guideline standards in the Directive for faecal coliforms but several fail on occasions. These failures remain unexplained and may be a result of diffuse or agricultural sources.

OIL AND OIL SPILLS

The whole of Region 6 lies within the European Waters Special Area established by IMO in 1999. This means there should be no discharge of oil or oil/water mixtures from any ship whilst it is in the area. This does not prevent occasional illegal discharges being made but within Region 6 there have been very few of oil slicks attributed to vessels. There have also been no oil spills as a result of accidents to ships. There is no oil production in Region 6 and few exploration wells have been drilled in the area. There is an OSPAR EcoQO, which is intended to reveal the extent of oil pollution affecting seabirds. This suggests that no more than 10% of the dead or dying common guillemots found on beaches should be oiled. However, no formal surveys have been undertaken in the Region to demonstrate compliance or otherwise with this EcoQO.

NAVIGATION DREDGING AND AGGREGATE EXTRACTION

There are no major ports in Region 6 but there are numerous small fishing harbours and smaller ports used by the many ferries operating services from the Scottish mainland to the islands and between the islands. Some dredging is required to maintain these harbours and there are five designated disposal sites within the Minches. However, the quantities of material dredged are small compared to those in Regions with major ports and only about 25,000 tonnes of material was dredged in 2002. The majority of the navigation dredging within Region 6 takes place in Northern Ireland waters but even here the quantities involved are relatively small, about

134,000 tonnes were disposed of off the Bann estuary in 2002. A limited amount of dredging for aggregates (sand) is undertaken off the coast of Northern Ireland in Region 6 but the quantities are relatively small, typically less than 400 t/day.

CONSTRUCTION

The majority of the coastline in Region 6 has been little altered by construction. There are some coastal defence works on the Scottish mainland coast in the south of the Region but, apart from these, the main changes wrought by man's activities are the result of harbour construction at the various coastal settlements and of bridges and causeways linking island communities. There are no plans currently for construction of wind farms in the Region but in the past there have been a number of experimental wave energy projects. The main alterations to the coast in recent years are those associated with fish and shellfish farming with mooring of rafts and cages in the relatively sheltered lochs and firths and construction of the necessary shore based facilities to service these installations. Such activities have an undoubted visual impact but they bring much needed employment and revenue to the Region.

MARICULTURE

Most of the fish and shellfish farms in Scotland are situated within Region 6, although there are important sites also in Regions 1 and 7 and in the Strathclyde area of Region 5. Although most hatchery facilities are land based with pumped sea water systems, most production takes place in cages or from rafts moored offshore in the many sheltered voes and embayments around the Islands and the sea lochs of the west coast of mainland Scotland. The industry is large, producing trout, salmon, halibut, cod and haddock, mussels, oysters, clams, scallops and queens. It has grown considerably over the years and continues to do so. Production of salmon in 2002 reached 145,000 tonnes and was expected to reach 175,000 tonnes in 2003 but production of other species is also growing.

Although concerns have been expressed over nutrient release, either from unused food or excretion, improvements in fish farm practices have led to reductions in the quantities of unused food and although nutrient concentrations do show increases locally around mariculture sites they do not exceed the OSPAR assessment criteria and are not thought to cause any problems. In only a single sea loch in the western Isles the water N:Si ratios were found to exceed those at which phytoplankton species composition may shift from diatoms towards flagellates. Chemicals are used in the form of medicines, as antifouling agents on cages and in treatments to combat sea-lice. Most antifouling agents are copper based and although concerns exist as to the possible adverse effects on biota living near the mariculture sites, to date no problems have been identified. The position is similar for medicines. Restrictions exist on which medicines can be used, in what quantities and in what way. In-feed medicines are of particular concern in this context as surplus food can lead to accumulation of the medicine in sediments below fish cages. However, studies have shown the polychaete worms that dominate the sediments below fish cages are unlikely to be adversely affected.

Escaped fish from mariculture enterprises can interbreed with their wild counterparts and this is an issue of concern because whereas wild salmon have wide genetic diversity farmed salmon do not. It is thus possible that the offspring of wild and farmed salmon interbreeding may benefit from hybrid vigour but this is not passed to the next generation due to outbreeding depression with resultant much lower fitness and productivity in subsequent generations. With species such as cod etc the majority of the breeding stock is still taken from the wild and so loss of genetic diversity is less of a concern.

Establishing a fish or shellfish farm requires registration of the business and site and a discharge consent must be obtained. This will specify the production tonnage and quantities of medicines that can be discharged. In 2003 the Scottish Executive published a Strategic Framework for the Aquaculture Industry in Scotland which sets out objectives and priority actions designed to achieve sustainable development of the industry in Scotland. These and other measures already in place, seek to minimise adverse impacts of mariculture activities and encourage the production of fish and shellfish as a means of filling the gap left by reduced wild stock production. An issue of concern in this context is the source of the food materials used. Questions arise over the sustainability of stocks of those species caught principally for the purpose of creating feed pellets

for use on fish farms. However, the increased use of fisheries by-products in fish feeds and the development of new feed materials in which vegetable oils can be used to replace fish oils and up to 75% of the fish meal can be replaced by plant proteins may minimise this potential obstacle to continued expansion of the industry and avoid over exploitation of the wild fish stocks currently used for fish meal based feed..

BIOLOGICAL EFFECTS – CONTAMINANT SPECIFIC OR OTHERWISE INCLUDING BENTHOS

There were no identifiable details of any such activities being undertaken in Region 6 in the sector report on Environmental Quality, except for the results of a survey of the effects of TBT. This survey showed that there continues to be clear evidence from the level of imposex found in dog whelks, of contamination by TBT in the Region, as elsewhere around the UK. However, the scale of effects was not such as to adversely affect reproduction.

LITTER

The sector report on Environmental Quality gives only a very limited amount of information on the regional prevalence of litter based on the results from a single survey conducted in 2003 by the Marine conservation Society (MCS). Equally there is no information on the regional effects of litter in the sector report on Habitats and Species. Consequently it is not appropriate to go into any detail in this chapter. However, a brief summary of the litter issue is provided in the final chapter of this Integrated Assessment. Within Region 6 only three beaches were surveyed in the MCS Beachwatch 2003 survey. As in other regions beach visitors were judged to be the largest source of litter items found, accounting for almost 24% of all litter found. This was closely followed by fishing debris, which accounted for almost 21% and, with about 12% of the items found attributed to shipping, Region 6 had the highest percentage of items from this source (next highest Region 1 at 2%).

HABITATS AND SPECIES

FISH ASSEMBLAGES

The fish assemblages found in the Minches and firths along the west coast of the Scottish mainland are composed of whiting (*Merlangius merlangius*), sprat (*Sprattus sprattus*), Norway pout (*Trisopterus esmarki*), hake (*Merluccius merluccius*) and haddock (*Merlanogrammus aeglefinus*). The basking shark (*Cetorhinus maximus*) is also commonly seen and was once subject to targeted commercial fishing.

The common skate (*Dipturus batis*) is locally abundant at certain sites, including some sea lochs, and a tag and release programme for this species is run in association with Glasgow Museum. Further south in the North Channel the common skate is also caught, in the southern more open waters of the Region between the North Channel /North coast of Ireland and Tiree

COMMERCIAL STOCKS AND LANDINGS

It is difficult to separate the landings of commercially exploited fish caught in Region 6 from those caught in Region 7 because for the purpose of assessment by the International Council for the Exploration of the Sea (ICES) the two Regions are taken as one. Stocks of cod and whiting in area VIa (west of Scotland) and haddock in area VIb (Rockall) are thought to be at or close to historically low levels in 2000-2003. Haddock in area VIa have shown a temporary recovery following recruitment of a single strong year class and together with *Nephrops* are harvested sustainably. Both the cod and northern hake stocks are at risk of reduced reproductive capacity and are subject to recovery programmes. Anglerfish are considered to be at risk of reduced reproductive capacity and the state of the megrim stock is uncertain. Both species suffer high levels of discards. The status of the pelagic stocks (herring, mackerel and horse mackerel) are less certain mainly due to unreliability of the landings and effort data. The west of Scotland sandeel is thought to be at a high level but the fishery is closed after 31 July each year to protect sandeels as a food source for breeding birds.

Herring are also caught in the southern part of Region 6 and the stock of this population is currently considered to be above the precautionary reference limit (B_{pa}),as is that of the neighbouring Clyde stock (Region 5). Both the common skate and the basking shark are on the OSPAR list of threatened or declining species and the EcoQO for “the presence and extent of such species” will presumably serve to give a better idea of numbers present.

(In 2004 ICES defined "at risk of being harvested unsustainably" as referring to stocks where fishing mortality is above the precautionary reference point (F_{pa}). This is equivalent to the previous terminology "harvested outside safe biological limits". The term "full reproductive capacity " describes stocks where the spawning biomass is above the precautionary reference point (B_{pa}). This is equivalent to the previous terminology "inside safe biological limits". A more complete explanation of the new terminology can be found in the sector report on Fish and Fisheries, which also contains a map showing the ICES areas.)

IMPACT OF FISHING

Fishing gear is not totally selective on the targeted species and under-sized fishes, as well as species of no commercial value, may be caught and have to be discarded. The UK's commitment to the ecosystem approach for fisheries management means that increasing attention is being devoted to reducing by-catch and discarding; the results should benefit the ecosystem generally. Even on target fishes however, fishing can have distinct detrimental effects on stocks by reducing genetic diversity through selective removal of the older, larger and later maturing specimens. Also certain species tend to be slow-growing and relatively unproductive and species such as the common skate have been reduced to a fraction of their earlier abundance, even in Region 6 where it can still be found.

In addition to its effects on fish stocks there are also potential impacts on seabirds through removal of food supply, on sea mammals caught and drowned in fishing nets and on animals living on the seabed. In Region 6 measures have been taken to protect the sandeel stock during the period considered crucial for seabird chick survival. There do not appear to be particular concerns in Region 6 over the numbers of marine mammals caught inadvertently in fishing nets but the UK Small Cetaceans By-catch Response Strategy does seek to reduce the catch of cetaceans – mainly dolphins and porpoises, to the lowest possible level. Bottom trawling is known to disturb and reduce the numbers and diversity of larger bottom living invertebrates but has a smaller effect on many of the smaller invertebrates. It can also have some beneficial effects in that scavenging animals benefit from the carrion left exposed after the passage of fishing gear. The scale of these effects in Region 6 has not been studied and there is no quantitative information.

PLANKTON

The free floating microscopic plant life of the sea (phytoplankton) forms the base of the marine food web and provides food for the animal plankton (zooplankton) and in turn their predators. Changes in the assemblages of phytoplankton and/or zooplankton imply changes in environmental conditions and vice-versa. They also imply changes in the assemblages of fish etc higher up the food web through changing availability of food and/or changes in the environmental conditions they prefer. For example changes in plankton may be brought about by intrusion of warmer waters into an area which will bring with them warmer water fish species such as red mullet and be less suitable for colder water fishes such as cod. An understanding of what is happening at the planktonic end of the food web is therefore fundamental to the understanding of the marine ecosystem generally.

There have been various observations of plankton over the years in Region 6 including routine sampling for toxic phytoplankton species undertaken by the Scottish Environment Protection Agency (SEPA) and, since 1996, by FRS on behalf of the FSA. However, none of these studies have been prolonged and no systematic sampling strategy has been followed. This means that for Region 6 there are no records that permit any assessment either of what is normal or of what changes there might have been over the years. However, it is possible to infer what must have happened from the Continuous Plankton Recorder (CPR) survey findings. Although there are no routinely operated routes through Region 6 one is operated from north of Malin Head westwards into the Atlantic (Malin Head is just outside Region 6 on the north coast of Ireland). There are also routes to the north in Region 7, Sule Skerry to Reykjavik and two routes to the south in the Irish Sea (Region 5).

The CPR records from these routes all show the same picture and clearly reveal a shift in both phytoplankton productivity and in the assemblages of both phytoplankton and copepods which make up the bulk of the zooplankton in the North Atlantic and in the waters around the British Isles. Since it is from these waters that the

waters in Region 6 are mainly derived it follows that these same changes have also probably occurred in Region 6. The changes noted in the surrounding Regions occurred around 1987 and were associated with changes in the movement of water currents. The changes are believed to be associated with marked changes in the Northern Hemisphere Temperature (NHT) in sea surface temperature and in the North Atlantic Oscillation (NAO). The planktonic assemblages are now more typical of the warmer dynamic regime previously seen to the south of the UK and much less typical of the cold temperate regime that previously typified UK waters, particularly those in more northern latitudes

BENTHOS

During the last few years the JNCC has devoted considerable effort to collecting and mapping information on what benthos sampling has been carried out in UK waters. During the past 30 years the conservation agencies have commissioned many surveys to support the selection and designation of marine protected areas (Special Areas of Conservation (SACs)). There have been two large UK-wide systematic surveys: the Inter-tidal Survey of Great Britain and Ireland and the Marine Nature Conservation Review. With a few exceptions it is now clear that information is available on the benthic communities found around most of the UK coastline. However, there is only limited information for many offshore areas to the west of the country, including the more open areas of Region 6. Effort is now turning to analysing the available data with a view to identifying changes. These efforts are being hampered by a lack of information from consistently collected samples except for a few, mostly coastal and estuarine sites. Furthermore, survey effort appears to have declined in the last ten years.

Within Region 6 the NMMP has benthic monitoring sites in Lough Foyle and the Bann estuary, plus a site off the coast of Antrim, on the Northern Ireland coast and in Loch Linnhe on the west coast of Scotland. These sites have been sampled annually but the time series of data is as yet inadequate for the purpose of identifying changes over time. However, detailed assessments have been carried out (*MEMG, 2004*) of the abundance and diversity of benthic species at these sites and scores have been allocated according to an experimental version of a Biotic Index (AMBI). As it currently stands, under this scheme zero is considered to indicate a normal healthy regime whereas a score of seven represents an extremely stressed or polluted site. The Loch Linnhe and north coast of Antrim site scored 2.41 and 2.78 respectively, indicating some degree of stress whereas the Bann and Lough Foyle sites scored 3.93 and 3.21 respectively indicating a higher level of stress. However, this index is influenced by salinity stress and by the nature of the seabed and none of the four areas was considered to be seriously impacted by human activities.

In common with the activities of the other conservation agencies in their respective areas Scottish Natural Heritage has conducted an assessment of the status of Scotland's marine waters and concluded that, despite their active survey effort in recent years, the extent, abundance status and ecology of most marine habitats remains poorly understood. They noted particularly the increasing numbers of fish farms and the relatively poor understanding of their impact on the benthic environment.

The sector report on Habitats and Species concludes that in relation to EcoQOs for benthos much remains to be done to establish what is meant by OSPAR aims for "the density of sensitive and opportunistic species" or for "the presence and extent of declining species" or what is meant by the EU target of "biodiversity decline should be halted by 2010." Clearly even when these terms have been clarified there will be a paucity of data in Region 6 and most other Regions around the UK, on which to assess compliance.

SEABIRDS

Seabird numbers and breeding success are assessed annually throughout the British Isles by the Seabird Monitoring Programme (SMP), which began in 1986 and is co-ordinated by the JNCC's Seabird Colony team. Since 1989 the results of the SMP have been published in an annual report. This is entitled "Seabird numbers and breeding success in Britain and Ireland" and is produced by JNCC in collaboration with RSPB and the Shetland Oil Terminal Environment Advisory Group (SOTEAG). While the SMP conducts annual monitoring of a sample of the seabird population in the UK complete censuses of all seabirds in the UK have been conducted to obtain total population estimates, which provide

a baseline against which subsequent monitoring can be compared. The most recent UK population estimates were obtained in 1998-2002 during Seabird 2000 a JNCC-led census of breeding seabirds in the UK and Republic of Ireland.

Twenty-five species of seabird are known to breed in the UK and total numbers have increased from around 4.4 million in 1969-70 to 6.7 million in 1998-2002. Not all species have experienced the same success and there are considerable variations between species year to year and between breeding sites.

The EC Birds Directive requires Special Protection Areas (SPAs) to be established for seabirds where there are breeding populations of European importance or where the seabird assemblage is of international importance. Within the Region 12 such sites have been designated, two on the coast of Northern Ireland and the rest in Scotland including two on the Outer Hebrides. The Region holds 32% of the world population of Manx shearwaters on just six island colonies.

Apart from the impact on breeding success of the availability of food the availability of nesting sites and the presence of predators can play a big part. At some colonies Great Skuas have taken to predating on other seabirds, apparently in response to lack of food fish. It is feared predation by Great Skuas may become more serious if quantities of fishing discards and sandeel stocks continue to decline. The main predation problems at present however, are experienced by ground nesting species such as puffins, petrels, shearwaters, gulls, terns and Black guillemots and on some islands invasions by brown rats or American mink have led to complete extinction of some ground nesting birds. The ill-advised introduction of hedgehogs has also caused problems for ground nesting seabirds on some islands.

SEALS

Two species of seal are found in UK waters. The larger of these – the grey seal (*Halichoerus grypus*) typically breeds on rocky coasts and in caves. In addition to coming ashore to give birth and wean its pups mating takes place on shore at the breeding sites. At other times resting can be at other haul out sites, though it prefers sites undisturbed by humans. In Region 6 there are several breeding sites in the Inner Hebrides to the south of the Region and several more on the Outer Hebrides. Pups are usually born between mid-September and mid-November in Region 6. About 90% of the UK population of grey seals, which accounts for about 39% of the world's total grey seal population, breed in Scotland, a large proportion of them in Region 6.

The other seal species found in UK waters, the common or harbour seal (*Phoca vitulina*) also comes ashore to give birth but the pups can swim very soon after birth, although both mothers and young need to come ashore to rest and to moult. About 88% of the total population of 33,800 common seals lives in Scottish waters mainly in the Hebrides and west coast of Scotland, although substantial numbers are also found in Orkney and Shetland (Region 7). Pups are born between late May and early July but because the pups can swim soon after birth, accurate estimation of pup production is not easy and is usually based on counts at selected haul out sites during the moulting season.

Populations of both seal species have grown since records were first collected systematically in the 1960s and there are signs that the population of grey seals is stabilising. Both species were affected by outbreaks of Phocine Distemper Virus (PDV) in 1988 and 2002 but common seals were worst affected and suffered the majority of the fatalities. The outbreak in 2002 mainly affected seals in the Wash (Region 2) and numbers in Region 6 were hardly affected. Neither species is considered to be either rare or threatened in UK waters but both are listed in Annex II of the EC Habitats Directive because they are considered rare or threatened elsewhere in Europe. Under the terms of this Directive the UK is required to select representative sites as Special Areas for Conservation (SACs) and to this end has designated as proposed SACs, 11 haul out sites for common seals and 11 breeding sites for grey seals. Several of these proposed SACs are in Region 6 e.g. on Islay, Eriskay and Skye. One EcoQO has been established for seals and another has been proposed. Both are expressed in terms of population numbers and utilisation of breeding sites and thus require simple numerical data to allow tracking of trends over time. Such data are collected routinely by the Sea Mammal Research Unit at St Andrews and form the basis of the management advice provided annually to the Natural Environment Research Council's Special Committee on Seals (SCOS).

CETACEANS

Although 28 species of cetacean have been recorded in UK waters only about 12 are known to occur in Region 6, although only five are recorded regularly – minke whale, killer whale, Risso's dolphin, white beaked dolphin and harbour porpoise. The total species complement is similar to that found elsewhere at the same latitude and is considered to be satisfactorily diverse. However, estimates of population with confidence limits exist for only a few species. One of the few for which estimates exist is Risso's dolphin in the Minch where it is estimated at least 142 animals are resident. Dedicated cetacean surveys are currently being conducted in Region 6 in the Inner Hebrides and should substantially add to the information now held on the Joint Cetacean Database. This database is the product of amalgamating three previously separate databases; the data in it were used to produce an atlas of cetacean distribution. Strandings of cetaceans within Region 6 are recorded and summarised by the Scottish Agricultural Centre's Veterinary Investigation Centre.

HABITATS

The sector report on Habitats and Species describes the various measures that are available, have been and are being taken to protect habitats and species around UK coasts. It reviews a range of key habitat types and indicates areas where important examples of each are to be found, as well as the threats each habitat type is currently facing and may face in the future. There are no Marine Nature Reserves in Region 6 but there is one marine SAC in Northern Ireland and 12 marine SACs along the Scottish coastline and islands mostly in the Inner Hebrides and lochs of the southern part of the Region.

Most of the coastline of Region 6 is rocky and the majority of the important examples of habitat types found in the Region are related to that type of land form and seabed. However, Lough Foyle in Northern Ireland is considered to be an important area for *Zostera* spp. – sea-grasses. A number of sub-littoral sand and gravel habitats are identified in the deeper waters of some of the long inlets of the Scottish west coast – notably Loch Linnhe. Maerl beds are considered to be particularly well developed around the Islands of Region 6. Maerl is the collective term used for a group of calcareous red seaweeds and it provides a habitat for a wide variety of marine plants and animals. It is of particular interest in the sense that it appears to fall between various forms of possible protection, because with rare exceptions it is usually found only at sub-tidal level. Except in Scotland, where the limit for an SSSI is mean low water spring tides they cannot therefore be given SSSI protection even when it occurs inter-tidally, as happens on the shore of Loch Sween.

The term tidal rapids is used to describe a broad range of high energy environments caused by deep tidal streams and tide swept habitats. They are particularly well represented in Region 6 because of the many constricted entrances to sea lochs. They often also feature maerl and horse mussel (*Modiolus modiolus*) beds. Some of these tidal rapids have protection under the EC Habitats Directive as SACs, for example the tidal rapids of Lochs Duich, Long and Alsh; this latter SAC includes Kyle Rhea which has some of the strongest tidal streams encountered in the UK. A number of these tidal rapids have been blocked off in the past by construction of solid causeways between communities and there are concerns that this could happen again at other sites as better communication links are established between islands and communities on the islands

KEY POINTS AND CONCLUSIONS

Global surface temperature has increased by about 0.6°C in the last 100 years and this trend is reflected in three indices of Scottish land temperature all of which are relevant to Region 6. Comparisons of these records of mean annual temperatures between 1873 and 1902 and 1961 to 1990 indicate a clear warming of between 0.11 and 0.39°C. There also appears to have been a trend towards drier summers, at least in Northern Ireland, with attendant relatively wetter winters. Records of sea surface temperature in the North Atlantic indicate a warming of between 0.2 and 1°C/decade since 1981 and water entering the Region via the North Channel has increased in temperature by about 0.6°C during that period. Two records from within the Region near Millport and in the Tiree Passage also clearly indicate a warming trend, although the Tiree Passage record follows a pattern more similar to that in Region 7 in the Scottish Coastal Current. Wave heights in the Region appear to have been increasing since at least the 1960s when reliable records began to become available and indicate an increase of about 0.03 m/yr.

Most of the coastline of Region 6 is rocky and rates of erosion along both the coasts of Northern Ireland and Scotland are low, although in the Outer Hebrides many of the small beaches are experiencing loss of beach material. Sea level rise due to thermal expansion and ice melt is offset in Region 6 by the fact that the land is still subject to uplift following retreat of the ice-cap after the last ice age. Thus the dangers of coastal flooding as a result of sea level rise are probably less in the Region than elsewhere around the UK.

In relation to chemical contamination, environmental quality in Region 6 is for the most part good. There is little or no industry and few towns of real size to contribute contaminant inputs on any scale. Nevertheless, contaminants are detectable as they enter the Region via the air and in the waters flowing through the Region from the Atlantic and through the North Channel. They are however diluted and adverse effects are rarely detected. Nutrient inputs from land are relatively small and winter concentrations of DIN and DIP are below those regarded as indicative of a risk of eutrophication. The detection of algal toxins in shellfish has been an increasingly serious problem in recent years. There is no evidence to suggest that such incidents are due to enhanced nutrient levels. Increased surveillance of algal toxins has taken place and there is increased awareness that the wider scale changes in plankton productivity and composition noted in other regions may be a contributory factor in this apparent trend.

In common with other regions some monitoring is undertaken of the presence of contaminants that have given rise to concerns in the past e.g. metals, HCH, CBs and PAH. In almost all cases the concentrations found in samples from Region 6 were lower than those found in other coastal areas and below all concentrations set as indicative of any cause for concern. One notable exception however was a single sediment sample from the Bann estuary in Northern Ireland which was found to contain unusually high concentrations of PAH. There does not appear to be any explanation for this odd result. Pilot studies have been undertaken for a range of newly designated priority pollutants and a recent survey of TBT contamination included sites in Region 6. All the results indicted that although TBT continues to be present at most locations, exposure levels are insufficiently high to cause interference with reproduction in dog whelks.

Within Region 6 there are few designated bathing waters and all passed the current mandatory standards set by the relevant EC Directive. Microbiological contamination could be of rather more significance in relation to the Shellfish Hygiene and Shellfish Waters Directives because there are extensive shellfish culture operations in the Region. In Northern Ireland there is only one designated production area but this has several separately classified harvesting areas all of which were classified as class A or B. Scotland recognizes marked differences in shellfish hygiene quality according to the growing season but even under the worst conditions all harvesting areas achieved either class A or B status in 2003. Under the terms of the Shellfish Waters Directive all the areas monitored in Northern Ireland met the requisite standard in 2001.

