6 ECOLOGY

6.1 Regional overview

In general, the North Sea is a complex and productive ecosystem which supports important populations of fish, seabirds and marine mammals. Pelagic and benthic communities are interlinked in more or less tightly coupled food webs which together with the abiotic environment, make up marine ecosystems. These ecosystems are dynamic and influenced by a range of biological, physical and chemical factors operating over different spatial and temporal scales.

Climatic and hydrographic variability, in particular the extent of Atlantic inflow are important ecological determinants of the character and extent of plankton communities. In recent years, spring and autumn blooms in the SEA 5 area have become more evident with primary production increasing throughout the year. Oceanographic conditions also influence the transport of zooplankton, fish larvae and cephalopods with direct consequences for associated predator populations.

Key predators include seabirds which breed in internationally important numbers on cliffs along the SEA 5 coast and utilise important offshore feeding areas. Marine mammals including harbour porpoise, white-beaked dolphins and minke whale are also present (particularly during summer), while coastal waters of eastern Scotland support a resident population of bottlenose dolphins. Both grey and common seals forage extensively within the area, targeting fish and cephalopods with coastal areas supporting important breeding colonies for both species.

Fish spawning areas are found throughout SEA 5 with the juvenile stages of many commercial fish species remaining within coastal nursery areas for a year or two before moving offshore. Offshore areas are characterised by fish communities dominated by haddock, whiting and cod. Migratory species such as herring and mackerel are also found although their distribution is seasonal. Diadromous species such as salmon, sea lamprey and eels are present with coastal rivers supporting important populations. Sandeels, a key prey species for a number of seabird and marine mammal species are distributed throughout the area, closely associated with well-oxygenated, medium to coarse sand. Important *Nephrops* stocks are found on a range of muddy-sand sediments.

Benthic communities are intrinsically linked to the physical nature and characteristics of the substrate. Offshore communities are spatially distributed over large scales, with distinctive species assemblages associated with particular substrate types. Sedentary species with high abundance and biomass dominate sheltered coastal areas whereas exposed beaches have lower diversity, abundance and biomass. Dense populations of intertidal benthos found in many of the sheltered inner firths and estuaries support important fish and waterbird populations.

6.2 Plankton

6.2.1 Introduction

To support the SEA process, the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) was commissioned to review plankton ecology in the SEA 5 area (Johns 2004). The review describes the composition and dynamics of the plankton community of the area, and identifies seasonal and hydro-climatic factors which can markedly affect it. The review was primarily based on data provided by the Continuous Plankton Recorder (CPR) survey.

Relevant information contained in previous SAHFOS reviews for SEA 2 and SEA 4 was also utilised.

The CPR survey provides a long-term dataset of plankton abundance in the North Atlantic and North Sea. Data collected from the survey allows long term changes, as well as seasonal cycles, in the plankton community to be identified. For the purposes of SEA 5, a data set containing over 11,000 samples from 1960 to 2002 was analysed; each sample representing 18km of tow and approximately 3m^3 of filtered seawater.

6.2.2 Planktonic communities

Plankton can be divided into phytoplankton (plants) and zooplankton (animals).

The most common phytoplankton groups are the diatoms, dinoflagellates and the smaller flagellates, often referred to as pico or nanoplankton. Much of the picoplankton consists of bacteria and blue-green algae, and can make up 15-30% of the overall plankton biomass (Klinkenberg & Schumann 1995).

The phytoplankton community of the SEA 5 area has shown considerable variation over the CPR time series. The most frequently recorded taxa are dinoflagellates (*Ceratium*) which is in line with the rest of the North Sea where there is an increasing trend of dinoflagellate dominance. The long term abundance of different *Ceratium* species has varied; in the late 1980s there were significant peaks of *Ceratium fusus* and *Ceratium furca*, since when abundances have dropped off, *Ceratium lineatum* has also shown considerable variation. The diatoms *Hyalochaete* spp. and *Thalossiosira* spp. are also abundant in the SEA 5 area and have displayed recent peaks in abundance. Historically *Thalossiosira* spp. are more abundant in the SEA 5 area than in the North Sea as a whole.

The SEA 5 zooplankton community is dominated in terms of biomass and productivity by copepods, particularly *Calanus* species which constitute a major food resource for many commercial fish species (Brander 1992). The main calanoid copepods in SEA 5 and the wider North Sea are *Calanus helgolandicus* and *C. finmarchicus*. Significant changes in the populations of these two species have occurred in recent years and these are discussed further in Section 6.2.4.

Meroplankton are the larval stages of benthic organisms that spend a short period of their lifecycle in the pelagic stage before settling on the benthos. Important groups within this category include the larvae of starfish and sea urchins (echinoderms), crabs and lobsters (decapods) and some jellyfish (coelenterates). Echinoderm larvae are of relevance to the oil industry as they can clog water intake filters, due to their spiny nature and the large concentrations that can occur rapidly (Reid & Hunt 1986). Reid & Hunt (1986) noted that potential problems could occur when larval abundances were greater than 2,000 individuals per CPR sample. However, in the SEA 5 area abundances of this magnitude happen on less than 1% of samples, compared with over 3% of samples in the North Sea. In both the SEA 5 area and the North Sea, decapod larvae have increased in abundance over the past few years in keeping with a general increase in meroplanktonic organisms in the North Sea (Lindley & Batten 2001).