Although there are occasional reports of oil slicks being sighted in the Region that are attributed to discharges from ships, oil pollution incidents have not proved an issue of serious concern in the Region. There was only limited information on the presence of litter in the Region in the sector reports but it is clear that the Region does not escape the aesthetic effects caused by this ubiquitous contaminant or the effects that it can cause on marine life.

There are two designated sites in the Minches where disposal of material dredged from harbours is permitted but the quantities involved are small. Larger amounts are disposed of in Northern Irish waters but even here the amounts are small compared to those involved in Regions 1, 2 or 5. There is some dredging for aggregates in the Region off the coast of Northern Ireland, but the scale of construction works is generally small with no current plans for large scale wind, tide or wave energy power generation. Coastal defences have been constructed on the southern parts of the Scottish mainland coast and causeways and bridges have been built linking islands and island communities.

Mariculture is a major activity in the Region but is increasingly regulated so as to minimise impacts on the environment and wild stocks of fish and marine organisms more generally. Fears have been expressed over a variety of possible adverse effects. These range from impacts on plankton – toxic blooms or simply excessive algal growth, to concerns over accumulation of unused food, medicines and interbreeding between wild

salmon and escapees from the fish cages. Whilst some adverse effects may have occurred in isolated instances, improvements in fish farming practices and better regulation have largely eliminated the worst problems. Research and monitoring into possible side effects continues to demonstrate most fears over adverse impacts are groundless and to inform the industry of best practices accordingly.

In terms of habitats, Region 6 is unlike most other regions in that it is an area where common skate is still locally abundant and where the basking shark, which was targeted commercially, is also commonly seen. However, most of the fish species currently commercially exploited are believed to be subject to too great a fishing pressure and in some cases stock sizes are at increased risk of, or are, suffering reduced reproductive capacity. The status of the sandeel stock is uncertain but in order to ensure sufficient food is available for breeding seabirds the fishery is subject to closure on 31st July each year. There is a fishery for *Nephrops* and this is harvested at sustainable levels. Apart from the data on the effect of fishing on targeted fish species there is little information in the background material available for this report concerning adverse side effects of fishing on other species. Nevertheless, effects such as by-catch mortality and seabed disturbance must arise but apparently not on a scale to give rise to particular concerns.

Data on the presence of cetaceans indicate a species mix typical of that encountered in other similar latitudes. Efforts are being made to improve the quality of the data available by means of dedicated cetacean surveys but as yet reasonably reliable population estimates only exist for Risso's dolphin in the Minch. Both species of seal normally found in UK waters are encountered in large numbers in the Region particularly around the Outer Hebrides and west coast of Scotland. In compliance with the EC Habitats Directive a number of breeding sites for grey seals and a number of haul out sites used by the common seal have been designated as SACs. However, although considered rare or threatened elsewhere in Europe neither species is considered to be at risk in the UK. Neither species was seriously affected in Region 6 by the epidemics of PDV and there is some evidence that numbers of grey seals are beginning to stabilise. Seabirds also appear to do well in the Region although predation of eggs and young by escaped American mink, rats and hedgehogs is a problem in some locations. Also at some seabird colonies Great Skuas have taken to predation on other seabirds apparently in response to a shortage of food fish.

There are only limited consistently collected records of plankton in Region 6 but there is no reason to suppose any anthropogenically induced changes have occurred other than those noted in other regions, which are probably climate change related. An assessment by SNH of the availability of information on the status of marine waters around Scotland concluded that too little was known about the abundance, status and ecology of most marine habitats. It also concluded that not enough was known about the impact of fish farming on the benthic environment.

In a more general context most of the coastline of Region 6 is rocky and the majority of important examples of habitat types reflect this type of land form. Lough Foyle in Northern Ireland is however considered an important area for *Zostera*. Typical hard substrate habitats are those occupied by maerl and horse mussels although there are some sub-littoral sand and gravel habitats in some of the larger Scottish lochs. There are also several areas of tidal rapids and construction of causeways across these, as has been the practice in the past, is for obvious reasons considered undesirable in habitat protection terms.

Region 7:
Scottish Continental Shelf

INTRODUCTION

This Region is second only to Region 8 in terms of high exposure to storms from the North Atlantic and lack of direct human impact. Figure 7.1 shows the location of the Region in relation to Regions 1 (northern North Sea), 6 (Minches and west Scotland) and 8 (which covers the rest of the UK EEZ) and the location of the main places mentioned in this chapter. The southern boundaries of Region 7 are made up of a series of more or less straight lines comprising the median line between Ireland and UK, a line separating Region 6 from Region 7 which takes in the southern tip of the Outer Hebrides across to Cape Wrath on the Scottish mainland to John O'Groats, skirts south and east of Orkney up to and along the west of Shetland and, in an

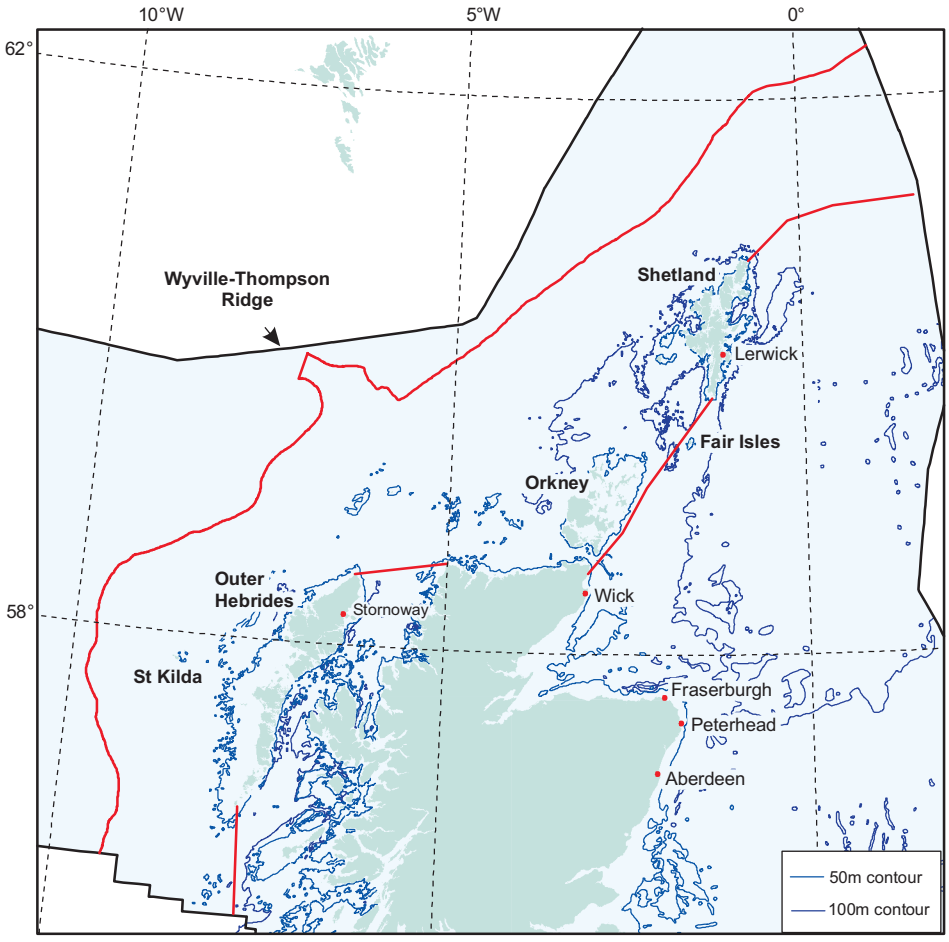


Figure 7.1. Map of Region 7. Bathymatric contour data copyright UKHO

easterly direction out to the median line between UK and Norway. The outer, westerly boundary runs along the continental shelf edge and with low input of material from the land the waters have low turbidity. The northern boundaries follow the line of the shelf break. Apart from the shallower waters around the islands where depth in many cases shelves rapidly down to about 150 m, water depth is typically 150-500 m. The Outer Hebrides, Orkney and Shetland are relatively sparsely populated and 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. The only industry of note is the oil industry, which has important shore facilities in Orkney and Shetland with a number of oil fields along the northern boundary of the Region to the west of Shetland. Hydrographically the Region is important as it includes the Wyville-Thompson Ridge which 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 Fair Isle Channel between Orkney and Shetland is also important as a route through which water can flow into the northern North Sea (Region 1) from the North Atlantic.

PHYSICAL ENVIRONMENT

WEATHER AND CLIMATE

The three main weather parameters that drive ocean circulation are the wind speed and direction, air/sea heat exchange and evaporation/ precipitation. These affect the strength of the Atlantic thermohaline circulation thereby altering the distribution of sea surface temperature and salinity on a broad scale. Stronger, more frequent westerly winds over the north Atlantic will drive a greater influx of North Atlantic water towards the British Isles northwards along the continental shelf edge and through Region 7. They will also bring with them warmer air temperatures and higher rainfall.

A major factor affecting North Atlantic circulation is the North Atlantic Oscillation (NAO) – for a brief description of this see Chapter 1. From about 1960 the NAO has experienced its biggest change since the 1860s with the Winter Index (December to March) showing an upward trend following a negative phase in the 1960s. Although there are indications that similar changes have occurred in the past 500 years the rise between the 1960s and 1990s appears to be unusually large. High Index years are generally associated with warming in the southern North Atlantic and north-west European shelf waters with cooling in the Labrador and Nordic Seas. Positive Index winters are typified by more intense and frequent storms in the vicinity of Iceland and the Norwegian Sea and there is a strong link between the NAO and the wave climate in areas west of Britain such as Region 7.

Global surface temperature has increased by about 0.6°C since the late 19th Century and this increase is probably the largest in any century during the last 1,000 years. Three regional terrestrial measures of temperature change have been produced for Northern Ireland and Scotland. One of these, the Scottish Islands Index relates directly to Region 7. It is based on records from Stornoway and Lerwick and shows a pattern of warming entirely consistent with the global warming trend. Figure 7.2 shows the long-term changes in monthly average in temperature, wind and rainfall at Lerwick. Interestingly the temperature in 2000 and 2001 dropped following higher years in 1998 and 1999. This is not necessarily inconsistent with global warming because most of the warming is believed to be a result of an increase in mean minimum temperature rather than a significant change in mean maximum temperature.

Figure 7.3 shows average wind speeds at Lerwick have increased by about 0.5 knots every 10 years although there has been considerable variability between years. The very marked difference between the winters of 1994/95 and 1995/96 is attributable to the extreme difference in NAO in those two winters. For the UK as a whole the 24 month period ending March 2001 was the wettest since records began in 1766, with the last 12 months being the wettest of all. This contrasts with the records for Lerwick (Figure 7.2) which show lower rainfall during 2000 and 2001 with the greatest amounts being in the late 1960s.

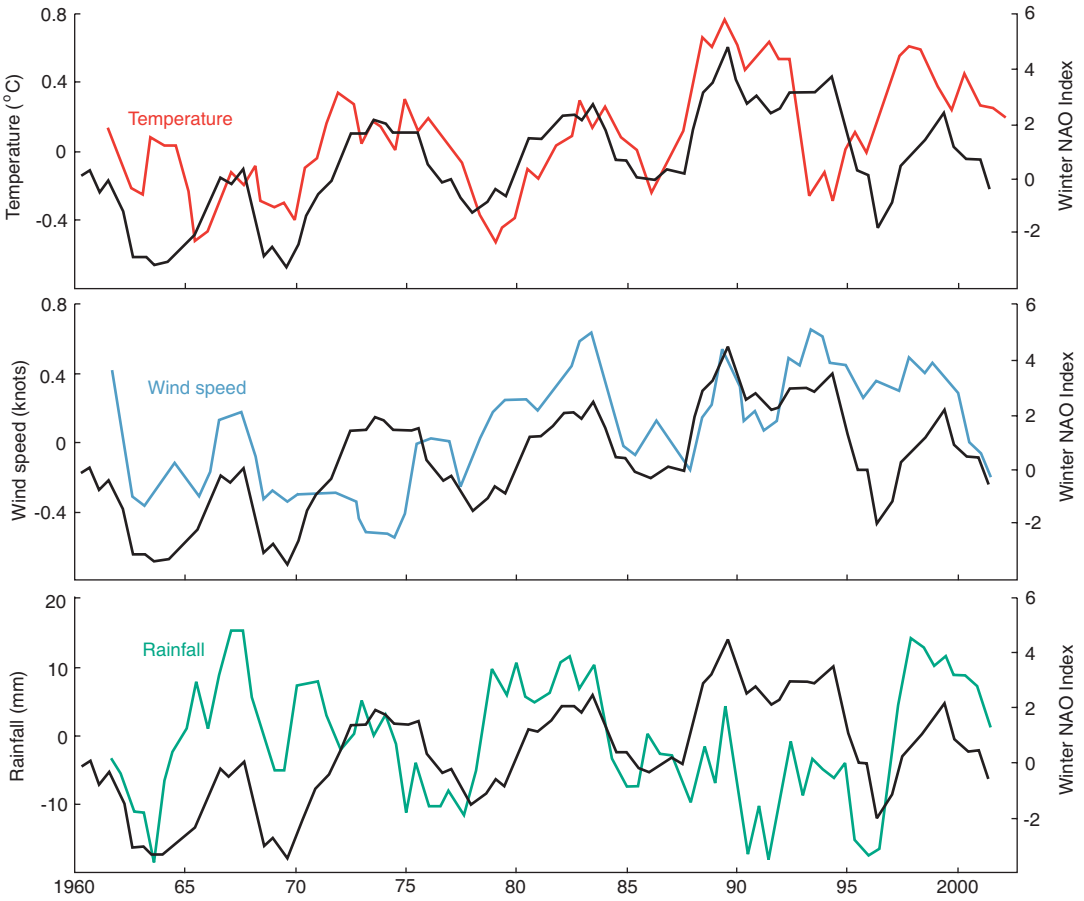


Figure 7.2. Long-term changes in the monthly average air temperature, wind speed and rainfall at Lerwick Long term changes in the monthly average air temperature, wind speed and rainfall at Lerwick and changes in the NAO Winter Index. For temperature and wind, the large change through the year due to seasonal changes has been removed by subtracting the long-term (1961-1990) monthly averages, leaving the smaller change from year to year. Courtesy of FRS

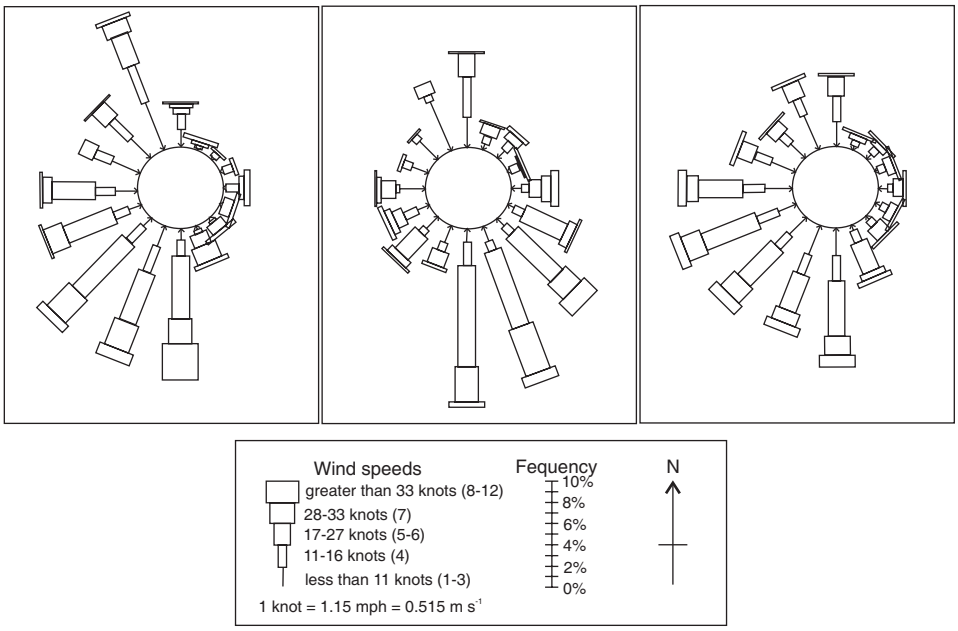


Figure 7.3. Lerwick wind roses for extreme NAO Index years and full data series Frequency, force and direction of the wind at Lerwick, for winter (December to February). Left is winter 1994/5, centre is winter 1995/6, right is full data series, 1983-2000. Courtesy of FRS and Andy Tabor

SEA TEMPERATURE

Changes in sea temperature induce shifts in the geographic distribution of marine biota and changes in biodiversity with direct effects on breeding success and species composition from phytoplankton to fish. Figure 7.4 shows the trend in winter sea surface temperature (SST) averaged over the eastern North Atlantic between 15 and 20°W and 55 to 60°N and suggests a small but distinct warming trend in Region 7. Data for global ocean temperature change suggest there has been an overall rise of about 0.04°C per decade, mainly in the upper 300m. This fits with the overall warming trend seen in the wider eastern North Atlantic (Figure 7.5) of about 0.4°C between 1981 and 2000 for the whole of Region 7 and 8. A shelf edge index of SST has been created using records from ocean transects and a 1° resolution long-term sea surface temperature data set. This suggests warming of between 0.12 and 0.29°C over the past century.

Records for Fair Isle (Figure 7.6) are also relevant to Region 7 because although Fair Isle is just in

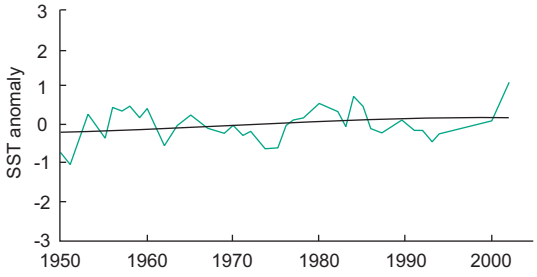


Figure 7.4. Winter (January to March) SST Anomaly, 1950-2002, eastern North Atlantic (55-60°N, 25-15°W)Time series produced by averaging the winter data sets by year. Anomalies produced by subtracting the mean calculated for the whole period. Long-term trend based on a second order polynomial. Courtesy of the ICES Oceanographic Data Centre

Region 1 (Northern North Sea) it is influenced mainly by water flowing from the north-west i.e. out of Region 7. This record also shows a warming trend.

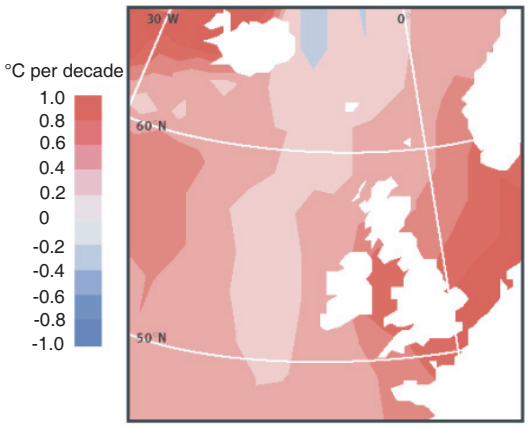


Figure 7.5. SST trend for 1981-2000 Red shading indicates warming (a positive trend in temperature) and blue shading indicates cooling (a negative trend in temperature). Trend values are °C per decade. Courtesy of the FRS, taken from Reynolds Optimally Interpolated Sea-Surface Temperature dataset provided by the NOAA-CIRES Climate Diagnostics Center, Boulder, Colorado, USA, from their Web site at http://www.cdc.noaa.gov/

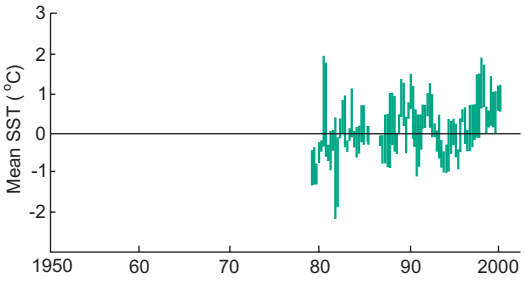


Figure 7.6. Monthly mean SST at Fair Isle The large change during the year due to seasonal changes has been removed by subtracting the long-term monthly averages. Courtesy of FRS (Fair Isle Marine Environment & Tourism Initiative)

SALINITY

Figures 7.7 and 7.8 show the winter and summer sea surface salinity averaged over the eastern North Atlantic in an area bounded by 55 to 60°N and 15 to 25°W.

This large area lies within Region 7 and is one of relatively weak salinity gradients spatially, particularly in winter when deep convection produces a homogeneous water mass down to about 600m. The low values of the 1970s were associated with the Great Salinity Anomaly (GSA). This is believed to have been caused by "fresher" water created in the Arctic in the 1960s drifting across the Atlantic with the prevailing current reaching UK waters in the mid 1970s. The GSA was formed during an extreme negative phase of the NAO. The apparent inter-annual variability in the records during the late 1980s is probably attributable to the very few observations made during that period and may not be a true picture of what actually happened. Salinity levels over the whole area were higher in 2002 than at any time in the previous decade.

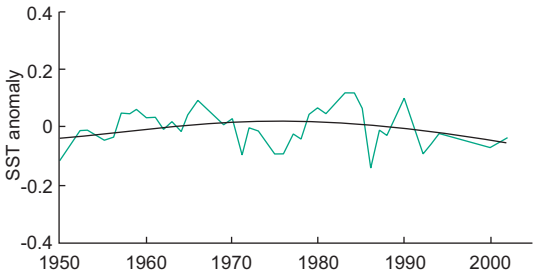


Figure 7.7 – Winter (January to March) SSS Anomaly, 1950-2002, eastern North Atlantic (55-60°N, 25-15°W). Time series produced by averaging the winter data sets by year. Anomalies produced by subtracting the mean calculated for the whole period. Long-term trend based on a second order polynomial. Courtesy of the ICES Oceanographic Data Centre

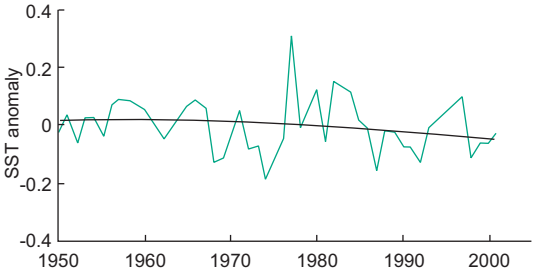


Figure 7.8. Summer (July to September) SSS Anomaly, 1950-2002, eastern North Atlantic (55-60°N, 25-15°W). Time series produced by averaging the summer data sets by year. Anomalies produced by subtracting the mean calculated for the whole period. Long-term trend based on a second order polynomial. Courtesy of the ICES Oceanographic Data Centre

WAVES

Wave climate consists of three components: the long-term mean climate, the annual seasonal cycle and non-seasonal variability on both the short-term (within year) and long-term (inter annual). In UK waters there is a strong seasonality, with wave heights peaking in January although extreme waves may occur at any time between October and March. Figure 7.9 shows the monthly mean wave heights and wind speed for an area north of the Hebrides based on satellite altimetry data from the Geosat, ERS-1, ERS-2, TOPEX-Poseidon and Jason missions.

The biggest wave heights experienced in UK waters are encountered in Region 7 in the Outer Hebrides where the long-term mean significant wave height (Hs) is around 3 m. The annual range of Hs i.e. the difference between winter and summer, follows a similar pattern and in UK waters is again greatest in Region 7. Analysis of satellite altimetry data has shown that a large part of the inter-annual variability in monthly mean wave heights during winter months can be described by a linear relationship of the wave height anomaly to the NAO index. To the west of the British Isles in Region 7, the relationship is particularly strong (Figure 7.10) and accounts for about 70% of the variance and implying monthly mean wave heights of between 3 and 7 metres when it is highly positive.

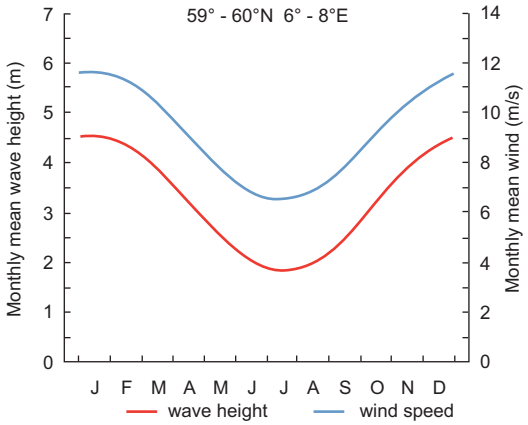


Figure 7.9. Monthly mean wave heights and wind speeds derived from ERS-2 and TOPEX-Poseidon altimeter data from 1985 onwards. The location box indicates the area of averaging. Courtesy of Satellite Observing Systems Ltd.

Reliable long-term measurements of wave heights in the North-west Atlantic are available only since the 1960s and the records from ocean weather ships Lima and Juliet indicate a rise of between 1 and 2% between 1978 and 1985. Other records, including satellite altimetry data, all show a similar picture and a recent analysis of the combined records suggests an average increase in Hs for the North-east Atlantic as a whole of about 0.03 m/yr from the 1960s through to at least the early 1990s.

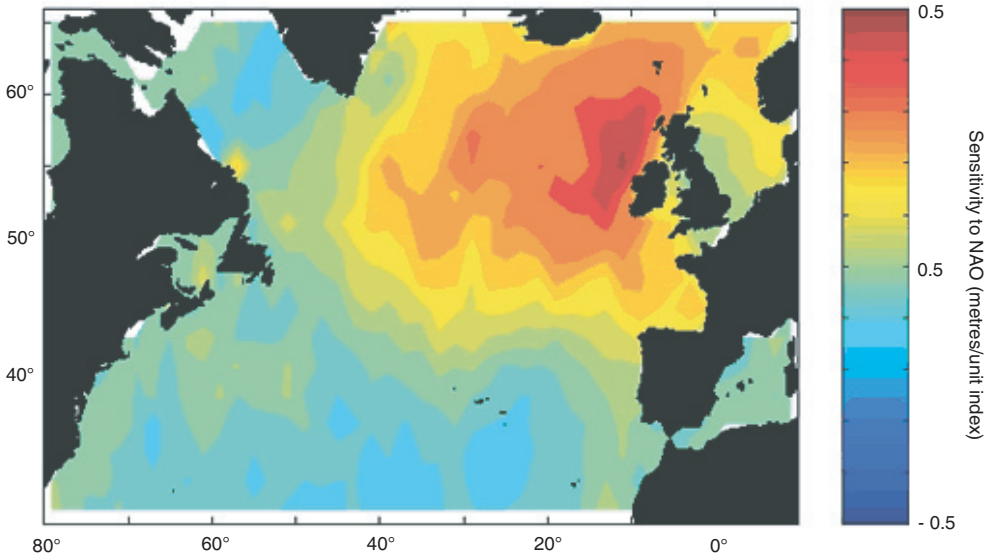


Figure 7.10. Sensitivity of winter monthly mean significant wave height to NAO around northern Europe. Courtesy of David Woolf, SOC

CIRCULATION

Circulation can be defined as the net movement of a body of water as a result of residual currents. Understanding circulation in an offshore area such as Region 7 is important as it gives an insight on the influence of the oceanic North Atlantic area on the passage of water through the Region and onwards. Three distinct types of current are recognised, tidal currents, surge currents and density currents. UK waters respond strongly to tidal forcing at the Atlantic boundary, in general amplifying the two tides a day component of the tide generated by the varying gravitational pull of the sun and moon. Surge currents are meteorologically forced by wind streams and atmospheric pressure, whereas density currents arise as a result of density gradients caused by temperature and/or salinity differences between two water bodies.

Figure 7.11 shows by arrow direction and length the overall circulation in UK waters and clearly shows water in Region 7 flowing northwards along the shelf west of the Hebrides, around Scotland and out of the area, either north of Shetland or into Region 1 (northern North Sea) via the Fair Isle Channel between Orkney and Shetland. This picture of circulation is derived from a mathematical model and represents average conditions derived from hind-casting using observations of meteorological conditions and actual water movements at various points in time. The model simulation does give a

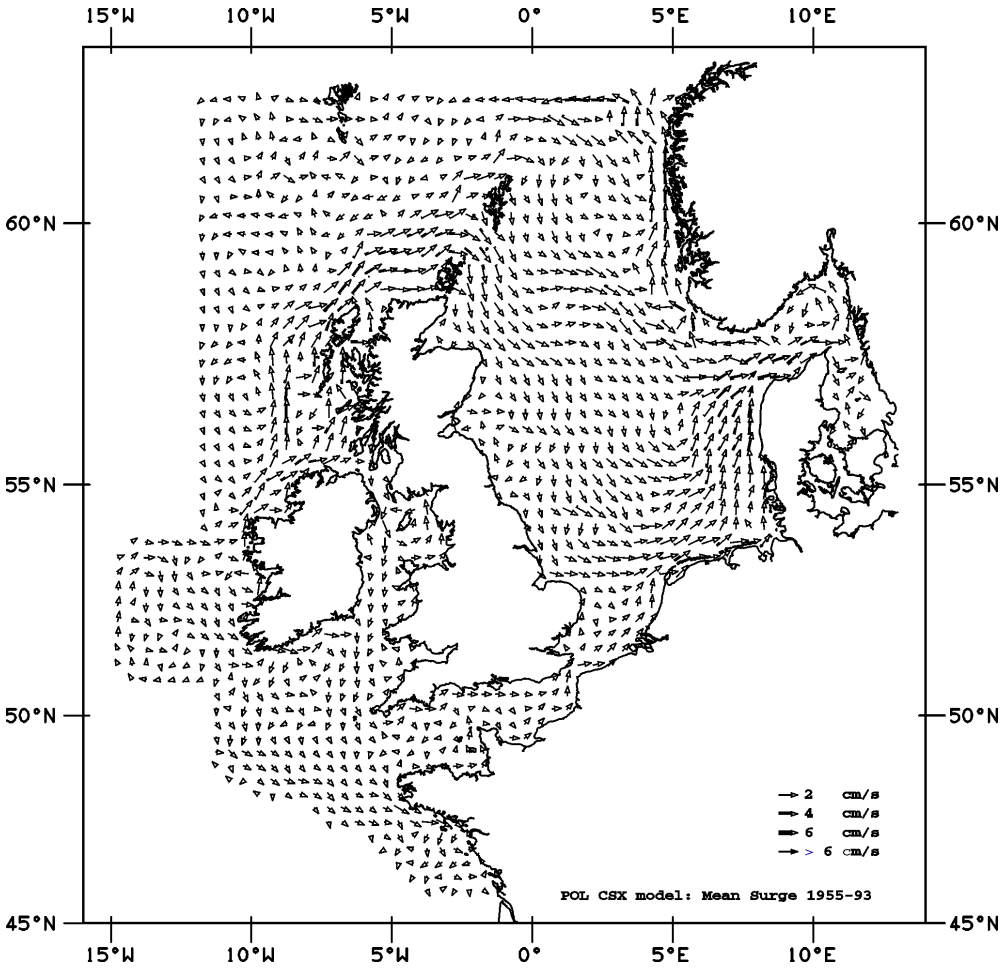


Figure 7.11. Climatological residual currents from the POL model based on annual means from 1955-1993 (Figure 2 of Smith *et al*. paper). Courtesy of Jane Williams, POL

reasonably accurate picture of overall water movements but at any given time the picture may be very different, especially at a local level. For example the flow through the Fair Isle Channel can vary considerably.

Actual observations at the shelf edge to the extreme west of Region 7 show the existence of an along slope current, the European Shelf Current (ESC) stretching the full length of the slope to north of Shetland. This current is considered to be forced by the combined effect of the shelf slope and the adjustment of shelf and oceanic regimes to meridional density currents. The ESC exhibits some seasonality, with weaker flows in spring and stronger flows in autumn and the mean current speeds are estimated to be between 0.05 and 0.2 m/sec, with higher speeds where the flow is 'squeezed' by depth contours. Year round measurements west of the Hebrides had a maximum flow of 0.15 m/sec. The maximum current in summer was at about 200 m depth but in winter, flow was much more uniform throughout the water column. Combining these measurements with the observed tracks of drogues suggests an ESC mean transport of about 2.5 Sv (1 Sv $=10^6 m^3$/sec)

SEDIMENT CONCENTRATION AND TRANSPORT

The water mass passing through Region 7 is of North Atlantic origin and has a low suspended sediment load. The coastline of the Region is essentially rocky and the seabed tends to rise fairly steeply towards the coast, resulting in sandy rather than muddy beaches. Thus, except locally very close to the shore, suspended sediment concentrations are normally low and transport of what suspended sediment there is follows the general circulation pattern in a northerly or north-easterly direction.

CHANGES IN SEA LEVEL, COAST AND SEABED

Sea level at a particular location is a combination of tidal level, surge level, waves and mean sea level (MSL). Global MSL has increased by about 120 m since the last ice age some 20,000 years ago. Based on tide gauge data for the last century the rate of rise was between 1 and 2 mm/yr as a consequence of thermal expansion of the ocean due to warming and melting of the ice-caps and glaciers. Concerns over the apparent increase in the rate of ice melting would tend to be supported by analysis of satellite altimetry data for the 1990s which suggest global MSL is rising by around 3 mm/yr i.e. rather more rapidly than the average for the 20th Century. This may however be an artefact as the satellite records cover a much shorter time period.

Due to post-glacial recovery, the land in Scotland is uplifting whereas in southern England it is submerging. The 'absolute' or average sea level rise for the UK, as a result of land movement, amounts to about 1 mm/yr or 10 cm over the century. Thus in Region 7, where the rate is lower than the absolute, this rise more than negates the effect of sea level rise due to warming. Against this must be set the increase in wave heights, given the extremely exposed nature of the coastal boundary of the region.

As mentioned in the introduction and elsewhere in this chapter, the coastline of Region 7 is rocky and change occurs only slowly. There are numerous small beach areas and many of these are eroding due, it is believed, to decreasing sand supply to the beaches. Erosion is particularly noticeable in Shetland. The fragmented outline of the Island coastline of the Hebrides, Orkney and Shetland and that of the north coast of mainland Scotland makes it difficult to divide the coastline into cells in the same way as was done for the rest of the UK for the 'Futurecoast' project. This is because the individual beaches are small and often confined to deeply indented bays, thus true 'cells' would be small and numerous. Many were therefore grouped together to make larger "sub-cells" for management purposes. The scale of the problem can be more easily understood from the fact that Region 7 was allocated 4 cells compared to only 7 for the whole of the rest of the Scottish coastline. The Orkney coastline (Cell 10) was classified as stable with eroding pocket beaches.

ENVIRONMENTAL QUALITY

NUTRIENTS

The islands and mainland areas bounding Region 7 are relatively unpopulated and the Atlantic waters which pass through the Region are essentially unaffected by nutrient inputs as a consequence of industrial or agricultural activity. At a very local level mariculture activities do lead to increases locally in nutrient concentrations due to fish excretion and

decomposition of unused fish food. The occurrence of blooms of toxin forming phytoplankton can be associated with eutrophication and in recent years there have been more numerous reports of shellfish being contaminated by various toxins of algal origin. However, it is unlikely that these are attributable to nutrient inputs from mariculture operations as they occur over a much greater area than simply the location of the fish farms. Nutrient concentrations are primarily those of the Atlantic water. The most likely explanations for the more numerous cases being reported are the twin facts that culture is taking place in new areas and monitoring is now required under the terms of the EC Shellfish Hygiene Directive. If the change is a real one then changes in phytoplankton species structure due to changes in the temperature regime may well be involved.

HAZARDOUS SUBSTANCES - METALS, ORGANICS AND POLYCYCLIC AROMATIC HYDROCARBONS

With the exception of activities associated with the oil industry in Shetland and Orkney and oil wells on the shelf edge boundary west of Shetland, there is little or no industrial activity and few towns of any size. The area is therefore regarded as pristine and few measurements of hazardous substances have been made, except in response to particular incidents such as strandings of marine mammals. Some of those stranded on the Hebrides, Orkney and Shetland have been autopsied and samples of blubber and liver have been analysed as part of the UK Marine Mammals Stranding Project. Where the data are numerous enough to reveal a general picture they suggest a reduction in lead concentrations over the last 20 years and concentrations of polychlorinated biphenyls in porpoises are generally lower than those found elsewhere e.g. in the Irish Sea (Region 5). The effect of TBT did cause some concern in the late 1980s when it became apparent that the use of this compound in anti-fouling paints was having an adverse effect on a variety of non-target organisms. Of particular concern in Region 7 was the presence of a large number of oil tankers at the Sullum Voe oil terminal (West Shetland). Monitoring between 1987 and 2001 using dog whelks as the indicator of exposure showed that population effects were probably occurring in 1987 but the level of exposure has since declined with the biggest change occurring between 1991 and 1993. This change reflects reduced shipping traffic between 1984 and 1990 since when it has been fairly static. A total ban on the use of TBT on all ships is due to come into force in 2008.

RADIOACTIVITY

As in Region 6 the presence of radionuclides originally discharged from the Sellafield site in Region 5 is detectable in Region 7. However, the concentrations present are lower again than in either Regions 5 or 6 and do not give cause for concern in relation to either human health of possible effects on marine organisms.

MICROBIOLOGY

There is one identified bathing water in Region 7. In 2003 this passed the mandatory microbiological standards set by the EC Bathing Waters Directive. Monitoring of microbiological quality is required where molluscan shellfish are grown under the terms of two EC Directives. The Shellfish Hygiene Directive sets out standards for *E.coli* and faecal coliforms in bivalve shellfish flesh. The standards define whether the shellfish can be sold directly for human consumption (class A), after passage through an approved purification plant (class B) or must first be relayed for an extended period in a class A or B area. There are 31 shellfish production waters in Region 7 along the western coasts of Hebrides and Shetland and in Orkney. In 2003 eight of these were graded class A, 18 class A/B seasonal and five class B.

Monitoring of microbiological quality is also required under the Shellfish Waters Directive. This lays down standards for a variety of contaminants and is aimed at protecting or improving the quality of shellfish growing waters. Waters so designated under this Directive are not necessarily the same as those classified under the Shellfish Hygiene Directive or vice versa although current policy is that they should broadly coincide. A derogation obviates the need for monitoring if it can be shown that waters have consistently met the standards and are unlikely to have deteriorated in quality. Within Region 7 17 areas have been designated as shellfish growing waters. The majority were only designated in 2002 and so it is not possible to assess whether there have been improvements over time. Several sites consistently comply with the Directive's guideline standard for faecal coliforms but several others fail on occasion. These failures remain unexplained but may be as a result of diffuse or agricultural sources of microbiological contamination.

OIL AND OIL SPILLS

Deliberate discharges of oil or oil/water mixtures from ships are prohibited under the North West European Waters Special Area, which was set up by IMO in 1999. This has not in practise stopped all such discharges but within Region 7 very few oil slicks were reported in 2001 attributed to vessels. There have been no oil spills as a result of accidents to shipping since the loss of the *Braer* on Shetland in 1993. The majority of the oil was rapidly dispersed and became thoroughly mixed in the water column. Some of the oil became adsorbed onto suspended sedimentary material and was deposited in two main areas, Burra Haaf on the south-west coast within Region 7 and to the south-east of Fair Isle in Region 1 (where it had no lasting effects). There were no apparent toxic effects on bottom living organisms and the visible effects were minimal both in extent and duration. However, contamination of some fish, including farmed salmon, and shellfish (molluscs and crustaceans) by PAHs was detected, particularly in shellfish from the south-west coast within Region 7 where the oil had settled with the sediments (e.g. *Nephrops* from the Burra Haaf). On a precautionary basis exploitation of various fish and shellfish species was prohibited pending return to what was considered normal background. In some cases e.g. wild fish, PAH concentrations rapidly returned to those for reference fish (<40 μg/kg wet wt muscle tissue) and the Exclusion Zone was lifted for farmed salmon on the south-west coast of Shetland 11 months after the oil spill. PAH concentrations in shellfish remained elevated for prolonged periods, especially in shellfish obtained from areas of sediment deposition such as the Burra Haaf. Restrictions on the sale of *Nephrops* were not lifted until March 2000, with the final restrictions, on mussels, being lifted during May 2000.

Some exploitation of the oil reserves west of Shetland is taking place, chiefly from floating production, storage and offloading installations (FPSOs) and export is by shuttle tanker. An exception to this pattern is the Clair field, now under development in the shallower area of the Region and will make use of a conventional fixed platform and export oil to Shetland by pipeline..

Oil based drilling muds were used in the deep waters west of Shetland but, in line with practice generally on the UK continental shelf (UKCS), discharges from this source have now ceased. Oil based muds are still used west of Shetland, as they are on the rest of the UKCS, but discharge of cuttings with oil concentrations in excess of one percent is prohibited. Cuttings may be reinjected into the sub-sea formation or are brought ashore for treatment and disposal.

NAVIGATION DREDGING AND AGGREGATE EXTRACTION

There is little or no port or harbour dredging requirement in Region 7 or extraction of aggregates for construction or beach recharge purposes. Two Licences have been granted for the extraction of Maerl (a calcareous seaweed) for use as a soil improver on acid soils of the Islands. Only one of these has thus far been taken up and a condition of the licence is that monitoring must be undertaken following a programme set out by SNH.

CONSTRUCTION

There are no major construction projects underway or planned in Region 7 apart from the development of the oil fields west of Shetland. Most of the Region is relatively sparsely populated. Construction projects in the past have, with the exception of oil industry shore bases, been confined to construction of harbours for the fishing fleet and causeways interconnecting islands. There are no plans for major renewable energy projects in Region 7 although test sites are in operation and others have been proposed on both Orkney and Shetland.

MARICULTURE

Mariculture is an important activity in Region 7 with fish farms around both Orkney and Shetland. However, unlike the practice in Region 6 most of the cages and rafts are moored in waters off the coast. These are generally deeper and have stronger current regimes. As a result there have been fewer concerns over increases in nutrient concentrations, residues of medicines or anti-fouling agents, or accumulation of unused feed materials, fish faeces etc. below the cages. Winter N:Si ratios did exceed levels thought to influence phytoplankton species composition at all the site examined around Shetland but no particular problems have been encountered and the ratios are thought simply to reflect the norm for that area. The possibility of escaped fish interbreeding with their wild counterparts is however just as much

an issue of concern in Region 7 as in Region 6. The concern applies particularly to salmon because farmed salmon have a low genetic diversity. It is therefore possible that offspring of wild and escaped farmed salmon may benefit from hybrid vigour but this is not passed on to later generations which in fact would have lower fitness and productivity. This issue is less of a concern with species such as cod, halibut and haddock because the majority of the breeding stock for these species still comes from the wild.

In 2003 the Scottish Executive published a Strategic Framework for the Aquaculture Industry in Scotland which sets out objectives and priority actions designed to achieve sustainable development of the industry in Scotland. All fish and shellfish farms require registration of the business and site and a discharge consent must be obtained. This will specify the production tonnage and quantities of medicines that can be discharged. The overall aim is to minimise adverse impacts of mariculture activities and encourage production of fish and shellfish to fill the gap left by falling catches of wild fish. A growing issue the industry has to face however, is the impact that increasing production of farmed fish is having on the stocks of wild fish used as the source of the fish pellets fed to the farmed fish. However, the increased use of fisheries by-products in fish feeds and the development of new feed materials in which vegetable oils can be used to replace fish oils and up to 75% of the fish meal can be replaced by plant proteins may minimise this potential obstacle to continued expansion of the industry and avoid over exploitation of the wild fish species currently used for fish meal based feeds.

BIOLOGICAL EFFECTS - CONTAMINANT SPECIFIC OR OTHERWISE

Given the relatively uncontaminated nature of this Region compared to Regions 1 to 5 and even Region 6, little effort has been expended in looking for biological effects in Region 7 and there was no information of significance in the sector reports.

LITTER

The sector report on Environmental Quality contains very little information on the regional prevalence of litter based on the results of a single survey by the Marine Conservation Society (MCS) in 2003. Equally there is no information on the regional effects of litter in the sector report on Habitats and Species. Consequently it is not appropriate to go into any detail in this chapter. However, a brief summary of the litter issue is provided in the final chapter of this Integrated Assessment. Only a single beach in Region 7 was surveyed in the MCS Beachwatch 2003 study. On this beach fishing debris was the main source of litter, comprising about 65% of all the litter items found. In contrast Region 7 had the lowest percentage of beach visitor debris of the seven regions surveyed.

HABITATS AND SPECIES

FISH ASSEMBLAGES

The nature of the fish assemblage found in an area is largely governed by water depth and temperature and by the nature of the seabed. In Region 7 the seabed is mainly coarse and rocky inshore, shelving rapidly out to smoother sandy mud. Water temperatures are generally lower than in the adjacent Regions, which are more sheltered and water depths are relatively deep, typically 150 – 500 m. Consequently the species found represent a transition between true deep water and relatively shallow water. The main fish species found west of the Hebrides and Northern Scotland are haddock (*Merlanogrammus aeglefinus*), poor cod (*Trisopterus minutus*), Norway pout (*Trisopterus esmarki*), whiting (*Merlangius merlangus*) and grey gurnard (*Eutrigla gurnardus*). Along the shelf edge to the very west of Region 7 the fish assemblage is dominated by silvery pout (*Gadiculus argenteus*), blue-mouth redfish (*Helicolenus dactylopterus*) and hollowsnout rattail (*Caelorinchus caelorhincus*)

COMMERCIAL STOCKS AND LANDINGS

There is some fishing for cod, haddock and whiting in Region 7 but increasingly, large twin-rigged otter trawlers are operated in the deeper waters targeting anglerfish. This fishery produces a by-catch of megrim, ling and tusk and has led to a reduction in fishing activity on inshore grounds. Northern hake is also caught in Region 7 but while a recovery programme is in progress it is no longer the subject of targeted fishing. Saithe is targeted in deep water along the shelf edge in the west and north-west of the Region. The fishery for saithe has declined in

recent years but the stock has shown evidence of increased abundance. Adult herring and extensive shoals of mackerel and horse mackerel are found along the shelf edge and there is some exploitation of Norway pout etc. for fish oil and fish meal use but on a much smaller scale than in Region 1 (northern North Sea). As has been the case elsewhere around the UK, annual landings of almost all species have declined from a peak in the 1980s (Figure 7.12).

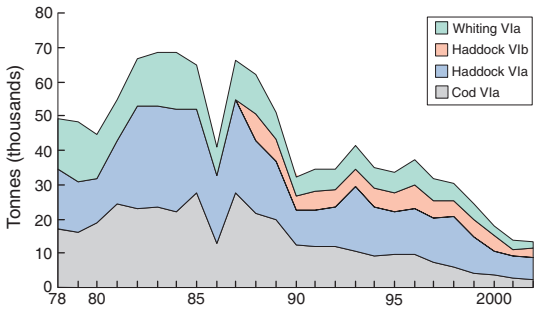


Figure 7.12. Landings of roundfish species from the west of Scotland. Species shown are whiting, haddock and cod

The status of most of the main commercially exploited stocks is assessed annually by the International Council for the Exploration of the Sea (ICES). Since 1999 their advice has been expressed in precautionary approach terms with the aim of ensuring stocks are kept within safe biological limits. It is difficult to separate the landings of commercially exploited fish caught in Region 7 from those caught in Region 6 (Minches and West Scotland) because for the purpose of assessment by ICES the two Regions are taken as one. Stocks of cod and whiting in area VIa (west of Scotland) and haddock in area VIb (Rockall) are thought to be at or close to historically low levels in 2000-2003. Haddock in area VIa have shown a temporary recovery following the recruitment of a single strong year class and is harvested sustainably. Both the cod and northern hake stock are at risk of reduced reproductive capacity and are subject to recovery programmes. Anglerfish are considered to be at risk of reduced reproductive capacity and the state of the megrim stock is uncertain. Both species suffer high levels of discards. Fishing pressure on the herring stock is however believed to be low. Fishing pressure on mackerel and horse mackerel is high and in the long-term unsustainably so.

(In 2004 ICES defined "at risk of being harvested unsustainably" as referring to stocks where the fishing mortality is above the precautionary reference point (F_{pa}). This is equivalent to the previous terminology "harvested outside safe biological limits". The term "full reproductive capacity" describes stocks where the spawning biomass is above the precautionary refernce point (B_{pa}). This is equivalent to the previous terminology "inside safe biological limits". A more complete explanation of the new terminology can be found in the sector report on Fish and Fisheries, which also contains a map showing the ICES areas.).

IMPACT OF FISHING

The main impacts of fishing in Region 7 appear to be on the commercially exploited stocks, with several stocks currently being exploited at rates believed to be outside safe biological limits. Over-fishing of fish populations tends to place the larger individuals under most pressure and can reduce genetic diversity by selectively leaving larger numbers of fish that grow more slowly and mature earlier. Unlike the majority of fisheries around the UK there seems to be less concern over mortality of non-target fish species caught as a by-catch in commercial fishing operations and neither the sector report on Fisheries nor the one on Habitats and Species mention the issue of by-catches of seabirds or sea mammals as a problem in this Region. There are however, major concerns over the impact of bottom trawls on the cold water coral reefs found in the deeper waters along the shelf break edges of the Region. These coral reefs grow extremely slowly and are fragile habitats that are easily damaged by towed trawls.

PLANKTON

Phytoplankton is the term used to describe the free-floating microscopic plant life of the sea, which forms the base of the marine food web. Phytoplankton provide food for the animal plankton (zooplankton) and in turn their predators. Copepods are the dominant zooplankton group in the North Atlantic and they and the phytoplankton are normally found in the upper 40 m or so of the water column, where the light can penetrate. Copepods are small crustaceans, typically 1 mm long, and the

successful development of larval fish to adult stocks is highly dependent on the abundance, composition and timing of occurrence of the zooplankton. Light and nutrients and to some extent temperature are the main agents governing the growth of phytoplankton.

There have been intermittent observations of plankton in Region 7 on various occasions in the last century and since 1996 FRS has undertaken routine monitoring for toxic phytoplankton species on behalf of the FSA.. However the only consistent regular record of the plankton community is that provided by the Continuous Plankton Recorder (CPR) survey which has one route through Region 7. This route runs from Sule Skerry, about 30 miles off the north coast of Scotland, to Reykjavik in Iceland and was first operated in 1939. There was break during the war years but the route has been operated continuously since the mid-1940s with records available for most months throughout that period. This route is only one of five CPR routes that run westwards from the British Isles. The samples collected by the CPR are analysed visually to arrive at an assessment of Phytoplankton colour and this gives a coarse measurement of phytoplankton biomass/chlorophyll. Preliminary studies comparing this CPR Colour Index with satellite measurements of chlorophyll show good agreement. The CPR samples are also analysed for the main zooplankton species and these provide a baseline for a range of species as well as indices of abundance and diversity. From these records it is possible to identify changes in the composition of phytoplankton and zooplankton.

Around 1987 a change was noted in the colour Index in the North Sea. Closer examination of samples from other routes showed that the same pattern of change was apparent in oceanic waters out to approximately 20°W to the west of Ireland and north into Region 7 (Figure 7.13)

The composition of both the phytoplankton and zooplankton had clearly changed and seemed to be linked to changes in other biological variables as well as physical and chemical parameters. The changes were so marked that they have been described as a regime shift. There is some evidence that the slope current west of the British

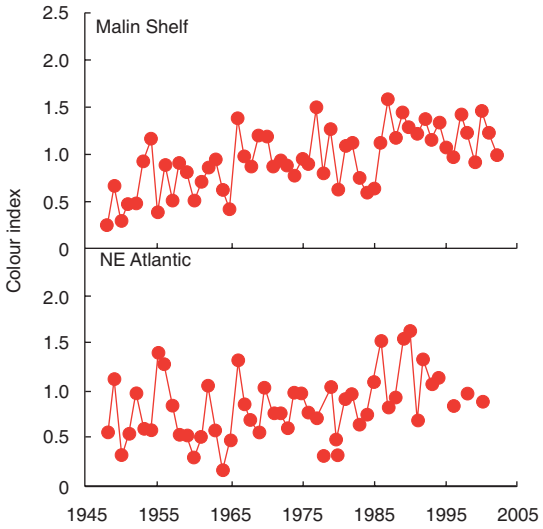


Figure 7.13. Mean Phytoplankton Colour Index for Main Shelf and NE Atlantic

Isles that runs northwards along the western boundary of Region 7 has been more active since the 1980s with pulses of warmer water extending further north than in earlier years. This current is the primary route by which plankton assemblages move further north and it is also the route followed by fish such as mackerel and horse mackerel. It is now clear that the regime shift was associated with, if not brought about by, changes in the Northern Hemisphere Temperature (NHT) anomalies and the winter NAO.

The changes that have taken place are particularly well portrayed in Figure 7.14 This shows the changes in species assemblages of calanoid copepods that occurred between 1958-1981, 1982-1999 and 2000-2002. Nine species assemblages were recognised based on stable biotope components such as geographical location or water mass. Major biogeographical shifts have clearly taken place for all 9 assemblages. The number of warm water species has increased northwards and now extends throughout Region 7 while the diversity of colder-temperate and sub-arctic species has declined.

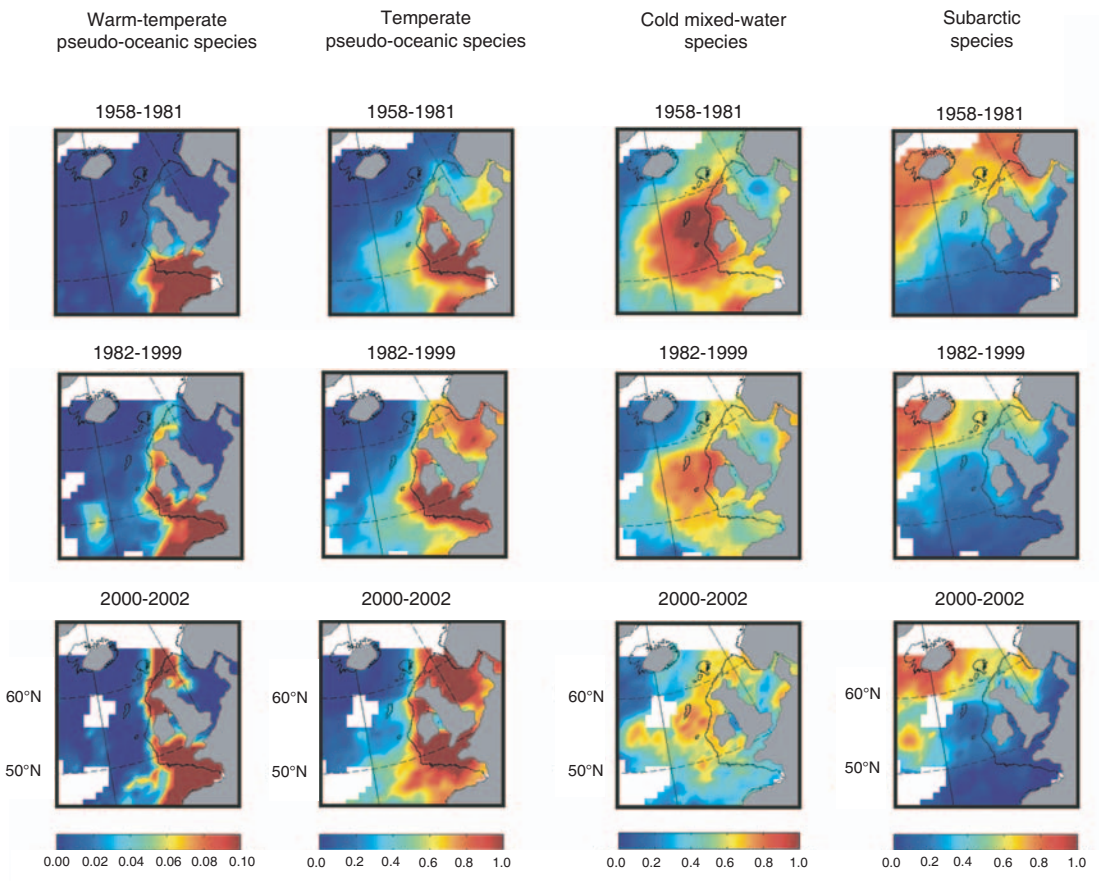


Figure 7.14. Changes in Calanoid copepods

BENTHOS

In recent years a concerted effort has been made to establish what benthos sample data exist for UK waters. The overall aim is to establish a baseline against which changes in the future can be assessed. The conservation agencies have commissioned a number of surveys during the past 30 years in order to support this activity and the selection and designation of marine protection areas (i.e. Special Areas of Conservation (SACs)). There have been two large UK-wide systematic surveys: the Inter-tidal Survey of Great Britain and Ireland and the Marine Nature Conservation Review. This was conducted in the late 1980s and early 1990s. Efforts to actually gather in the data are continuing via MarLIN and the National Biodiversity Network. Figure 7.15 shows where benthos sample data are available to this Network and clearly shows that there is very little information relevant to Region 7 most of which is remote and difficult to access.

Some samples have been collected on, or just off, the west coast of the Hebrides and around Orkney and Shetland and along the north coast of Scotland but, with the exception of a few further samples taken around St Kilda towards the western boundary of the Region to the west of the Hebrides, there is very little information available on the benthic community of the Region. Given concerns about the impact of trawl gear on fragile reef communities in the deep waters this is clearly a gap in information that needs to be addressed

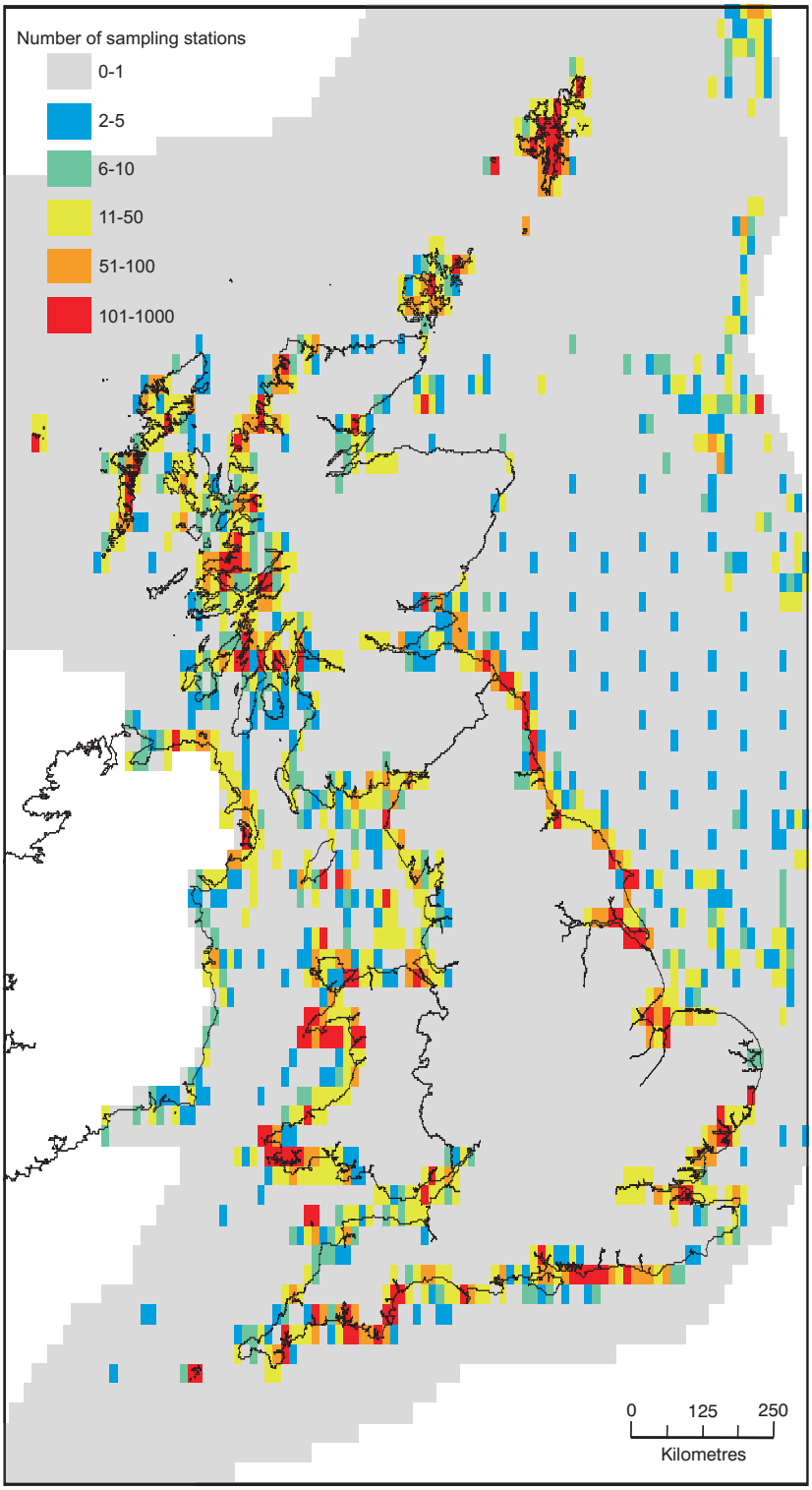


Figure 7.15. A map of UK waters showing the density of biological sample data that has been made available to the National Biodiversity Network in January 2004

SEABIRDS

Seabird numbers and breeding success are assessed annually throughout the British Isles by the Seabird Monitoring Programme (SMP), which began in 1986 and is co-ordinated by the JNCC's Seabird Colony team. Since 1989 the results of the SMP have been published in an annual report. This is entitled "Seabird numbers and breeding success in Britain and Ireland" and is produced by JNCC in collaboration with RSPB and the Shetland Oil Terminal Environment Advisory Group (SOTEAG). While the SMP conducts annual monitoring of a sample of the seabird population in the UK complete censuses of all seabirds in the UK have been conducted to obtain total population estimates, which provide a baseline against which subsequent monitoring can be compared. The most recent UK population estimates were obtained in 1998-2002 during Seabird 2000 a JNCC-led census of breeding seabirds in the UK and Republic of Ireland.

Twenty-five species of seabird are known to breed in the UK and total numbers have increased from around 4.4 million in 1969-70 to 6.7 million in 1998-2002. Not all species have experienced the same success and there are considerable variations between species year to year and between breeding sites.

Region 7 contains some of the largest seabird colonies in the UK concentrated around the Northern Isles and the islands of the Atlantic Frontier such as the St Kilda archipelago which holds the world's largest gannet colony. Under the requirements of the EC Birds Directive about a quarter of the sites designated by the UK as SPAs are located in Region 7 due to their qualifying interest in one or more seabird species and/or their seabird assemblages. The Region is the only one to hold breeding Leach's storm petrels, with 94% on St Kilda. This is the largest known colony in the eastern Atlantic but it is under threat from predation by Great Skuas. Otherwise Leach's petrels are more affected by the state of Region 8 because this is where they forage during the breeding season feeding on macroplankton brought to the surface by oceanic upwelling beyond the edge of the continental shelf.

Changes in the size and demography of the sandeel stock around Shetland have caused successive years of breeding failure for Arctic terns, Arctic Skuas, Great Skuas and Black-legged Kittiwakes and Atlantic Puffins. Populations of Arctic Skuas, Arctic Terns and Black-legged Kittiwakes in Shetland declined by 42%, 19% and 62% respectively between 1985 and 1988. The collapse of the sandeel stock around Shetland is now believed to be due to oceanographic changes that have brought about changes in plankton and have thus affected sandeel recruitment rather than excessive fishing mortality. However, the effect of fishing on the sandeel stock remains unclear and fishing for sandeels has been banned over a large area in order to assist seabird population recovery. OSPAR is testing a system of EcoQOs including the use of Black-legged kittiwake breeding success as an indicator of sandeel availability near their colonies. The fishing industry does however have an influence on seabird feeding behaviour and a number of species have become reliant on discards of offal and by-catch. For example almost 80% of the UK population of northern fulmars breed in the Region feeding mainly on macroplankton at the surface but also heavily reliant on discards of offal from fishing vessels. There are concerns that reduced quantities of discard material will have an adverse impact on such species. Northern fulmar numbers increased steadily throughout the last century but the increase appears to have slowed and a slight decline has occurred in Shetland during the last 15 years.

SEALS

Two species of seal are resident in the UK and both occur in Region 7. The grey seal (*Haliochoerus grypus*) is the larger of the two and favours haul out sites away from human disturbance where it can rest, give birth, wean its young and mate. Typically grey seals breed on exposed rocky coasts and in caves. The largest concentrations of breeding seals are found in the Hebrides where pups are typically born between mid-September and mid-November and on the Orkneys where timing of birth is somewhat later, typically between mid-October and early December. The second seal species found in UK waters is the common or harbour seal (*Phoca vitulina*). This species also requires haul out sites where it can rest and give birth but mating occurs in the water and the pups can swim almost immediately after birth. As with grey seals the largest numbers of common seal are found in the Hebrides and Orkney. They may be found up to 100km from land but typically occupy more sheltered waters than the grey seal. In Region 7 females give birth between late May and early July.

About 90% of the grey seals breed in Scottish waters most of them on Hebrides, Orkney or Shetland. These colonies account for about 40% of the world population and total numbers have grown since records began in the 1960s and by 2002 were estimated to be between 97,900 and 123,000. There is increasing evidence that numbers have begun to stabilise. Despite the name, common seals are less numerous in the UK than grey seals but the population in Scottish waters accounts for the majority of the total number. Between 1996 and 2001 the population of common seals was estimated to be around 33,800, with 29,800 or 88% of these in Scottish waters, most of them in Region 7.

Epidemics of phocine distemper virus (PDV) affected British seals in 1988 and 2002. The virus affected both species but caused death mainly in common seals. The 2002 outbreak did not seriously affect either species in Region 7. Neither species is considered to be rare or threatened in UK waters but because they are so considered in other parts of Europe both species appear in Annex II of the EC Habitats Directive. In compliance with this Directive a number of Special Areas of Conservation have been designated as being representative sites of importance either as haul out sites for common seals or as breeding sites for grey seals. One of the 11 SACs for common seals and four of the 11 sites for grey seals are to be found in Region 7. One EcoQO has been established for seals and another has been proposed; both are expressed simply in terms of numbers and utilisation of breeding sites thus allowing numbers to be tracked over time.

CETACEANS

An atlas of cetacean distribution in north-western European waters was published in 2003. This amalgamated information held on three data bases into a single joint cetacean data base. The atlas shows the distribution and relative abundance of all 28 species recorded in UK waters in the latter part of the last century. Of the dozen or so species that have been recorded in Region 7 only four may be said to be common: minke whale, Risso's dolphin, white-beaked dolphin and harbour porpoise. Several other species occur along the shelf break to the west of the Region.

HABITATS

The sector report on Habitats and Species describes the various measures that are available, have been taken and are being taken to protect habitats and species around UK coasts. It then reviews a range of key habitat types and indicates areas where important examples of each are to be found and the threats they face now and may face in the future. Region 7 is well represented in terms of designated SACs with ten such areas.

Of the key habitats identified for the purposes of compliance with the requirements of the Convention on Biological Diversity the Hebrides, Orkney and Shetland are all shown as having mud-flat areas – these are all small, albeit locally important and are in danger of erosion as part of the current trend in lack of new material (see section on changes to the coast). Tidal rapids are not a common habitat type in UK but they are important as areas where maerl beds are found. One such area is in Region 7 - Orkney, but in a few instances these habitats have been destroyed by construction of solid causeways e.g. the Churchill Bowers joining Vatersay and Barra in Orkney. The horse mussel (*Modiolus modiolus*) can form dense beds in depths of 5 – 70 m often in moderately tide-swept areas. Such beds have been identified in Hebrides, Orkney and Shetland and are regarded as requiring protection because although the species is long-lived it has a low rate of recruitment due to predation in the early years of life.

Maerl is the collective term used for several species of calcareous red seaweed. It is slow growing but can form dense beds. Several areas of maerl have been identified in Orkney and the Hebrides and Shetland. In these areas it is of considerable interest as soil conditioner for the naturally acid soils of these islands. A licence has been granted for the extraction of up to 4,000 m^3/yr for 5 years in Wyre Sound (Orkney). As a condition of that licence monitoring is being undertaken. *Lophelia pertusa* is a colonial branching coral with a hard calcareous shell. It is found in cold (4-12°C) waters mainly beyond the continental shelf but occurs on the edge of Region 7 in the area west of Shetland in the area known as the Atlantic Frontier in oil prospecting parlance.

KEY POINTS AND CONCLUSIONS

Region 7 is completely exposed to the influence of the Atlantic and winds from all directions except the east from which the Island complexes of Shetland, Orkney and Outer Hebrides offer some shelter. The Region shows some differences in the way the physical environment has changed relative to other regions. The Scottish Islands Temperature Index based on records from Stornoway and Lerwick is directly relevant and shows a warming that is entirely consistent with that experienced over land elsewhere in the British Isles. However, in the first two years of the present century both temperature and rainfall decreased. Average wind speeds have been rising by about 0.5 knots/decade, indicating an increase not just in storminess but also perhaps in storm intensity. 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.

There are few salinity records on which to base an assessment of long-term trends but in 2002 salinity was higher throughout the Region than at any time in the previous decade. The biggest wave heights experienced in waters bordering the UK are experienced in Region 7, on the Outer Hebrides where the long-term mean significant wave height is about 3 m. Consistent with the increase in average wind speed noted in the records for Lerwick, the available data suggest a rise in wave heights of around 0.03m/decade. The prevailing current system in the area is dominated by an along shelf slope current known as the European Shelf Current (ESC) but this is subject to some seasonality and variable speeds according to the influence of depth contours. Some of this water moves with the Scottish Coastal Current and in the North of the Region passes over the Wyville-Thompson Ridge and into the North Sea between Orkney and Shetland. What sediment transport there is follows the general line of the ESC but, apart from inshore areas close to beaches where beach loss is occurring, suspended solids loads are low. In Region 7 sea level rise due to ocean warming and ice melt is largely offset by land uplift and the increase in risk of coastal flooding as a consequence of global sea level rise is minimal in the Region.

In terms of the presence of chemical contamination, including radioactive materials environmental quality in the region is good. Essentially the concentrations of contaminants present are those of the North Atlantic and addition of any further quantities from the Islands is small and essentially insignificant except perhaps on a very local scale. There are some concerns over the use of chemicals in mariculture which is practiced extensively in the Region but there is there is little quantified evidence of adverse effects and better water movement around the cages means such problems are less likely to occur than in Region 6 where most mariculture takes place in enclosed waters. Changes in phytoplankton composition, including the increasingly identified presence of species giving rise to algal toxins in shellfish, is not thought to be associated with input of nutrients i.e. is not related to eutrophication. As in Region 6 the reasons are more likely to be related to overall climatically induced changes and/or increasingly diligent surveillance for algal toxins due to the requirements of the EC Shellfish Hygiene Directive. Microbiological quality monitoring is only undertaken in this Region in connection with the Shellfish Hygiene Directive. Because changes have been made to the way in which this work is undertaken in Scottish waters comparisons with data from earlier years is impractical but in 2003 eight production sites were graded class A with the remaining 23 sites graded class A/B or B. There were no class C areas.

Although there is interest in possible oil reserves west of Shetland oil pollution is not currently an issue in the Region. Few instances of oil slicks attributable to discharges from ships are reported in the Region and all the effects of the *Braer* spillage close to Shetland in 1993 have now ceased to be apparent. No major construction projects are planned or the Region. Although there is interest in the oil reserves west of Shetland, development there mainly involves seabed manifolds and floating production, storage and offloading facilities rather than surface structures. There is little port or harbour dredging activity in the Region. However, one of two licences granted for the extraction of up to 400 m^3/yr of maerl is currently active. The maerl is for use as a soil conditioner rather than in construction and strict conditions and monitoring have been imposed by Scottish Natural Heritage.

The types of habitat found in Region 7 range from small mud-flat areas and rocky shores and seabed along the island coasts to softer bottoms with rocky or coral outcrops in the deeper waters offshore. The species of fish found in the Region reflect the conditions afforded by deeper colder waters. Commercial fishing effort has increasingly turned to the deeper waters where anglerfish are the main target but where other species such as megrim, ling and tusk are also caught. The stock of western mackerel, which extends into Region 7, is thought to have declined in recent years and fishing mortality on the stock is regarded as unsustainable in the longer term. For most other species precautionary limits have been advised, with cod and hake subject to recovery programmes.

Aside from the impact fishing has on the target species the main concern in Region 7 is over the impact that fishing gear can have on the seabed and the benthic animals living there. Due to reduced food availability and colder water temperatures compared to those found in shallower waters closer to the coast, rates of growth and reproduction of most deep water benthic species are low. Disturbance of the seabed by trawl gear is a new pressure on this type of environment and there are serious concerns over potential damage to slow growing corals and other species. Concerns also arise over how to protect a number of shallower water habitats e.g. those occupied by maerl and horse mussels and tidal rapids, at least one of which was destroyed by construction of a causeway.

The changes in plankton noted in other regions are just as apparent in Region 7 as elsewhere. The Region has been well surveyed by the CPR and these records are supplemented by intermittent station specific samples. There is clear evidence of changes in both phyto- and zooplankton abundance and species diversity and dominance. These appear, as elsewhere, to be associated with changes in physical environmental conditions and involve a northward shift in species previously considered typical of warmer waters to the south.

The Region is an important one for seabirds and about a quarter of the sites designated in the UK as SPAs under the EC Birds Directive are located in this single Region. The Region contains some of the largest seabird colonies in the UK concentrated around the Northern isles and Atlantic Frontier islands such as St Kilda which holds the world's largest gannet colony. St Kilda is also the only place around the UK to hold a breeding colony of Leach's storm petrels (94% on St Kilda). This species is under threat from predation by Great skuas but otherwise is more affected by the state of Region 8 where it forages for macroplankton brought to the surface by upwelling along the continental shelf edge.

Changes in the size and demography of sandeel populations that appear to have been brought about by natural events have had a substantial negative effect on the breeding success of those seabird species that rely on sandeels to feed their young. Black-legged kittiwakes have been particularly badly affected. Fishing vessels do compete with seabirds for sandeels and a ban has been imposed around Shetland in an attempt to enable the nearby seabird colonies to recover. Almost 80% of the UK population of northern fulmars breed in the Region, feeding mainly on macroplankton but they have also become heavily reliant on discards of offal from fishing vessels. If measures to reduce fishing vessel discards continue as planned, this source of food will reduce, with likely negative effects on northern fulmars and other species that have become reliant on this food source. There are signs that the northern fulmar population around Shetland, which rose steadily throughout the last century, actually declined by about 15% in the last 15 years.

There is little direct information on the presence of cetaceans in Region 7 in the material from which this chapter is derived. There is however no reason to believe their diversity or numbers is other than typical for such an oceanic area. Both species of seal normally resident in UK waters are found in large numbers in the Region where the Islands provide numerous breeding sites for grey seals and haul out sites for common seals. The major part – well over half, of the UK population of common seals is found in the Region and about 40% of the world population of grey seals live in Scottish waters. Although not endangered in anyway in UK waters- the epidemics of PDV did not seriously affect numbers of either species in the Region, as required under the EC Habitats Directive, the UK has designated several SACs for both common seals and grey seals.

Region 8: Atlantic North-west Approaches, Rockall Trough and Faroe-Shetland Channel

INTRODUCTION

This Region is the most exposed of the eight regions and accounts for the remainder of the UK Continental Shelf. It is separated from Region 7 by the 500 m depth contour of the continental shelf. The Region has three distinct areas (Faroe-Shetland Channel, Rockall Trough and Bank and the Atlantic North-west Approaches).There is no landmass in the Region to give any shelter from wind or waves and the only land in the Region is the small rocky outcrop of Rockall. Turbidity levels due to suspended inorganic material in the water are extremely low. Figure 8.1 shows the location of the Region in relation to Region 7 (Scottish Continental Shelf) and the location of the main features mentioned in this chapter. Shipping and fishing are the only significant human activities in

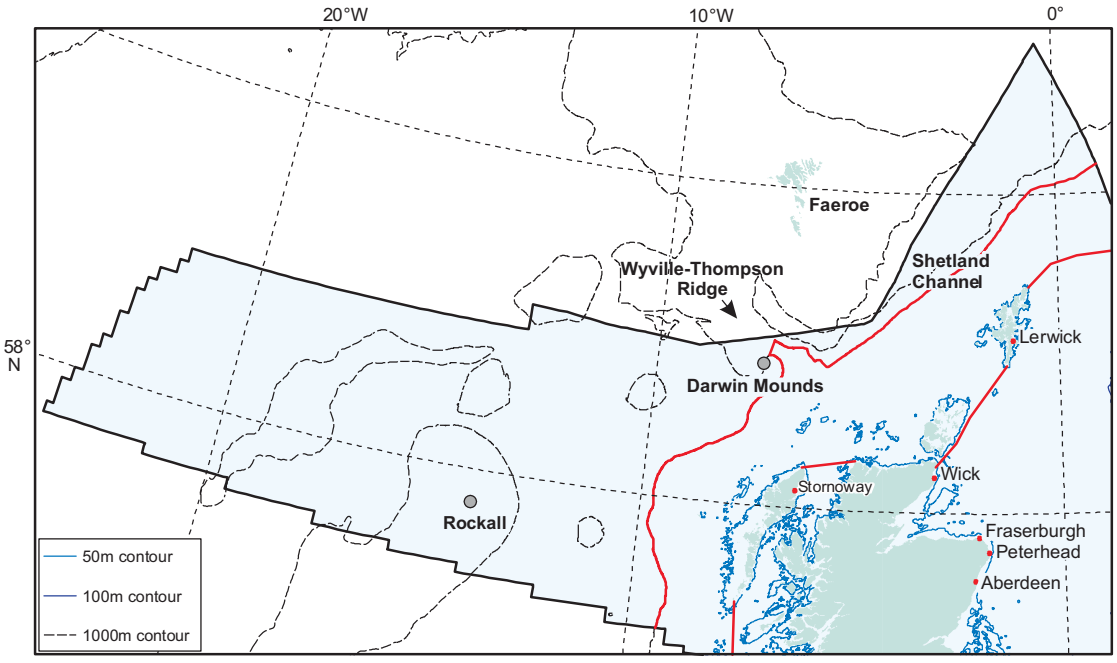


Figure 8.1. Map of Region 8. Bathymetric contour data copyright UKHO and BODC

the area, although there is some exploration for oil. The seabed shelves steeply on the eastern boundary as the continental shelf gives way to the deep Atlantic with water depths of >500m. The seabed is not evenly flat but has numerous outcrops and troughs, where unusual types of fauna are to be found, making the area important on habitat conservation grounds. Hydrographically the Region is important because it includes the Rockall Trough through which North Atlantic water passes en route to the Faroe–Shetland Channel and from there into the North Sea and Skaggerak. The Region is almost separated into two parts by the Wyville-Thompson Ridge (Region 7). Water over the Ridge is relatively warm but overlies the two different deep water masses either side of the Ridge which have very different temperatures. As a consequence the benthic communities east and west of the Ridge are markedly different. As an essentially oceanic region with no direct land based inputs many of the measurements of physical, chemical and biological environmental quality have thus far received only limited attention. Accordingly the careful reader will note the omission of a number of headings used in other chapters.

PHYSICAL ENVIRONMENT

WEATHER AND CLIMATE

Region 8 is the truly oceanic region in UK waters and here the three main weather parameters that drive ocean circulation are wind speed and direction, air/sea heat exchange and evaporation/ precipitation have their maximum influence. These directly affect the strength of the Atlantic thermohaline circulation and can thereby alter the distribution of sea surface temperature and salinity on a broad scale. Over the UK the prevailing winds are westerly and stronger more frequent westerly winds tend to bring warmer air and more rain. In Region 8 due to changes the North Atlantic Oscillation (NAO) are of particular importance – for brief description of this see Chapter 1. A positive or high NAO Index indicates a stronger than usual sub-tropical high pressure centre and a deeper than normal Icelandic low with stronger winter storms crossing the Atlantic ocean on a more northerly track i.e. through the western half of Region 8. A negative or low NAO tends to be associated with an anticyclone over Iceland with less stormy conditions and colder than normal winters. Thus the NAO hass a major influence on

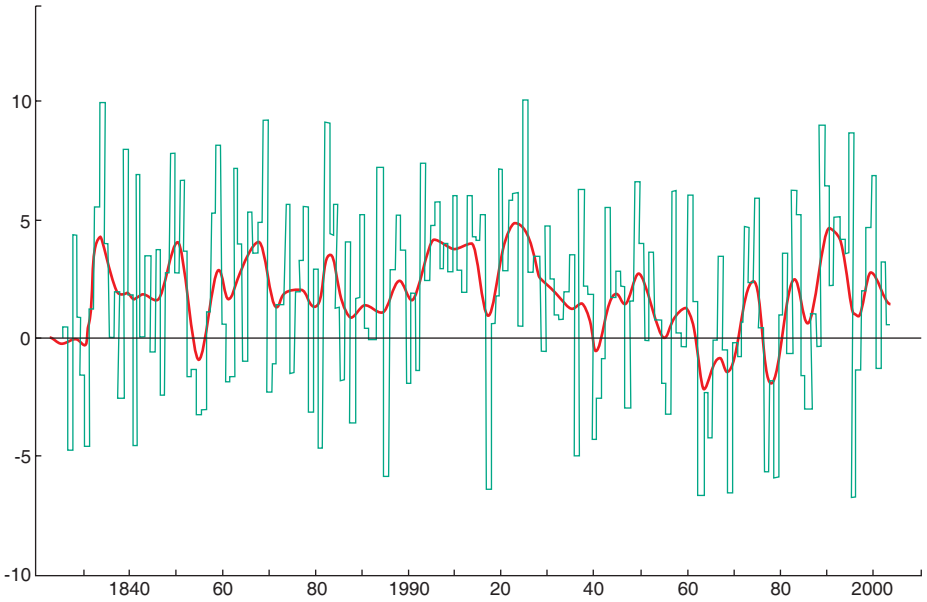


Figure 8.2. NAO Winter index Based on the normalised pressure difference between Gibraltar and Reykjavik. Data series ends at December 2003. Courtesy of CRU, UEA

the North Atlantic circulation and was for example a major factor in the phenomenon known as the Great Salinity Anomaly (GSA) in the 1970s.This arose during an extreme negative phase in the NAO when 'fresher' water formed in the Arctic was fed through the Fram Strait into the Nordic Seas. From there some passed through the Denmark Strait into the sub-polar North Atlantic gyre.

The most extreme variations in the NAO to have occurred since the 1860s have occurred since about 1960 with an upward trend from very low levels then until at least the 1990s (Figure 8.2).

Since then there have been marked fluctuations. The winter of 1994/95 had one of the most positive values on record but was followed by one of the lowest values on record in 1995/96. The oceanic response to NAO variability includes changes in the distribution and intensity of winter convection activity in the North Atlantic. The intensity of wintertime renewal of intermediate and deep water in the Labrador Sea and the Greenland-Iceland-Norway Sea is characterised by inter-decadal variations that appear to be synchronous with variations in the NAO. These changes in turn affect the strength and character of the Atlantic thermohaline circulation and the horizontal flow of the upper ocean especially in open waters such as those in Region 8. This in turn alters the oceanic poleward heat transport and the distribution of sea surface temperature (SST).

SEA TEMPERATURE

Global sea surface temperature rose from about 1910 to about 1940 and then remained steady until around 1970 when warming began again. Records for the wider eastern North Atlantic suggest a rise of about 0.4°C between 1981 and 2000 in Region 8. Figure 8.3 shows the de-seasoned upper ocean temperature anomalies for the Rockall Trough from 1975 onwards and although there has been considerable inter-annual variability an overall warming trend of about 0.3°C is apparent.

The maximum temperature anomaly was recorded in 2002 and was probably due to an influx of warm water. The warming trend that is particularly apparent in these records for the 1990s is not unique and earlier records suggest a similar event occurred in the late 1950s.

The Fisheries Research Services (FRS) Laboratory in Aberdeen regularly takes measurements of hydrographic conditions in the Faroe-Shetland Channel and has records since 1900. These show that over the last four decades Atlantic water passing through this Channel has become warmer by about 0.3°C/decade. Temperatures decreased slightly in 2001 but this reversed in 2002 and values increased again.

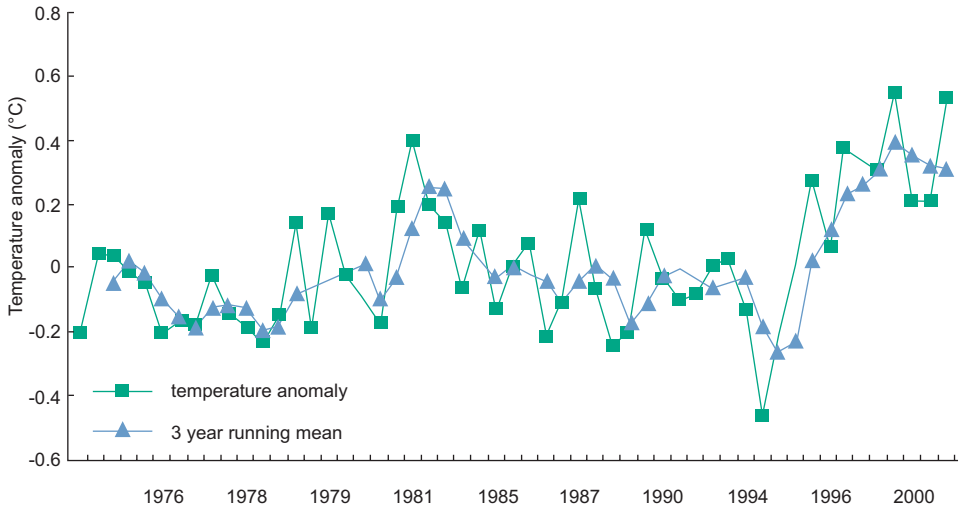


Figure 8.3 – Temperature anomalies from the Rockall Trough. Data has been averaged across the section, the seasonal cycle removed and a three-point running mean included. Nominal Position: 60° 30'N, 3° 00'W. Courtesy of Penny Holliday, SOC

East and west of the Wyville-Thompson Ridge in the deep water either side of the Ridge temperature conditions are markedly different. West of the Ridge water temperatures are typically around 4°C but east of the Ridge they are considerably colder at about -1°C.

SALINITY

Figure 8.4 shows the de-seasoned upper 800 m salinity anomalies from the Rockall Trough from 1975 to 2002

The maximum salinity anomaly occurred at the end of the 1990s. In contrast the early part of the 1970s was characterised by the low values experienced during the GSA in the late 1970s. In 2001 the Rockall Trough showed signs of again freshening (and cooling) following a peak in salinity in the period 1998 – 2000. However, salinity and temperature remained high relative to the long-term mean. FRS records of salinity in the Faroe-Shetland Channel show an increasing trend since the passage of the GSA in the late 1970s. There was a downward turn in 2001 but a return to higher values again in 2002 (Figure 8.5).

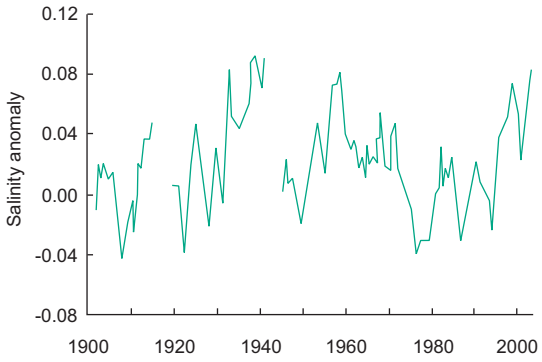


Figure 8.5. Salinity anomalies in the Faroe-Shetland Channel. Courtesy of FRS

WAVES

The measurement of waves is a relatively recent development with only very crude instruments available prior to about 1955. Since then a wide range of instruments for measuring waves has been developed, especially in recent years. These include directional wave buoys, downward looking lasers and HF radar. For Region 8 the use of satellite altimetry is particularly valuable as deploying and maintaining ships or buoys in such exposed waters is difficult.

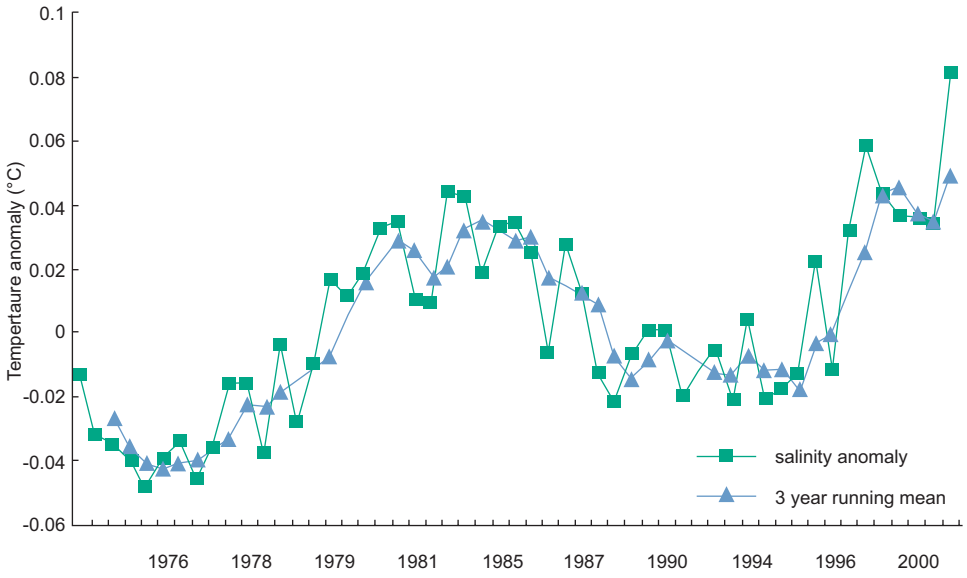


Figure 8.4. Salinity anomalies from the Rockall Trough from 1975 onwards Data has been averaged across the section, the seasonal cycle removed and a three-point running mean included. Nominal Position: 60° 30'N, 3° 00'W. Courtesy of Penny Holliday, SOC

Figure 8.6 shows wave data from the Met Office MAWS buoy in the North-west Approaches.

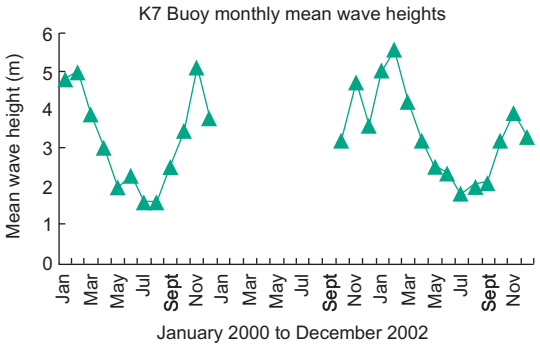


Figure 8.6. Wave data from MAWS Network. Courtesy the Met Office

The available data from ships and wave buoys suggest that mean winter wave heights in the North-east Atlantic increased significantly between the 1960s and 1980s. Satellite data show they continued to do so into the early 1990s when the maximum individual wave height (11.8 m) and the maximum individual monthly mean wave height (7.3 m) were recorded.

CIRCULATION

Circulation can be defined as the net movement of a body of water as a result of residual currents. The circulation in Region 8 is essentially from south-west to north-east, running roughly parallel to the 500 m depth contour separating Regions 7 and 8. Upwelling occurs along the shelf edge bringing nutrient rich water to the surface with associated enhanced productivity which is of significance to the cetacean and seabird species that rely on this source of food. Circulation in Region 8 is of relevance to understanding the state of the seas because deeper water from the North Atlantic must pass through the Rockall Trough and on into the Faroe-Shetland channel and potentially into the North Sea. The mean transport of water through the Rockall Trough has been calculated to be 3.75 Sv (1 Sv = $10^6 m^3$/sec) but the flow is known to fluctuate considerably on inter-annual time scales. There was an unusually strong northward transport in the Rockall Trough in 1988/89 and again in 1998 with peaks of 7.9 Sv in 1988/89 and 7.5 Sv in 1998. This relatively warm, saline water in the upper 5-600 m crosses the Wyville-Thompson Ridge and continues into the Faroe-Shetland Channel where it mixes with water that has circulated clockwise round the Faroes. This addition results in an increased average transport along the west Shetland slope of about 4.55 Sv, with a spring minimum and an autumn maximum.

ENVIRONMENTAL QUALITY

NUTRIENTS

Region 8 is not subject to any direct land-based forms of nutrient input and nutrient concentrations in the Region are not an issue of concern. Indeed the concentrations of winter dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) are those that would be regarded as natural background in an EcoQO context. There has never been any suggestion that the waters of this Region are at risk of eutrophication and the OSPAR draft Common Assessment Criteria are irrelevant except in the sense that the Region gives an indication of oceanic background concentration on which to base the OSPAR region specific background concentrations.

HAZARDOUS SUBSTANCES – METALS, ORGANICS AND POLYCYCLIC AROMATIC HYDROCARBONS

There is no industrial activity in the area (the Atlantic Frontier oil development is covered in chapter 7) and no direct land-based forms of input of hazardous substances to Region 8. Few measurements have been made of hazardous substances in samples of water, fish or sediments. The main relevance of any such data would be their suitability for establishing background reference concentrations for hazardous substances.

OIL AND OIL SPILLS

Region 8 is included in the North West European Special Area set up by IMO in 1999 under the terms of the MARPOL 73/78 Convention. This prohibits any discharge of oil or oil/water mixture by a ship whilst in the Region. This does not preclude illegal discharges or discharges outside the area causing an oil slick that might be driven by the wind into the area. However, reported oil slicks in the area are rare events and no serious problems have been recorded. There have been no accidents involving shipping in the area that have led to oil spills.

NAVIGATION DREDGING, AGGREGATE EXTRACTION, CONSTRUCTION AND MARICULTURE

The waters of Region 8 are deep and no dredging or extraction of aggregates takes place in the area, similarly no construction projects have been undertaken or are contemplated. With no coastline or suitable land mass from which to operate mariculture is not an activity practiced in Region 8.

BIOLOGICAL EFFECTS – CONTAMINANT SPECIFIC OR OTHERWISE

Relative to other regions Region 8 is regarded as a pristine area and no effort has been made to collect any form of biological effect information within the area. As the area is regarded as pristine the effect of contamination on benthos is not an issue requiring consideration in Region 8. What little information has been collected on benthos is addressed in the Habitats and Species section of this chapter.

LITTER

The sector report on Environmental Quality contains very little information on the regional prevalence of litter based on a single Beachwatch survey conducted in 2003 by the Marine Conservation Society. As the name implies this survey did not cover Region 8 although MCS report does suggest that litter is known to occur in the Region. Equally there is no information on the regional effects of litter in the sector report on Habitats and Species. Consequently it is not appropriate to go into any detail in this chapter. However, a brief summary of the litter issue is given in the following chapter of this Integrated Assessment.

HABITATS AND SPECIES

FISH ASSEMBLAGES

The fish assemblages found in any area are mainly determined by water depth and temperature and by the nature of the seabed. Along the shelf edge boundary with Region 7 the fish assemblage is dominated by silvery pout (*Gadiculus argenteus*), blue-mouth redfish (*Helicolenus dactylopterus*) and hollowsnout rattail (*Caelorinchus caelorhincus*). Of the waters further from land, the best studied in Region 8, is the Rockall Trough. The same species are found here as on the shelf edge, along with blue whiting (*Micromesistius poutassou*). In the deeper waters of the area various species of cod, grenadier and arrowtooth eels dominate.

COMMERCIAL STOCKS AND LANDINGS

The deep waters of Region 8 are increasingly fished by large twin-rigged otter trawlers targeting anglerfish. This fishery results in by-catches of megrim, ling and tusk. On the Rockall Bank the water is relatively shallow (<200 m) and large vessels fish for haddock, grenadier. The orange roughy (*Hoplostethus atlanticus*) is also exploited commercially although the UK market for such species is relatively small.

Assessment of the status of the species fished in the deep waters of Region 8 is made difficult by lack of reliable data. The advice in 2003 from the International Council for the Exploration of the Sea (ICES) on haddock was that in 2004 catches should be reduced to the lowest possible level. The stocks of anglerfish and northern hake are at risk of reduced reproductive capacity and were considered to be outside safe biological limits.It was therefore recommended that fishing effort on anglerfish should be reduced and northern hake is already the subject of a recovery programme. ICES also recommended that catches of megrim should not be allowed to increase relative to the total catches in previous years.

(In 2004 ICES defined "the term "full reproductive capacity" as referring to stocks where the spawning biomass is above the precautionary reference point (B_{pa}). This is equivalent to the previous terminology "inside safe biological limits". A more complete explanation of the new terminology can be found in the sector report on Fish and Fisheries.)

No formal assessment of the stocks of deepwater fishes is practicable but it is known from fishing experience that most of these species tend to aggregate around seabed features such as sea mounts. The low water temperatures in which these fish live implies slow metabolism which, coupled with variable food availability, means these deepwater species generally have a slow growth rate and are long-lived, but also have a high age of maturity. Fishing effort around a sea-mount could therefore cause local depletion of a species and recovery would be slow. The orange roughy is one deep water species which is already believed to be threatened and it has been included in the provisional OSPAR list of threatened species. Concerns have also been expressed over some deep water squaliform sharks.

IMPACT OF FISHING

The main concerns over the impacts of fishing in Region 8 centre around the impact on populations of deep water slow growing fish caught for human consumption – see above, and the effects of trawled gear on seabed features such as sea-mounts and the fragile life forms for which these features form a habitat. There are major concerns over the impact of bottom trawls on the cold water coral reefs found around such features. These coral reefs grow extremely slowly and are fragile habitats that are easily damaged by towed trawls. Particular concern has been raised over the Darwin Mounds coral reef communities in this Region. In order to protect these fragile reef communities it is considered essential that fishing does not occur with towed gears on or close to the seabed. In recognition of this an area of 1,300 km^2 was protected in 2003 by an EU Emergency Regulation banning the area to all such fishing. The area is likely to be declared an SAC, which will reinforce the existing level of protection afforded by the fishing ban. However, the potential for damage in other parts of the Region with similar features is real and at some stage decisions will have to be taken on whether to restrict fishing over an even larger area than that covered by the Darwin Mounds closure order (see Habitats section).

PLANKTON

There have been very few observations of plankton in Region 8. However, the Continuos Plankton Recorder (CPR) survey route from Sule Skerry to Reykjavik does pass through a small area in the middle of the Region and analysis of CPR records, for this route and more generally, suggest that changes observed in other regions will also have applied to Region 8. Thus it can be postulated that around 1987 a regime shift occurred and that since then there has been a northward shift in warm water species and a reduction in the diversity and abundance of colder-temperate and sub-arctic species. Figure 7.4 in Chapter 7 illustrates this shift well for assemblages of calanoid copepods which dominate the zooplankton of the North Atlantic.

SEABIRDS, SEALS AND CETACEANS

Seabirds, seals and cetaceans may all be sighted in Region 8 but only as migrants in passage or foraging for food in the areas of upwelling. There is nowhere for seals to rest and no counts have been made of seabirds or cetaceans suitable to allow any form of assessment of numbers in the Region over time. Some of the effects on these marine species of activities such as fishing and shipping may be beneficial through provision of additional sources of food. Set against this are the damaging effects of mortality through by-catch in fishing gear and noise disturbance.

HABITATS

The range of habitats in Region 8 is restricted to those found on the seabed in deep water and on features such as sea mounts, sea mounds and shallower water areas such as the Rockall Bank. In practice very little is known about this type of habitat but the cold dark nature of the waters at the seabed means species that live there are likely to be slow growing and have slow rates of recruitment or regeneration. One of the few species known to occur in any quantity is *Lophelia pertusa*. This is a colonial, branching coral with a hard calcareous skeleton. It is known to form thickets or banks which in turn provide a habitat for feather stars and shelter for fish species. The overall extent of *L. pertusa* reefs in Region 8 is unknown due to the difficulty inherent in conducting surveys in exposed deep waters. However, reefs are known to exist in the north-eastern tip of the Rockall Trough and on the north-west and south-west parts of the Rockall Bank. Scattered banks are known to occur elsewhere in the North-west approaches, on sea-mounts and banks but these records are at best semi-quantitaive and come from fortuitous capture in fishing and geological survey gears. The breaking off of pieces or clumps of *L. pertusa* by demersal trawls and repeated use of heavy rock-hopping gear physically damages reefs and associated reef species. The intensity of demersal trawling and the location of the areas affected by such activity is unclear and it is therefore difficult to quantify the scale of effect on *L. pertusa*. However, it is anticipated that more sites will be given SAC designation under the EC Habitats Directive in order to prevent long-term damage to the cold water coral habitats and their associated epifauna. The benthic community west of the Wyville-Thompson Ridge is largely made up of different species from, and is more diverse and abundant than, that to the east of the Ridge. This is a reflection of the fact that the bottom water masses on either side of the Ridge have different temperatures, that to the east being much colder

and therefore restricting the range of species able to survive and grow in the area. The benthos on the eastern side of the ridge is therefore likely to be even more vulnerable to damage by fishing and other gear deployed on the seabed.

Additional protection may be afforded on two counts under proposals being discussed under the OSPAR Threatened Habitats programme. Under this scheme *L. pertusa* reefs are identified as a threatened habitat, which at least off the Norwegian and Swedish coasts, is often associated with other hard corals such as *Madrepora oculata* and the redfish (*Sebastes vipera*) and squat lobster (*Munida sarsi*) both of which are commercially eploited. Carbonate mounds, the tops of which are often associated with *L. pertusa* and *M. oculata* reefs, have also been identified as a threatened habitat. Carbonate mounds are known to occur in the Rockall Trough where their margins have very steep sides.

KEY POINTS AND CONCLUSIONS

The only land mass in Region 8 is the uninhabited rocky outcrop of Rockall. As such the Region is largely untouched by man's activities on land and the area is best regarded as part of the North Atlantic, although it is almost separated into two parts by the Wyville-Thompson Ridge. Seawater temperatures in the Region have increased in the last 100 years. Between 1981 and 2000 temperature in the wider eastern North Atlantic rose by about 0.4°C and records collected by FRS suggest a warming in the Faroe-Shetland Channel of about 0.3°C/decade in the last four decades. Salinity seems to fluctuate markedly, but the FRS records for the Faroe-Shetland Channel suggest a tendency towards higher salinity since the passage of a body of low salinity water in the late 1970s. The wave climate records suggest that wave heights tended to increase between the 1960s and 1980s and into the 1990s with a maximum wave height of 11.8 m being recorded in that period.

As an oceanic region little attention appears to have been paid to what concentrations of contaminants are found in the Region, other than to establish what might reasonably be regarded as background reference concentrations. The detection of oil slicks that can be attributed to discharges from ships is rare and oil pollution does not appear to feature as a concern in the Region. As a deep water area construction and dredging impacts do not occur, although there is interest in oil exploration and exploitation in the eastern (Atlantic Frontier) part of the Region.

Fishing is the only major human activity in the Region and is increasingly pursued using large twin-rigged otter trawls targeting anglerfish. Around Rockall large vessels fish for haddock, orange roughy, grenadier and other deep water species. Formal assessment of the stocks of deep water fishes is not practicable. However, they are known to congregate around bottom features such as sea mounts and their rate of reproduction and growth is known to be slow. Thus local depletion of a population around a sea mount is likely if fishing effort around that site is intense and the orange roughy has already been listed by OSPAR as a threatened species. The stocks of northern hake and anglerfish are regarded by ICES as at risk of reduced reproductive capacity and a reduction in fishing effort is advised.

Apart from the stock depletion effect on target species, serious concerns exist over damage trawl gear can cause to the seabed and the marine species that live there such as deepwater corals and the animals associated with them. As with the targeted fish species, rates of recovery following damage or mortality are likely to be slow. In response to these concerns a protected area of 1,300 km^2 around the Darwin Mounds was declared by the EU in 2003. Fishing in this area is now prohibited and it is likely that the area will be added to the list of SACs designated by the UK when listings of offshore sites are proposed. The Wyville-Thompson Ridge almost splits Region 8 into two and habitat conditions are markedly different on either side of the Ridge. The benthic community west of the Ridge is richer and more diverse than that to the east where the bottom water is appreciably colder (typically -1°C as opposed to about 4°C to the west of the Ridge).

Section 9:
Integrated Assessment

INTRODUCTION

The previous eight chapters of this review have sought to summarise what is known about the environment of the eight separate regions of the seas around the UK coast. Where practicable, information was provided on what changes have been taking place, what is thought to have caused the changes and what effects the changes have had on the physical, chemical and biological quality of the marine environment around the UK. It is apparent, from the summaries of information in these preceding chapters, that some aspects of environmental quality or change are common to all or at least most regions, whereas others are particular to one or a very few regions. In terms of changes or effects these also vary in intensity between regions according either to some particular geographical feature of a region, the sensitivity of the environment in that region or to the intensity of the particular activity to which change is attributable. The purpose of this integrated assessment chapter is to draw attention to these common and particular aspects with a view to focussing attention more clearly on what is good about the marine environment around the UK, what the main problem issues are and what might be done to ameliorate or remedy them.

For the most part the material included in this integrated assessment chapter is derived from the eight previous regional assessment chapters. However, in a few instances new material drawn from the original four sector reports is included here. These additions relate mainly to material that was only very briefly covered in the sector reports with little or no breakdown at all to regions, for example on litter and non-indigenous species or where it was provided in a generic sense, for example measures taken to control fish catches. Finally, some information on inputs has been included in this integrated assessment section of the review where it is useful by way of explanation of changes observed or differences between Regions .

The previous eight regional sea chapters of this review have each followed the same structure, with the summaries of information on what is known etc being provided under the same headings of physical environment, environmental quality and habitats and species, including fish and fishing. For the purposes of this integrated assessment it is more appropriate to examine what is known about:-

- physical processes and climate and the impacts that changes at this level are having on other sectors such as biology,
- the sea floor and coastline environments and the way these are being subjected to change, with attendant effects on other interests,
- the chemical environment in terms of contaminants and effects and
- the biological environment, its status and how it is being protected

This structure more readily lends itself to an assessment of the extent to which the environment is changing or has been changed and the extent to which it can be regarded as sustainable, biologically diverse, ecologically sound and healthy. It also helps to identify more readily issues that can be addressed by action at a purely UK level and those where action at a European, or even global level, would be more appropriate. The identification of cross sector problems and assessment of their seriousness, often in the absence of any stated objectives or indicators, unavoidably involves judgement. The judgements offered are those of the author, although they were discussed and were broadly accepted by the State of the Seas Steering Group (SSSG) established by Defra to oversee the task. This does not however, necessarily imply full endorsement by either the SSSG or Defra.

For the purpose of this review of the state of the seas, the sea area around the UK was divided into eight Regions each of which is broadly internally similar. To avoid repeated use of the sometimes

lengthy names of the different sea Regions this integrated assessment chapter generally refers to Regions simply by number. A map is available in the Preface to this overall review and this shows each of the Regions used; they are numbered from 1 to 8 moving clockwise round the coast from the north of Scotland/south of Shetland and back to the west of Shetland/north of Scotland.

The seas around the UK are diverse and offer a range of different habitats. Typical salinity away from the influence of land run off is around 35 and temperature varies with season, depth and proximity to the shore but is typically between 5 and 22°C. In the deeper waters to the west and north of Scotland the water is consistently colder at around 5°C or less. Water depths in the coastal seas shelve away from the coast to a maximum of about 50 m in the southern North Sea to 150-300 m to the south-west of England and west and north of Scotland. To the west of the Scottish continental shelf the depths increase to 500m and more. Waters close to the shore and in the shallower areas like the southern North Sea, which has a generally sandy or muddy seabed, appear dirty due to the suspended sediments stirred by the generally strong tidal currents and by wave action. The seas around the UK support a range of anthropogenic activities ranging from shipping trade, fishing, exploitation of oil, gas and marine aggregates, all of which tend to have interactions with each other. They also support a varied wildlife which in turn is affected by these anthropogenic activities. Over and above these various interactions is the impact of changing weather and climate.

PHYSICAL PROCESSES AND CLIMATE - CHANGES AND EFFECTS

WEATHER

The prevailing winds over the UK are from the west or southwest. If their intensity strengthens or their frequency increases the weather over the UK tends to become warmer and wetter. The westerly winds are driven by the differences in atmospheric sea level pressure between the sub-tropical high and polar low pressure systems. These produce a see-saw effect known as the North Atlantic Oscillation (NAO), the scale of which is most noticeable during the months November to April. During this winter season it can account for more than a third of the total variance in sea level pressure. A positive or high index i.e. higher than normal surface pressure south of 55°N results in more and stronger storms on a more northerly track, with increased westerly winds and mild wet winters over northern Europe and chilly wet summers, but overall warming of the European shelf seas. A low or negative index has the opposite effect; there tends to be more easterly winds, winters become colder and summers warmer in the UK. In addition to the changes in weather and climate effected by the NAO, changes in temperature as a consequence of global warming affect both sea temperature and, as a consequence of thermal expansion and polar and glacial ice melt, sea level.

Although there are indications from other records that similar changes have occurred in the past 500 years, from about 1960 to the present time the NAO has experienced its biggest change since records began in the 1860s and the rise in values from the 1960s to the 1990s appears to be unusually large. In the same period and associated with the changes in the NAO, the average number of winter storms has increased, with the most noticeable increase being in the south. Winters have tended to become wetter in north-east England and summers have become drier over south-east England. The 24 month period ending in March 2001 was the wettest in England and Wales since records began in 1766, with the last 12 months of that period the wettest of all. Overall mean temperature over the land has increased by about 0.5°C during the last century. The upward trend in the NAO with more positive NAO winters can be linked to increased wave heights over the north-east Atlantic. This has been most noticeable in Region 4 where, at the Sevenstones LV, wave heights increased from about 2 m to about 3 m between the mid-1960s and 1990s. Smaller increases were also measured in the same period in Regions 1, 6, 7 and 8. There is however, little evidence of increased wave heights in Regions 2, 3, or 5, all of which are relatively sheltered from westerly winds.

Residual currents around the UK, after removal of the strong tidal signals, are generally very weak making it difficult to infer systematic circulation patterns. In some cases seasonal variability is important and there is some evidence of changes that can be linked to changes in the NAO. The North Atlantic Current, an extension of the Gulf Stream, driven primarily by the wind, flows

north-eastwards between Iceland and Scotland carrying warm, saline water towards the Arctic. Beneath this, cold denser water formed by air-sea cooling in the Nordic Seas returns to the Atlantic at depth via restricted channels in the sea floor. In addition a shelf current (part of the European Shelf Current) flows northwards along the edge of the continental shelf from Biscay to the west of Ireland and then on towards Norway via north-west Scotland. Water from both these currents enters the North Sea at its northern boundary, generally following an anti-clockwise path in response to the prevailing westerly winds before it exits along the Norwegian coast. There is also a net northwards transport through the Irish Sea in the form of pulses associated with the wind, though in summer localised flows at fronts may dominate. The net flow along the English Channel is weakly eastwards taking water into the southern North Sea.

There is little to suggest any lasting major changes in overall circulation patterns have occurred. There have however been numerous inter and intra annual variations that reflect normal responses to changes in atmospheric pressure, winds or ingresses of occasional pulses of water from major ocean current systems some of which appear to be linked to changes in the NAO and/or climate. The latter appears to be the most likely reason for the general northward extensions of warmer water and associated marine organisms that have been noted, rather than any change in circulation or major currents.

SEA TEMPERATURE AND SALINITY

In line with the increase in temperature noted over land, sea water temperatures have also increased. This increase has affected both coastal and offshore waters, although at the continental shelf edge (Region 7) the increase in the last century was between 0.12 and 0.29°C, whereas in Regions 1 and 5 the overall average increase in sea surface temperature has amounted to between 0.5 and 1°C. The Faroe-Shetland Channel sea water has also tended to become warmer, with temperatures rising at a rate of about 0.3°C/decade since the late 1960s minimum. Similar rates of change have been noted in the bottom waters of the North Sea since the 1980s. There is some evidence of a slight decrease in salinity to the west of the UK. However, there is little indication of a change in salinity in any of the eight UK regions, except perhaps in the northern North Sea where there has been a decrease since the 1970s, perhaps associated with greater land run-off as a result of wetter winters.

The increases in temperature do appear to have been associated with some significant changes in the numbers of what were previously regarded as fish species typical of areas further to the south. There have also been impacts on seabird populations with Mediterranean gulls now breeding in the UK and other species changes that can be attributed to changes in climate, for example the northward movement of species of plankton and fish previously only rarely encountered in UK waters. It also seems probable that the collapse of the stock of sandeels around the north-east coast of Britain, which has had a major impact on the numbers and breeding success of several seabird species e.g. on Shetland, is climate related.

There is clear evidence also of changes in both phytoplankton and zooplankton. These have been sufficiently large that they are regarded as representing a regime shift. Examples of such changes include: a general decline in the numbers of diatoms in the plankton and an increase in the numbers of dinoflagellates; a general northward movement of warmer water species of some 10° latitude: a 400% increase in echinoderm larvae in the southern North Sea and a switch in the relative numbers and timing of peak productivity of two calanoid copepod species. As these two species play a major role in the food of salmon and young cod, this switch has implications for the recovery of stocks of both species as well as the areas in which they are likely to be found in largest numbers in the future. There is less evidence of northward movements of benthic marine organisms typical of warmer waters, but on the whole the detail of past records is not sufficient to show such changes clearly.

SEA LEVEL AND COASTAL CHANGE

Since the last ice age some 20,000 years ago global mean sea level has risen by about 120 m and continued to rise by between 1 and 2 mm/yr throughout the last century. At any point in time sea levels are a combination of tidal levels, surge levels, mean sea level and waves. Around the UK coast, allowance must also be made for the effect of land movement as a consequence of post glacial adjustment. This results in a maximum

relative land uplift of about 1.6 mm/yr in central and western Scotland and maximum subsidence of about 1.2 mm/yr in south-west England. Thus for much of the country sea level rise is, to a greater or lesser extent, offset by uplift. However, sediment consolidation increases the subsidence in areas with thick sequences of Holocene sediments, which on average amounts to about 0.2 mm/yr but is between 0.5 and 1.1 mm/yr in south-east England. This means that the south-east of England is particularly prone to the effect of sea level rise as the two sources of subsidence combine. This can be seen in the loss of beach area along the south coast, of salt marsh areas along the south-east coast and coastal erosion generally along the coast of East Anglia. It also means that the south-east faces the greatest risk of coastal flooding. 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.

Coastal erosion as a result of waves, storm action and the generally soft nature of the coastline is a major concern along parts of the Yorkshire coast and along the coasts of parts of Norfolk, Suffolk and parts of the south coast in Region 3. Transport of the resultant suspended material tends to be inshore into many estuaries, both along the southern North Sea and Irish Sea coasts and results in siltation of harbour and port areas necessitating continuous dredging. The Mersey estuary (Region 5) is estimated to have lost about 10% of its total volume in the 70 years up to the 1970s, although there has been a slight increase in more recent years. Many beach areas around Scotland are currently also suffering loss of beach material, largely, it is thought, due to lack of supply of new material from offshore. The combined effects of coastal erosion, sea level rise and the high cost of maintaining sea defences in areas such as the south-east are matters of grave concern to householders and farming interests in the threatened areas. There has been a decision in principle to work with natural sedimentary processes in managing these problems, though it is not yet clear how property loss will be balanced against loss of coastal biodiversity in specific cases. If relative sea level rise continues to occur at present rates, particularly in the south-east it will necessitate a number of difficult decisions and call for novel engineering solutions - both hard and soft. It will also necessitate the establishment of an appropriate balance between managed retreat and construction of higher and stronger sea defences on the lines adopted in Belgium and Netherlands.

Sediment loading and the nature of the sediments has a bearing on the transport and location of contaminants, particularly those that are sparingly soluble and readily adsorbed onto particulate material. Such contaminants tend to travel with suspended sedimentary material and become locked or at least tend to accumulate in areas of sediment accretion. In many cases this means in estuarine areas but it may also occur in areas of sediment convergence where sediment pathways meet e.g. off Flamborough Head, along a line from Hythe/Dungeness to Boulogne etc or in soft bottom areas such as the mud patch off Sellafield where certain radionuclides accumulated in the past but which now acts as a source of continuing low level water contamination

There are at present no clear objectives as to what degree of physical environmental change is acceptable. This lack of definition is perhaps most critical in relation to what is to be regarded and agreed as acceptable in terms of coastal erosion and the risk of coastal flooding. For other changes e.g. in storminess, wave heights, salinity or temperature, there is arguably no need for more than the carefully selective maintenance of good records of what has happened in the past and is happening now and how the biological environment in particular is responding. Such records will allow accurate monitoring of status and permit informed decisions on what needs to be or can be done to bring the effects of the observed changes into line with any management objectives that have been agreed. In terms of temperature and wave heights there is an increasing possibility of relying on satellite measurements but these do require good ground truth measurements. This calls for maintenance of existing time series at key locations. Satellite measurements have limitations in relation to records of conditions below the sea surface and this too has implications for the maintenance of records of conditions at key stations and along key transects e.g. off Plymouth, the Isle of Man, the Ellett line between the west coast of Scotland and the Rockall/Anton Dohrn seamount and the Fair Isle and Faroe-Shetland Channels.

SEA FLOOR AND COASTLINE ENVIRONMENTS – ANTHROPOGENIC ACTIVITIES AND EFFECTS

OIL AND GAS EXPLOITATION

The nature of the seabed in the eight regions around the UK and the way it influences the animals in, on or close to it, is discussed in the final section of this integrated assessment where differences in habitats and species are discussed. This section looks at the way in which man uses, or otherwise impacts, the seafloor and coastal fringes of the marine environment.

The offshore oil and gas industry contributes significantly to the national economy but it does have an impact on the seabed, albeit only a small percentage of the total area, and does affect other user interests. The industry operates mainly in Regions 1 and 2 and it is in these Regions where the largest impacts have occurred. Oil/gas exploitation also affects Regions 5, 6 and 7, but to a lesser extent and, in a very minor way, Region 4 around Poole Harbour and Kimmeridge, where there is small scale exploitation of oil reserves. In Region 6 activity has largely been confined to exploration, with just a few wells being drilled. Region 7 has seen active exploration and there is some exploitation in the deep water area west of Shetland known as the Atlantic Frontier. In Region 5 activity is concentrated in Liverpool Bay and Morecambe Bay and is directed at extraction of the gas reserves in those areas. More extensive gas reserves, particularly in the southern half of the area are exploited in Region 2 and extensive oil reserves, plus some gas, are exploited in Region 1. In Region 7, due to the water depth, exploitation has to date involved the installation of floating production, storage and offloading installations fed from seabed manifolds by umbilicals, rather than fixed platforms. However, the Clair field now under development in the shallower area of Region 7 will use a conventional fixed platform and export oil by pipeline. Transport of the oil to shore is by means of shuttle tanker rather than by fixed pipelines. Elsewhere i.e. in Regions 1, 2 and 5, the oil or gas is extracted mainly from fixed platforms and transported via pipelines to shore based storage and handling facilities.

Although the presence of oil and gas platforms has the potential to interfere with shipping and fishing activities the risk of collisions has been minimised and in practice so far avoided by the establishment of exclusion zones around all platforms. There is evidence that some fish species are attracted into these areas by the shelter provided by the platforms. The pipelines between platforms and from platforms to shore also have the potential to interfere with fishing operations, although their routes are clearly defined on navigation charts and are known to most fishermen via a wheelhouse based electronic position indicating system developed jointly by the fishing and oil and gas industries. Most of the smaller pipelines (up to 16 inches in diameter) are buried during construction to protect them from fishing gear impacts. The actual interaction with larger unburied pipelines is an issue of concern to fishermen and is currently being investigated.

Drilling of oil and gas wells gives rise to drill cuttings and these were usually deposited from the drilling platform onto the seabed. In many instances several wells are drilled from a single platform and piles of the drill cuttings tend to accumulate around the installation concerned. In the southern North Sea (Region 2) where the water is relatively shallow and tidal currents more active such piles were dispersed fairly rapidly. However, in the deeper waters of Regions 1 and 7 piles of drill cuttings, particularly those that involved the use of oil-based drilling muds (OBMs) that are not water wettable and tend to stick together, have tended to accumulate and thus cover any marine organisms previously resident in the sediments of the area. In order to facilitate directional drilling of many wells from a single position, oil based muds are often used. This add a contamination problem to the piles of drill cuttings and very high concentrations of oil derived contaminants, as well as their biological effects on community structure, were frequently detectable within 100-200 m of the installation, with progressively lower concentrations with distance from the source, reaching background 1 to 2 km down-current of the installation. Drill cuttings contaminated by oil based drill muds are no longer permitted to be discharged, but previous practices have left piles of oil contaminated cuttings around many installations in the northern North Sea (Region 1). Following cessation of the disposal of oil based cuttings the extent of down current contamination has decreased. Questions remain however, over what will happen when installations reach the end of their production life. At this point the OBM contaminated cuttings may

be disturbed, either deliberately or accidentally during the decommissioning operation, or through disturbance by fishing gear if fishing is allowed to resume in the previously declared exclusion zone. Such disturbances may give rise to further releases of oil with resultant biological effects down current of the disturbed cuttings pile..

OIL SPILLS

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 (3 to 400/year in number) do occur. Most typically involve the loss of less than one tonne of oil and their impact in environmental damage terms is insignificant. Much larger quantities of oil can be discharged in produced water but again practices in recent years have improved and the concentrations of oil in such discharges have been greatly reduced. Typical concentrations now average 21 ppm and a further overall tonnage reduction of 15% is planned by 2006.

Oil spills may also arise from accidents involving tankers and other shipping and slicks or more extensive surface oil/tar may be encountered as a result of deliberate discharges of oil or oily water from vessels. Oil slicks attributed to discharges from ships are still reported, despite the fact that in all the sea areas around the UK this practice has been prohibited since 1999 under IMO MARPOL Convention rules. There have been no significant oil spills in UK waters since the *Braer* accident off Shetland in 1993 and the *Sea Empress* accident off Milford Haven in 1996. The UK has had to develop considerable experience over the years with incidents involving different types of oil, sizes and locations of spill and the best ways in which to deal with them. On each occasion there have been prophecies of environmental and tourist industry disasters and undoubtedly some effects do occur. Seabirds in particular are liable to be badly affected, but the scale of impact is rarely as bad or as long lasting as predicted if the incident is properly handled. Although both the most recent oil spills caused significant problems for a period afterwards, recovery was in both cases fairly rapid and essentially complete within two years. On a precautionary basis certain areas remained closed to fishing around Shetland until PAH concentrations in shellfish returned to what was regarded as background. The last restrictions were not removed until May 2000 but these had related to only a small area where oil had become mixed with the sediments.

CONSTRUCTION

Region 8 has not been affected by construction of any form and, apart from the so far small scale oil developments in Region 7, most of that Region is also unaffected. Elsewhere the coastline around much of the UK has been modified to some extent although for most of Region 6 and large sections of the coast of Region 1 this is restricted to agricultural activity. In most other Regions construction has taken place to a greater or lesser 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 both the shape of the coastline and the variety and type of habitats available for wild life. In the past little attention was paid to the consequences of coastal and offshore construction but the agreement of other marine interests must now be sought whenever any form of construction is contemplated. This requirement applies whatever the construction proposal, be it a sewer outfall, groyne or breakwater, new stretch of seawall or even the sinking of barges as a means of reversing coastal erosion, as has successfully been done off stretches of the Norfolk and Essex coasts in Region 2.

With a few notable exceptions few major coastal construction projects are currently planned or in progress. There are port developments in Region 1 in the Firth of Forth and in Region 2 at Immingham and Felixstowe/Harwich. It has also recently been decided, following an Inquiry, to proceed with the Thames Gateway development. This will involve development of a substantial area of coastal marginal land and a major dredging project associated with the development. Elsewhere, apart from the construction of barrages at Cardiff and Swansea, the main activities are construction of new sewer outfalls associated with improvement of the quality of bathing waters and shellfish harvesting areas.

Offshore construction is either actively underway, or being planned, for the construction of offshore wind farms. These are perceived to cause less environmental impact than wind farms on land

and are regarded as an essential component of government strategy for renewable energy exploitation and reduction of carbon dioxide emissions. There have been various proposals for the use of other technologies to harness wave and tidal energy but none are yet regarded as commercially viable. The wind farm developments involve proven technology and are proceeding, mainly in Region 2 and the northern sector of Region 5, although some construction is also planned off the coast of South Wales in Region 4. To date only two wind farms have been constructed, at North Hoyle off the North Wales coast and at Scroby Sands off Great Yarmouth in Region 2. A further windfarm is under construction on the Kentish Flats also in Region 2. At least eleven further sites have been consented, each with up to 30 turbines and there are proposals for at least 15 more. Information is far from complete on the potential impacts of these wind farms on sediment transport, shipping, fishing, and on marine species including marine mammals and migrating birds and seabirds. Continued research into these potential impacts, particularly into the present actual distribution of seabirds and mammals and the likely effects on them, as well as extensive post construction monitoring of actual effects is required to test and refine design and to improve prediction capabilities.

AGGREGATE EXTRACTION

The onshore construction industry requires sand and gravel. In order to minimise the impact on land caused by quarrying and extraction of sand or gravel deposits, it is part of Government policy to encourage exploitation of deposits offshore provided this can be done with the minimum of effect on other interests – particularly fisheries and biological diversity. This involves consultation with other user interests and extensive data gathering in connection with the mandatory Environmental Impact Assessment process. In practice most of the exploitable deposits are located around England and Wales in Regions 2, 3, 4 and 5. There is some aggregate extraction off the coast of Northern Ireland in Region 6 but none off the coast of Scotland. However, small quantities of maerl (calcareous algae) are extracted from a site off Shetland for use as a soil conditioner. This activity is subject to close monitoring of the effects of extraction, under supervision of Scottish Natural Heritage. The quantities of marine aggregates extracted peaked in 1989 and have remained fairly static at around 20 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) the Bristol Channel (Region 4) and off the coast of Northern Ireland (Region 6). The relative proportions taken from Regions 2 and 3 are about to change following discovery of large resources in the eastern English Channel. It is forecast these will account for more than 50% of the total extracted in future years.

Although removal of material from the seabed does have an effect on the infauna living there, extraction is only permitted under licence. Conditions under these licences limit the area in which dredging is permitted and seek to ensure that a layer of the deposit being worked is left on which recolonisation can occur. The total areas involved are relatively small. In 2001 extraction was authorised from a total area of about 980 km^2 but in practice 90% of the activity took place in just 13 km^2. Fisheries concerns in relation to aggregate extraction range from effects such as simple interference with traditional fishing grounds, the removal of gravel deposits used by over-wintering crabs and the effect of fine outwash material on shrimps or fish. Timing of extraction can be restricted to minimise such impacts and concerns.

NAVIGATION DREDGING

Seabed material has to be removed in the course of construction of new port facilities and navigation channels or marinas and in the routine maintenance of such facilities where they are subject to siltation. Such activities go on as a matter of routine in all areas except Regions 7 and 8, although the amount of dredging undertaken annually in Region 6 is limited to only a few tens of thousand tonnes in the Minches and just over 100,000 tonnes in Northern Irish waters. Elsewhere, between 25 and 40 million wet tonnes are dredged and deposited at about 150 licensed disposal sites. The bulk of this activity - about 60%, takes place in Regions 2 and 5. There are no indicators of performance, although there are overall aims of increasing the use made of dredged material and ensuring effects are limited to those caused by deposition in the licensed areas. The sites at which disposal is authorised are carefully chosen in consultation with other interested parties and monitoring is undertaken to demonstrate that the impacts of disposal are confined to the deposition area.

Dredged materials are 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. Research and development is being undertaken with a view to increasing the amounts of dredged material used beneficially (currently about 1%) rather than it simply being redeposited elsewhere.

FISHING

The use of heavy trawl gear and dredges by the fishing industry is a further activity by which man exerts a substantial and widespread direct effect on the seafloor environment. The areas traditionally exploited by the fishing industry are generally fairly shallow – 150 m or less, and the seabed supports a wide diversity and abundance of marine species. These species are disturbed by the passage of trawls or dredges and may either be brought to the surface, when the gear is hauled and discarded as unwanted by-catch, or be left on the seabed in a damaged state and exposed to scavenging predators. Areas that are unfished or rarely fished and have low levels of natural disturbance are more vulnerable to damage by fishing gear than naturally dynamic areas that are trawled regularly. Thus in shallow dynamic environments, such as the southern North Sea (Region 2), that have a generally soft seabed, impacts on benthic species abundance and diversity are less than in deeper areas such as the northern North Sea (Region 1) or outer areas of the Western Approaches (Region 4) that have a coarser rocky seabed and are less exposed to natural disturbance by waves and tidal currents.

The distribution of trawling activity is far from uniform. Some areas are repeatedly trawled each year whereas others are fished at frequencies that allow recovery of the benthic community from the occasional impacts that occur. The effects of trawling on the seabed would be much greater if trawling effort were more evenly distributed. A number of dedicated investigations have clearly demonstrated that large, sensitive and fragile species are particularly vulnerable to the disturbance caused by bottom trawling. General surveys, such as the International Council for the Exploration of the Sea (ICES) North Sea Benthos study, reveal that, although benthos may not be in a completely natural state, its species structure and abundance is dominated mainly by seabed type and latitudinal considerations. Similarly, repeat surveys in the western English Channel (Region 4) of sites surveyed before trawling effort was so intense, demonstrate little change at some sites tending to support the patchy nature of fishing activity. Reliable means of assessing the scale of impact by trawl gear and dredges on the benthos of a region and agreement as to what is regarded as an acceptable level of change have yet to be devised although discussions on possible EcoQOs are underway in ICES. Such measures are urgently required if a sensible balance is to be reached between allowing unrestricted use of heavy trawls and dredges and total protection of the benthos with attendant cessation of bottom trawling for fish and dredging for scallops and queens.

The trawling 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. In these deep waters temperatures are lower and food supplies far less abundant and although the benthos is rich and diverse it is much slower growing and particularly vulnerable to physical damage. Recolonisation and restoration of conditions prior to damage could, it is estimated, take 1,000 years or more. The species known to be found on and around sea mounts and other seabed features in these deep waters are considered to be particularly diverse and vulnerable to damage by bottom trawls etc, especially as the fish species of interest to fishermen are known to congregate around such features with the result that fishing effort tends to be focussed around seabed features. As a result of the concerns these issues raise, fishing has been totally banned under EU legislation in a 1,300 km^2 area around an area in Region 8 known as the Darwin Mounds. Areas of a similar nature and therefore vulnerability are known to occur elsewhere in Regions 7 and 8.

MARICULTURE

Most of the fish and shellfish farms in the UK are situated in Scotland within Region 6, although there are important sites also in Regions 1 and 7 and in the Strathclyde area of Region 5. Although most hatchery facilities are land-based with pumped sea water systems, most production takes place in cage or from rafts. Off the west coast of mainland Scotland in Region 6 these are mainly moored close inshore in the

many sheltered voes and embayments around the Islands or in the sea lochs of the mainland. In Shetland and Orkney the position is slightly different in that the cages etc are moored in more open waters and in the Strathclyde area effort is directed mainly at shellfish culture. The industry is large, producing salmon, trout, halibut, cod and haddock, mussels, oysters, clams, scallops and queens. It has grown considerably over the years and continues to do so. Production of salmon in 2002 reached 145,000 tonnes and was expected to reach 175,000 tonnes in 2003 and production of other species is also growing.

Farming of fish involves provision of food, usually in the form of pellets, whereas shellfish culture relies on the phytoplankton food naturally present in the sea water. Concerns have been expressed over accumulation of organic matter and nutrient release, either from unused fish food or the excretion products of both fish and shellfish. However, improvements in fish farm practices have led to reductions in the quantities of unused food and, although nutrient concentrations do show increases close to some mariculture sites, they do not exceed the OSPAR assessment criteria and are not thought to cause eutrophication problems or to be directly linked to the occurrence of algal toxins detected in shellfish under the monitoring requirements of the Shellfish Hygiene Directive. Accumulation of organic matter etc below cages or rafts is less of a problem in Regions 1 and 7 where natural dispersion processes limit such build-up, elsewhere rotation of site use can minimise the potential problems. Normally, even when some organic enrichment, or in some cases anaerobic surface conditions occur, the area affected rarely extends beyond 50 m of the cages. Chemicals are used in the form of medicines, as antifouling agents on cages and in treatments to combat sea-lice and disease. Sea lice were a source of major concern to the industry and to wild salmon interests over the potential severe infections that could occur. However, recent improvements in sea lice control have resulted in lower sea lice levels at farms. Most antifouling agents are now copper based and, although concerns exist as to the possible adverse effects on biota living near the mariculture sites, to date no problems have been identified. The position is similar for medicines. Restrictions exist on what medicines can be used, in what quantities and in what way. In-feed medicines are of particular concern in this context as surplus food can lead to accumulation of the medicine in sediments below fish cages. However, studies have shown that the polychaete worms that dominate the sediments below fish cage are unlikely to be adversely affected.

Escaped fish from mariculture enterprises can interbreed with their wild counterparts and this is an issue of concern because whereas wild salmon have wide genetic diversity farmed salmon do not. It is thus possible that the offspring of wild and farmed salmon interbreeding may benefit from hybrid vigour but this is not passed to the next generation due to outbreeding depression with resultant much lower fitness and productivity in subsequent generations and potentially causing eventual extinction of the wild salmon stocks. With species such as cod etc the majority of the breeding stock is still taken from the wild and so loss of genetic diversity is less of a concern. An issue of growing concern however in this context is the sustainability of the stocks of fish currently being used to produce the feed pellets used in fish farming enterprises. This in turn may affect the sustainability of the industry and at the very least may restrict plans for further expansion if the availability of fish feed is constrained by enforced restrictions on fishing the wild fish sources. However, the increased use of fisheries by-products in fish feeds and the development of new feed materials in which vegetable oils can be used to replace fish oils and up to 75% of the fishmeal can be replaced by plant proteins may minimise this potential obstacle to continued expansion of the industry and avoid over fishing of the wild fish species currently used for fish meal based feeds.

Establishing a fish or shellfish farm requires registration of the business and site and a discharge consent must be obtained. This will specify the production tonnage and quantities of medicines that can be discharged. In 2003 the Scottish Executive published a Strategic Framework for the Aquaculture Industry in Scotland which sets out objectives and priority actions designed to achieve sustainable development of the industry in Scotland. These and other measures already in place seek to minimise adverse impacts of mariculture activities and encourage the production of fish and shellfish as a means of filling the gap left by reduced wild stock production. The extent to which the goal of minimum impact on other interests will be achieved in practice is seriously questioned by the opponents of the mariculture industry and its expansion.

LITTER

Litter presents an almost completely preventable series of problems that affect both the coastline and seabed. It poses hazards to beach users and wildlife alike and is also an aesthetic problem. A system has been devised aimed at grading recreational beach quality. Recent surveys suggest the overall situation improved somewhat in England and Wales between 2000, when 74% of bathing beaches were graded very good or good, and 2002 when 82% were graded good or very good. A measure of the scale of the litter problem is given by the quantity or number of articles collected per kilometre of beach. In September 2001 volunteers collected litter from 141km of beaches that amounted to 8.3 tonnes of assorted material – 50% more than in a similar survey in 1994. The materials collected included bits of glass, cans, paper and plastic containers and wrappings, bottle tops and cigarette stubs, four or six pack plastic ring yolks and balloons. The visual impact of such debris is obvious as is the hazard bits of glass and metal pose to humans and their pets. Less obvious is the impact on wildlife. A similar survey was conducted by the Marine Conservation Society in 2003 covering a total of 198 separate beaches with a total length of 134 km. Overall almost 87% of the litter found was attributed to beach visitors, 14.6% to fishing and 7.8% to sewage, with only 2% attributed to shipping.

Although not quantified at either a national or regional level fish, seals, cetaceans, turtles and seabirds are all known to become trapped e.g. in bits of old fishing nets and plastic or rubber rings. They are also known to ingest plastic particles, plastic bags etc in mistake for food. Some undoubtedly die as a consequence of such mistakes. The presence and effect of micro-plastic debris is a relatively new issue but there have been a number of reports recently in the scientific literature indicating wide spread occurrence of this type of material. OSPAR is currently reviewing the development of a seabird EcoQO based on the number of plastic particles found in northern fulmar stomachs. As an avoidable problem greater efforts to avoid inappropriate disposal of waste would save scarce resources being devoted to proving and quantifying such effects.

CHEMICAL ENVIRONMENTAL QUALITY AND EFFECTS

RADIOACTIVITY

It is frequently not fully appreciated that exposure to radionuclides arises from numerous sources and that inputs to the marine environment of radioactive materials arise from a wide variety of sources other than weapons testing, nuclear accidents and nuclear fuel production and reprocessing. Examples of other sources include 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 therefore be looked at in the context of exposure to all other forms of nuclear radiation including purely natural sources in the earth's crust.

The largest single input of artificial radionuclides around the UK arises from Sellafield on the Cumbrian coast in Region 5. Other minor sources arise from various nuclear powered electricity generating plants, naval operations, hospitals and radiochemical production at the Nycomed-Amersham plant at Cardiff (now GE (Healthcare)). 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 1,000 times lower than peak discharge levels. An exception is ^{99}Tc discharges which rose in 1994 following commissioning of the Enhanced Actinide Removal Plant (EARP). The increase in 1994 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. The peak discharge rate was reached in 1995 and ^{99}Tc has subsequently been detected in sea water and in lobsters, seaweeds and other marine biota, over a wide area of the northern Irish Sea (Region 5), around Scotland (Region 6) and in the northern North Sea (Region 1). Authorised annual discharge limits were reduced by slightly more than half from 200 to 90 TBq in January 2000 and the intention is to reduce the authorisation limit to 10 TBq 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 in sediments occur 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. 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.

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. All authorised releases of radioactive materials are subject to regular monitoring and assessment of exposure. In all cases individual doses experienced by the public are well within the internationally agreed dose limits. The effects of radiation exposure of marine organisms in the north-eastern Irish Sea are unlikely to cause adverse effects at the population level. This applies even to historical dose rates that are likely to have been at least ten times greater than present day levels.

NUTRIENTS

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. Nutrients may enter the sea from a variety of sources including sewage, industrial processes, run-off from agricultural land in rivers or by more diffuse drainage and from congregations of wild-life such as seals, wild fowl and seabirds. The phenomenon is not new but has been the cause of increased concern in recent years. As a consequence 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 extent to which anthropogenic input of nutrients present a risk to the ecological status of the eight regional seas around the UK differs markedly. There are no problems in Regions 6, 7 or 8 and outside these regions the lowest concentrations of nutrients are recorded in Regions 1 and 4. The highest concentrations of nutrients occur in coastal areas off the south-east coast of England in Region 2, but the indicative effects are below OSPAR assessment criteria. This may be due to the dynamic regime of the Region where wave and tidal energy combined with the relatively shallow depth results in naturally enhanced turbidity and rapid dispersion, restricting light penetration and algal growth. 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. Some localised problems occur in enclosed estuarine environments and harbours such as the Ythan estuary, Chichester, Langstone and Portsmouth Harbours.. In offshore areas nutrient concentrations are close to those set as background concentrations by OSPAR and only in the southern North Sea (Region 2) is there any indication of elevated concentrations, although this does not lead to problems associated with accelerated growth of algae. Within the northern Irish Sea concentrations of chlorophyll are close to background and even in the inner reaches of enclosed areas like Belfast Lough where the concentrations were considered high enough to indicate the potential for eutrophication there have been marked improvements following massive reductions in nutrient inputs.

Reductions have been made in direct inputs and nationally total direct inputs of nitrogen and phosphorus have been reduced by 35% and 50% respectively. In Region 1 inputs of nitrogen have been reduced by about 60%, but only marginal reductions have been achieved in Region 2. In 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. This fact indicates the importance of the oceanic source of nutrients in UK coastal waters.

As was mentioned earlier, in the section of this integrated assessment dealing with marine processes and climate, 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 the NAO and climate. At least so far as plankton are concerned, the records of the Continuous Plankton Recorder (CPR) suggest that the waters generally around the UK are not affected by nutrient inputs from land based sources. This makes the task of identifying changes at a more local level and disentangling them from the broader scale change, doubly difficult and a priority for science, as is development of a better understanding of the ecosystem consequences of nutrient input.

PERSISTENT TOXIC CHEMICALS

The industrial, agricultural and social activities of man result in the release to the environment of a wide variety of substances apart from radionuclides and nutrients. Some of these are toxic, persistent and bioaccumulative and can, if they reach the marine environment, pose a threat to marine organisms. Historically the presence of only a limited range of such substances has been monitored in the marine environment. Such substances include metals such as mercury, cadmium, lead, copper and zinc, organochlorine pesticides such as gamma-HCH (lindane), polychlorinated biphenyls PCBs or CBs) and a range of polycyclic aromatic hydrocarbons (PAHs). OSPAR and the EU have developed a system of selection and prioritisation to identify new priority substances for investigation. Pilot scale investigations for a number of these newly identified substances are being undertaken at a number of sites around the UK and a range of biological effects techniques is available to allow detection of effects on biota, even where there is no identified substance present to which to attribute cause.

Inputs from both direct and riverine sources of those substances known to be potentially dangerous to marine organisms that have been the subject of monitoring and controls on inputs in the past (i.e. metals, HCH etc) have been reduced by between 20% and 70% since 1990. Atmospheric emissions of these same contaminants have also been reduced by between 50% and 95% in the same period. There are insufficient quality long-term data sets to allow a rigorous assessment of trends in concentrations of hazardous substances on either a regional or national level. However, it is apparent that compared to the concentrations recorded in the 1970s and early 1980s concentrations of all the routinely monitored substances recorded in recent years, are lower (*Author's Note*). In areas like Liverpool Bay, Morecambe Bay and the Thames estuary concentrations of mercury in representative food fish are clearly lower than the peak levels measured in the 1970s before controls were applied to the industrial sources in these areas. They are however, still above natural background levels as measured in dab. Similarly HCH concentrations in sea water have declined to the extent that in northern areas they are often no longer detectable in sea water. There is however a general north-south increasing gradient for both HCH and CBs.

Despite the reductions in inputs and although concentrations of the routinely monitored substances are below the EQS concentrations (those above which marine organisms may be harmed) in all areas elevated concentrations do still occur. Metal concentrations in sediments are elevated above background, particularly in industrialised estuaries. Concentrations of mercury, copper, lead, PAHs, and CBs in sediments exceed the ecotoxicological assessment criteria (EAC) levels set by OSPAR in a number of industrialised estuaries, although concentrations of cadmium and zinc are below these levels except in a few estuaries in Regions 1 and 2. The highest concentrations of hazardous substances in biota were found in industrialised estuaries adjacent to areas with a known history of contaminant inputs. An exception is the presence of high concentrations of cadmium that were found in the liver of fish collected from a site on the Dogger Bank for which no obvious explanation has been found. Concentrations of copper and lead in biota were usually lower than those set as typifying background levels. Concentrations of PAH in mussels were below the EAC in all areas, but concentrations of CBs were above the EAC at about 30% of all sites monitored. Most of these were in, or close to, estuaries.

A limited amount of work has been undertaken directed at assessment of the possible presence of organic chemicals other than those routinely monitored. Such studies included surveys around England and Wales (i.e in Regions 2, 3 and 4,

and parts of Regions 1 and 5) for alkyl phenols and bromine based flame retardants. Only in the Tees estuary were concentrations of alkyl phenol ethoxylates and the alkyl phenol products of their degradation found at concentrations significantly above the levels of detection of the methods used. Further work is being undertaken in the Tees estuary but at present no further work is considered necessary elsewhere.

The interest in polybrominated diphenyl ethers (PBDEs), which were widely used on polymer products as flame retardants until the recent cessation of use within the EU, stemmed from the fact that they were manufactured at a site on the Tees estuary. Relatively high concentrations of deca-BDE were found in sediments in this area but not in biota. However, tetra- and penta-BDE compounds were found in the livers of fish from offshore reference sites and higher concentrations still (up to 1500 μg/kg) in the livers of dab and flounders from Tees Bay. Following the EU restrictions on these compounds concentrations in the environment are expected to decline over the coming years.

In terms of measurable biological effects, effects such as increased enzyme activity, formation of DNA adducts, elevated levels of fish disease and liver tumours were found in some fish populations particularly in areas where the highest concentrations of hazardous substances associated with these effects were found. An exception is in Cardigan Bay where disease levels appear to have increased unaccountably. Preliminary studies of metallothionein (MT) as a measure of metal exposure using dabs, flounders and mussels proved somewhat inconclusive and further investigations are required. No obvious correlation was found between levels in male and female fish or between the levels in fish and mussels from the same general area.

The oyster embryo bioassay has been used for over ten years to measure general water quality status in UK waters. The extent to which oyster embryos fail to develop normally to 'D' hinge larvae gives a measure of water quality. Tests undertaken between 1999 and 2001 in seventeen estuaries around England and Wales yielded variable levels of response but in only a few instances and then only one occasion within that period were the responses considered to indicate significant toxicity. A more detailed study in the Clyde (Region 5) during 1999 showed variability in both space and time and indicated the need for detailed study before trends over time can be assessed with confidence. Nevertheless, all the response levels measured between 1999 and 2001 were lower than those measured some ten years earlier (when they were typically 50 to 100%) and at no stage has the quality of coastal waters been indicated to be anything less than good. In a limited number of trials with newly developed sediment bioassay techniques, some sediments from industrialised estuaries were found to be toxic to the test species. However, in overall benthic community structure terms sediment particle size had a greater influence than contaminant concentrations.

Thus in general ecological health terms, although biological effects are detectable in or close to sites with a known history of contamination there is little to suggest known contaminants are currently having a serious impact on marine organisms, including fish, at the population level in any region around the UK. Concentrations are at or close to background in Regions 6, 7 and 8, in the outer parts of Region 4 and the northern sector of Region 1. Even in the southern sector of Region 1, and in Regions 2, 3, 4 and 5, evidence of contamination and/or effects of these historically monitored contaminants is essentially restricted to the inshore and estuarine areas.

Some work has been undertaken on a number of more recently identified biological effects. Of these the most notable is a survey of the effects of TBT on dog whelks. Dog whelks are naturally present around most of the UK coast but exposure to TBT, which was used as an anti-fouling agent in paints used on recreational craft, fishing vessels and merchant ships, causes an effect known as imposex. This effect was found still to be widespread, despite the limitations on its use as an anti-foulant already introduced in the UK (broader scale restrictions on the use of TBT based paints on ships more generally are due to come into force in 2008). TBT was in fact the most common cause of failure (29 in total around the coast of England) to meet List II guidelines for organic compounds under the Dangerous Substances Directive. However, the scale of the imposex effect typically observed has decreased in recent years and effects sufficiently serious to inhibit reproduction were only found in the immediate vicinity or within a few hundred metres, of point sources of TBT such as marinas or ship repair yards.

In the 1990s a number of organic substances were found to be capable of causing feminisation (endocrine disruption) of marine fish. In extreme cases this amounted to the presence of various stages of egg formation in the male gonad. Lower exposure levels were found to cause formation of the egg precursor vitellogenin (VTG). A research programme, funded by Defra, was initiated in 1998 following the earlier studies. This has incorporated on-going monitoring but also investigated effects on a wider range of species. Some feminisation has been found in flounder from estuaries such as the Tyne, Tees, Mersey and Clyde but there is some evidence, at least from the Tyne where secondary sewage treatment has been introduced, that the effects are less marked now than previously. Migratory trout and salmon do not appear to be affected nor do crabs and shrimps. The main substances causing feminisation have been identified as synthetic chemicals such as nonyl phenol and natural substances such as the female sex hormone 17ß-oestradiol (*EDMAR Research Report to Defra*).

OIL

The previous section of this integrated assessment discussed the impact of the oil and gas industry, particularly in relation to the physical impacts on the seabed but included reference to oil inputs from that source and from spillages and detectable discharges from ships. This section addresses the impacts of oil discharges particularly those from land based sources. The largest mass inputs of oil based hydrocarbons to the marine environment are from land-based sources reaching the sea by river run-off and from the atmosphere. Because oils are complex mixtures of hydrocarbons and few inputs from land-based sources are of the full mixture, input data are collected in different ways and direct comparisons of quantities reaching the marine environment by different routes are not possible. However, it is known that direct inputs of oil from refineries have been reduced approximately 20-fold since 1981 and volatile emissions of PAH to the atmosphere from land-based sources have reduced by about a factor of four since 1990. With the exception of PAH, the environmental concentrations and effects of which were discussed above, the majority of the oil reaching the sea from land-based sources is in dispersed form, does not give rise to visible surface films, is not particularly toxic and is relatively easily degraded. This applies equally to inputs of oil from offshore platforms in discharges of produced water etc. Oil inputs to the different regions around the UK from land-based sources vary. Due to the prevailing wind direction, inputs from the atmosphere mainly affect Regions 1 and 2. There are few direct inputs from any sources to Regions 6, 7 or 8 other than shipping and the limited oil developments in Region 7. Inputs from refineries obviously occur only where these facilities are situated (Regions 1, 2, 3, 4 and 5). Similarly, land-based run-off from motor transport use is clearly greatest where roads and traffic are greatest but there are no reliable quantified data for such inputs.

MICROBIOLOGICAL CONTAMINANTS

Although not fully within the descriptor chemical, microbiological contaminants 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 and are not known to have any adverse effects on the marine environment per se. They do however, pose a threat to humans via exposure to sewage contaminated bathing waters and through the consumption of contaminated bivalve shellfish. Three EC Directives require microbiological monitoring: the Bathing Waters Directive, Shellfish Hygiene Directive and Shellfish Waters Directive. All set standards for numbers of indicators of faecal bacteria in sea water and/or shellfish. A clear measure of the microbiological quality of coastal waters designated under these Directives is therefore available through information on the degree of compliance with the standards set by the Directives.

In 2003 in England and Wales over 98% of identified marine bathing waters met the current mandatory standards, an increase from 77% in 1990. Only six bathing waters failed to meet these standards, two in Region 2, two in Region 4 and two in Region 5. A similar improvement was recorded in Scotland where only two of the 60 identified bathing waters failed to meet the mandatory standards, compared to 19 in 1990. These improvements reflect the substantial investments that have been made in sewage treatment since 1990. In Northern Ireland all 16 identified bathing waters met the current mandatory standards in 2003 compared to 15 in 1990. Consideration has been given to the adoption of new, tighter standards and agreement on these is believed to be close. Clearly any tightening of the standards

will lead to more bathing water failures and an apparent reduction in the level of compliance compared to the position outlined above.

The Shellfish Hygiene Directive sets standards for the microbiological quality of bivalve shellfish flesh and intravalvular liquid. Depending on the numbers of faecal coliforms found to be present in samples of shellfish taken from a designated harvesting area, the shellfish may be sold directly for human consumption(class A) or be sold after passage through an approved purification system (class B). Shellfish failing to meet either standard may be designated class C, which means they can only be sold after approved heat treatment or extended relaying to meet class A or B standards. Shellfish failing to meet class C are prohibited from sale. In England and Wales in 2003, 249 harvesting beds were classified in 79 production areas. Four percent were graded class A and 81% class B compared to 5% and 69% respectively in 1999. Some further improvement is anticipated when the current AMP 3 schemes of sewage treatment upgrades are completed. In Scotland in 2003 157 harvesting sites were classified. Sixty-one percent were graded class A and 3% class B. 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 sites occur in Regions 4 and 5, whereas in Scotland they are in Regions 1 and 5, in the Firth of Forth and Inverclyde areas, where the population is mainly centred and sewage inputs are greatest.

The Shellfish Waters Directive seeks to protect or improve the quality of waters where shellfish grow. Most of the guideline standards it sets relate to chemical quality but it includes a guideline for the numbers of faecal coliforms in shellfish flesh. This guideline 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 Government has set an aspirational target equivalent to 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. There was little change in the extent of compliance achieved between 1999 and 2002 in England and Wales with between 5 an 18% failing in different years. Most of the failures were in Regions 4 and 5. For various reasons comparable data for Scotland and Northern Ireland are not available.

BIOLOGICAL ENVIRONMENT – STATUS, CHANGES AND PROTECTION

FISH STOCKS

In the absence of any exploitation the distribution and relative abundance of fish would depend on many factors, of which the main ones are temperature, depth, and the nature of the seabed. Thus changes in temperature, whether part of a natural cycle or anthropogenically induced climate change, could be very important in determining the extent to which changes brought about as a result of fishing pressure. This is particularly important in a UK context because the British Isles lie at the biogeographic boundary between the northern boreal province and the more southerly Lusitanean province and there is a natural biogeographic trend from SW to NE. Thus whilst some species are naturally widely distributed around the British Isles others are naturally restricted more to northern or southern waters. Changes in this natural distribution have already been noted as a result of climate change, with southern species becoming more common. These changes confound the understanding of the environmental effects of fishing, both directly on commercially exploited stocks and indirectly on other species.

The various regions around the UK are not all equally productive in commercial fisheries terms. Region 1 is by far the most productive and together with Region 2 yields almost 11% of the world's total catch of fish. The Irish Sea (Region 5) is and always has been much less productive. Fishing is nevertheless important in all other regions, although in Regions 7 and 8 the type of fishing gear used tends to be different and targets the different species found in these deeper colder waters. In most regions around the UK, landings of fish peaked between the 1970s and 1990s depending on the area and type of fish targeted but have in almost all cases fallen since. The peak and subsequent fall in both landings and stocks was, at least in part, due to improved efficiency in locating and catching the fish by more powerful and better equipped boats. The major mechanism used to limit catches has been a quota system based on Total Allowable Catches (TACs). This system has not been successful in regulating fishing mortality. It is therefore increasingly being augmented by a variety of technical measures such as new limits

on the mesh size allowed in the nets and the use of square panels to assist escape of undersize/ non-target species Other measures taken seek to control fishing effort in a more definite manner. Such measures include total or partial closure of a fishery e.g. a four year closure of the herring fishery in the North Sea in the mid-1970s and closure of the sandeel fishery off the north-east coast in the northern North Sea (Region 1) and in the Minch (Region 6) and limits to the number days allowed at sea and decommissioning of fishing vessels in order to reduce fishing effort. The recovery plans for example for cod and northern hake involve combinations of new mesh regulations and effort controls.

Although there is uncertainty about the relative importance of all the factors affecting the stock of commercially exploited fish species, knowledge of the actual level of most species is more complete. ICES undertakes an assessment of most commercially exploited stocks annually, basing its conclusions on data from commercial landings, research cruise investigations and observations of commercial fishing practices, including discards. This assessment is used to provide advice to national governments and the EU on what levels of exploitation are to be regarded as acceptable and/or what measures need to be taken to protect stocks. Since 1999 a precautionary approach has been adopted in the provision of advice and there are some limited signs that the stricter regime is working. Nevertheless, the current situation for most commercially exploited stocks is not good.

In the North Sea (Regions 1 and 2) the stock status of many demersal species deteriorated during the 1990s. In 2004 out of eight demersal species assessed by ICES, four were considered to be harvested unsustainably or at risk of being harvested unsustainably. In contrast the status of the herring stock is at full reproductive capacity. In the Irish Sea (Region 5) many demersal stocks are at risk of being exploited unsustainably. During the past decade the cod and whiting stock status has deteriorated further and this is a cause for serious concern. In Region 4 most of the commercially exploited demersal stocks in the South-west Approaches are at risk of being exploited unsustainably. The northern hake stock is the subject of a management recovery plan and Celtic Sea cod may require one. Furthermore, the mackerel stock has declined in recent years and the rate of exploitation is not considered sustainable in the longer term. The situation is much the same in Region 6, with many species considered to be being exploited unsustainably. The status of the stock of sandeel is uncertain but the fishery is the subject of an annual closure from 31st July to ensure sufficient food availability for young seabirds. Stocks of anglerfish, cod and whiting in west Scotland and Rockall (Regions 7 and 8) are harvested unsustainably and cod stocks are close to historically low levels.

Recovery plans include one for Irish Sea cod which was introduced in 2000 and is still in place. It includes a lower TAC, a closed area and a number of other technical measures. The proposals for recovery plans for West Scotland and North Sea cod included a temporary closed area in 2001 and an increased mesh size and effort controls. The recovery plan for northern hake includes a lower TAC and mesh size restrictions. It came into force in 2004.

Apart from the effect fishing has on actual numbers of the commercially targeted species it also affects species and genetic diversity. Some larger target species such as skates and rays are now estimated to be present at less than 10% of the abundance that would be anticipated without fishing. Indeed in some areas some species are essentially regarded as extinct e.g. common skate and angel shark in Regions 4 and 5. In Regions 7 and 8, where rates of growth of many species is slow, there are serious concerns about rates of recovery and OSPAR has already placed the orange roughy on its list of endangered species. The mean weight of individual fish has also declined as the larger individuals have been selectively removed. This may cause selection of those individuals that mature at a smaller size and thus affect the genetic diversity of fish populations. There is some evidence that plaice and cod have already been affected in this way and that other species may also be being so affected

Although fishermen seek only to catch the species they can sell, the nature of fishing operations is such that other fish species are caught incidentally and are also frequently killed. Fisheries, particularly industrial fisheries, also target fish species that are important prey for seabirds and, although discards of by-catch and offal provide a source of food for some seabirds, there are questions about the value of this fortuitous food source for young seabirds

compared to their natural food supply. Particular issues of concern in relation to by-catch of other species have arisen over the by-catch of marine mammals. The numbers of harbour porpoises being caught in the central North Sea gill and tangle net fisheries (Regions 1 and 2) were thought to exceed the ASCOBANS limit of 1.7% of the population. Measures have been taken to reduce by-catch numbers but it remains unclear whether they have been successful in reducing it below the 1.7% level. Numbers of common dolphins caught in Region 4 have also given rise to concern and various measures are currently being tested to reduce this e.g. by establishing a dolphin exclusion zone around fishing gear.

FISH ASSEMBLAGES

The structure of fish assemblages has changed markedly in response to fishing mortality. The most pervasive change has been a reduction in the abundance of large individuals and species, with some of the largest species that are most vulnerable to fishing, such as the common skate, now locally and regionally extinct. In some cases, smaller individuals and species have proliferated as larger species have been reduced in numbers. The consequence of decreases in the abundance of larger individuals and increases in the abundance of smaller individuals is that mean body size of fishes is much lower in heavily exploited communities. Since larger individuals feed, on average, at higher trophic levels, the reduction in mean size also reflects a decrease in the mean trophic level of the fish assemblage.

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SEABIRDS

By their very nature seabirds are visible and although some species spend much of their lives at sea away from land, all species nest ashore. They are therefore amenable to accurate population estimates and monitoring of demographic features such as breeding success. Complete censuses exist for all 25 seabird species found in the UK. These provide baseline data from which subsequent data can be compared. There are also sufficient data on breeding numbers and breeding success at both regional and national level to assess population changes. It is clear from these data that overall numbers of seabirds have increased from around 4.4 million in 1969/70 to about 6.7 million in 1998/2002. Part of the reason for the overall increase in seabird numbers is attributed to protection from hunting and persecution in the UK and overseas. Nevertheless, terrestrial pressures can have a large impact on population size of seabirds. Such pressures include availability of nesting sites and disturbance as well as predation by mammals such American mink, brown rats and hedgehogs. There are also concerns over the future impact of large-scale development of wind farms as these are considered likely to disturb birds and their migration patterns and may cause serious levels of mortality. In accordance with the requirements of the EC Birds Directive, 95 sites have been designated as SPAs due to their qualifying interest in one or more seabird species and/or their seabird assemblage (more than 20,000 breeding adults). Carmarthen Bay (in Region 4) is the first wholly maritime SPA in the UK and was established on account of its over-wintering population of scoter ducks.

Seabirds are long-lived and display high rates of annual survival of adults and low rates of post-fledgling survival. Not all species have experienced increases in numbers, indeed there have been marked declines in some species e.g. in European Shag and Herring Gull and there are marked variations in distribution. For example, between 1985 and 1990 the breeding populations of Arctic Skuas, Arctic Terns and Black-legged Kittiwakes on Shetland fell by 42%, 19% and 62% respectively. At present trials are underway of three EcoQOs involving seabirds. One of them relates to numbers of oiled common guillemots found dead or dying on beaches. A second EcoQO relates the breeding success of Black-legged kittiwakes to the availability of their sandeel prey. The third one involves counts of plastic particles in the stomachs of northern fulmars. Various trials have been made aimed at setting targets for seabird populations at various sites based on composite data for different species. These have all been found unsuitable because different species are affected differently by different pressures. Counts of numbers of individual species do however, permit trends to be assessed.

SEALS

Two species of seal are commonly resident in UK waters, the grey seal and the common or harbour seal. Both species are widely distributed. Although 90% of the grey seal population breed in Scottish waters (Regions 1 and 6), smaller numbers are found elsewhere on Skomer, Lundy, the Farne

Islands and at Donna Nook on the outer Humber estuary. The majority of breeding/haul out sites used by common seals are also in Scotland but significant numbers are also found along the east coast of England, (Regions 1 and 2) particularly in the Wash. Neither species is found in Region 3 but small numbers occur in Regions 4 and 5. Both species of seal are regarded as requiring protection at a European level, although neither is considered to be threatened or at risk in UK waters. In accordance with the EC Habitats Directive requirements, 11 SACs have been designated for common seals on the basis of the numbers using the sites for haul out purposes. Eleven more SACs have been designated for grey seals on account of their importance as breeding sites. There have been no assessments of the status of these SACs but mechanisms are in place to ensure a report is available in 2006.

Almost 40% of the world's population of grey seals are found in UK waters and numbers grew steadily between the 1960s and 2000, since when pup production has been broadly static. In 2003 the grey seal population was estimated to be about 123,000. The UK also holds about 40% of the European sub-species of common seal, with an estimated population size of 50-60,000 animals. Outbreaks of phocine distemper virus (PDV) in 1988 and 2002 affected both seal species but mortality was highest in common seals. Numbers had largely recovered by the time of the second outbreak, which had little impact in Scotland but killed up to 35% of the population in the Wash (Region 2). Seal population trends in the North Sea have been defined as an EcoQO and the available data could be used to report against this EcoQO.

CETACEANS

Cetaceans are less readily observed than seabirds or seals and of the 28 species known to occur around the British Isles only about ten are commonly recorded. The publication in 2003 of an Atlas of Cetacean Distribution in north-western European waters saw the creation of a single Joint Cetacean Database combining information previously held on three separate databases. Reasonably accurate population estimates exist for only a few species and in many cases only on a local scale. Line transect surveys in the early 1990s produced estimates for *Lagenorhynchus* dolphins in the North Sea and Celtic Sea; for minke whales, the white-beaked dolphin and harbour porpoise in the North Sea: and for short-beaked common dolphin in parts of the Celtic Sea and an adjacent offshore area. On a more local scale estimates exist for common bottlenose dolphin populations in the Moray Firth, Cardigan Bay and English Channel. There are no reliable methods of using sightings data to establish population trends and no indicators of state have yet been determined for cetacean populations in UK waters. Assessments of the status of cetacean species, as required by the EC Habitats Directive, have yet to be conducted. The target date for completion of these is 2006. The only EcoQO for cetacean species relates to the by-catch of harbour porpoise in the central North Sea which should not exceed 1.7% of the estimated population in the fishing area. Assessment of the present situation is hampered by lack of adequate data. Protection for dolphins has been afforded by designation of three candidate SACs, two of which relate to the bottlenose dolphins in the Moray Firth and Cardigan Bay. No candidate SACs have yet been designated for harbour porpoises, although this is under active consideration. Trials are being undertaken to limit the by-catch of common dolphins in Region 4 by establishing dolphin exclusion zones around fishing gear; the effectiveness of such measures is not yet clear and they are not therefore fully operational.

BENTHOS

Assessment of the availability of information about benthic populations shows a mixed picture. Adequate assessment of the status of benthic communities calls for both spatial and temporal data of reliable quality. Baseline data do exist for much of the coastal zone and coastline and for many regions of the coastal seas. Data also exist, but are far less complete, for the offshore sector of Region 4 and for Regions 7 and 8. There are major holdings of benthos data in both public and private sectors that are not readily available for status assessment and wider environmental management. It is also apparent, despite the recognised importance of the benthic environment, that surveying effort has declined in the past ten years.

Information is available for many taxa and areas but the amount of data available is only adequate, regardless of region, at a small number of sites, mainly in estuarine or inshore areas. Most data on benthos have been collected in the course

of monitoring of particular activities e.g. sewage sludge disposal, navigational dredging disposal, the impact of a particular effluent outfall or as one-off surveys of a particular area simply to establish what is present. Few data on benthic communities have been collected with a view to the direct assessment of the status of or changes in benthic communities in UK seas.

The data available from a survey of North Sea benthos conducted under ICES auspices show that the range and diversity of the species present is dictated by three main factors, the type of seabed and water depth and latitudinal position. It is also clear that in the deeper colder waters of Regions 7 and 8 that the species found are very different from those found in the shallower, warmer and more dynamic waters further south. Many of the species found in these Regions are fragile and slow growing and there are major differences between the species structure found either side of the Wyville-Thompson Ridge. The structure to the west being markedly more diverse and abundant than that found to the east, reflecting in particular the difference in temperature regimes either side of the Ridge. There are major concerns over the effect fishing operations may be having on the benthos generally but particularly in these areas, where regeneration rates are known to be very slow.

PLANKTON

Numerous studies have been undertaken of plankton in the waters around the British Isles, with the earliest recorded ones involving simple cone shaped nets, being initiated in the 1890s. International collaborative surveys were organised by ICES in 1902 and 1908 and studies with varying degrees of continuity have been undertaken since then at a variety of stations for example off the north-east coast of England (Region 1), off Plymouth (Region 4) and the Isle of Man (Region 5). However the bulk of the information on plankton variability around the British Isles derives from the Continuous Plankton Recorder (CPR). These records were started in 1937 and sampling is undertaken by towing a sampling device that continuously filters plankton out of the water onto a moving silk screen driven by a propeller which rotates at a rate determined by the speed of the towing vessel. Both phytoplankton and zooplankton are collected and assessment of the "greenness" of the record provides a good measure of phytoplankton abundance and primary productivity. Identification of the phytoplankton is undertaken (170 taxa most to species level) although the data have not yet been subjected to detailed analysis. Zooplankton are identified in most cases to species level. Several routes are operated well out into the North Atlantic. The records thus give a good basis on which to make assessments of changes over time and, because they cover a wide geographical area, to postulate the cause of any change detected.

The fact that clear changes have occurred and the reasons for them was discussed in earlier sections of this integrated assessment dealing with climatic change and nutrients. The details will not therefore be repeated here. A key point from the standpoint of the status of the seas, is that on the basis of the evidence from the CPR, at least so far as the plankton are concerned, the waters around the UK are relatively healthy and unaffected by contaminants or eutrophication. This is not to say that changes have not occurred but natural atmospheric and hydrographic variability appear to be the major contributory factor to ecosystem change in the shelf seas of north-west Europe. The plankton regime shift that occurred in the late 1980s coincided with sharp increases in Northern Hemisphere Temperature, sea surface temperature and the NAO.

NON-INDIGENOUS SPECIES

There is little information in the sector reports available to develop this review and the integrated assessment on non-indigenous species and nothing of a regional nature. The information available indicates that some 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 invertebrate animals. 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 e.g. *Bonamia* disease in oysters and the parasitic worm *Mytilicola virens.* However, more than half the introduced species are believed to have been introduced via shipping, either in ballast waters or via fouling of ship's hulls. There are therefore concerns that, as TBT antifouling paints are replaced, the possibilities of further transfers may increase

if the replacement antifouling agents are less effective. ICES has developed a code of practice governing the deliberate introduction of non-native species for mariculture purposes. IMO 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. These guidelines have already been adopted at some UK ports.

OVERALL ECOSYSTEM HEALTH AND HABITAT PROTECTION

Although there are often interminable delays in actual decision taking the UK does have a variety of national legislation to protect the marine environment using any of four separate designations: Sites of Special Scientific Interest (SSSIs) (though these do not extend below low water), Marine Nature Reserves (MNRs), Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). To date there are only three MNRs - Lundy Island (Region 4) and Skomer and Strangford Lough (Region 5). In January 2003 a 3.3 km^2 area within the Lundy Island MNR and SAC was designated as the first statutory No Take Zone for marine conservation in the UK. Preliminary results with this NTZ are considered to be promising with more and larger lobsters in the NTZ than outside it after only 18 months. Similar results were noted following the banning (by the local Sea Fishery Committee) of any form of scallop fishing around the Skomer NMR in 1990 (density now 4 times that recorded in 1984). Numerous sites have been proposed as SACs to protect marine features in nearshore waters and designation of SAC protected sites 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 13,000 km^2 and accounts for about 8% of the seabed within 12 nm or 1.8% of the UK continental shelf designated area.

Assessment of the status of these protected sites is currently underway with a view to completing reports on SSSIs in 2005 and the SACs and SPAs in 2006. To date the information collected for England suggests that 74% of the sandy and muddy shores and 87% of sea cliffs and rocky shores designated as SSSIs are in a favourable or recovering condition. In terms of the wider marine environment, the status of marine habitats in relation to man's impact on them, as with habitats generally, is a feature of the type of anthropogenic activity, its frequency and duration and the spatial extent of the area affected in relation to the total. As of November 2004 there were no systematic surveys and no surveillance or monitoring programmes had been completed that would enable an assessment of the status of habitats (i.e. how they may be changing) in UK marine waters. However, a considerable amount of information has been gathered regarding their current state. 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 the information on the full distribution of these habitats is incomplete the locations of most important examples of these priority habitats have been identified. In the absence of systematic survey data the status of these 14 habitat types is based on an 'informed view'. For nine of them the status is described as unknown, three are considered to be declining, one is stable and the other is fluctuating but shows no trend.

OVERALL POSITION – BRIEF SUMMARY

There are encouraging signs that the seas around the UK are in a somewhat more healthy state than in the past as a consequence of actions taken to tackle the problems identified in the last ten to twenty years. Some of the concerns that have been expressed over possible impacts have either not come to fruition or preventative action has been taken in time and the potential problem minimised or prevented. There is no evidence to suggest that the plankton has been adversely affected by pollutants, including nutrients. Seals and many species of birds are more numerous than in the past and, although arguably cetacean numbers overall are depleted because of past hunting, the species structure and numbers of cetaceans found in UK waters are similar to those found in other parts of the world.

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 wind farm all now require consultation with all possibly interested parties, usually involving an Environmental Impact Assesssment. The aim in all cases is to minimize so far as possible adverse impacts

on other potentially affected users. Only time and monitoring post the activity can show how successful these consultations are.

Steps have been 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. There are some encouraging signs that these reduction measures are paying off in that general water quality, as indicated for example by the results of oyster embryo bioassays, appears to have improved. In addition levels of contaminants such as mercury, cadmium, lead and other metals, TBT, PCBs and organo-chlorine pesticides, and the effects they were known to cause, are now lower than they were ten or more years ago. Also, whilst some coastal areas, particularly around the south-east and south coasts and in the Irish Sea are enriched with nutrients, harmful effects are limited in scale and essentially only occur in enclosed areas. Furthermore some of the areas worst affected in the past have shown real improvement.

This is not to say that changes have not occurred and will not continue to occur. The natural environment is continually changing and not all change is attributable directly to man or activities in the UK alone. For example, changes have taken place in the plankton and some seabirds have been particularly hard hit by changes in fish assemblages and distribution, but many of these changes are largely attributed to climate change and action at a purely UK level is unlikely to reverse that.

Set against the positive messages there are some negatives. Although there is nothing to suggest that fish stocks have been adversely affected by contaminants most commercially exploited fish stocks are in a seriously depleted state as a consequence of excessive fishing pressure and it remains to be seen whether the more positive measures now being taken in relation to managing fish stocks and minimising the effects of by-catch will have the desired effect. Some cetacean species, most notably dolphins and harbour porpoises, have recently suffered what appear to be unsustainably high rates of mortality as a consequence of certain commercial fishing operations. However, efforts are being made to find a solution to this problem and a ban on the type of fishing concerned has been declared unilaterally in UK waters as a move towards a solution. The impact of fishing gear on the benthic communities of the seabed is an issue of concern, particularly in deep waters where the communities are known to be fragile and slow to regenerate after damage.

Current action to restore fish stocks and protect species such as seabirds that are reliant on fish for their food, to their previous state and to allow nature and time to reverse damage to the benthic environment, may or may not be totally successful given the overlying effect of climate change and the effect this is having on the conditions favoured by colder water species such as cod. Climate change and particularly the impact this might have on sea level and coastal erosion is also an issue of concern, both from a human interests standpoint and from a nature conservation standpoint in relation to changes in habitats, especially in low lying areas and areas subject to coastal erosion.

Unfortunately it is not possible to give more than an ‘informed view’ on priority habitats and even assessment of the status of sandy and muddy shore, sea cliff and rocky shore SSSIs is thus far only available for England. More complete conclusions on the status of areas accorded SAC or SPA status will not be completed until 2005 and 2006 respectively. This is either because work to collect the necessary information is still in progress or because the appropriate data sets have yet to be made available or simply because the appropriate programmes are not in place. Meeting the deadlines presents a substantial challenge but progress is being made. Even when complete, the status of those areas of the coast and seas around the UK that are not protected under one or more of those designations will remain unknown, albeit that much of the area involved is around or close to towns, cities or ports etc. A classification system for marine habitats to support mapping and environmental management is in place and the JNCC is leading an EU Interreg-funded project on marine habitat mapping that aims to produce standards for seabed mapping and seabed habitat maps for north-west Europe.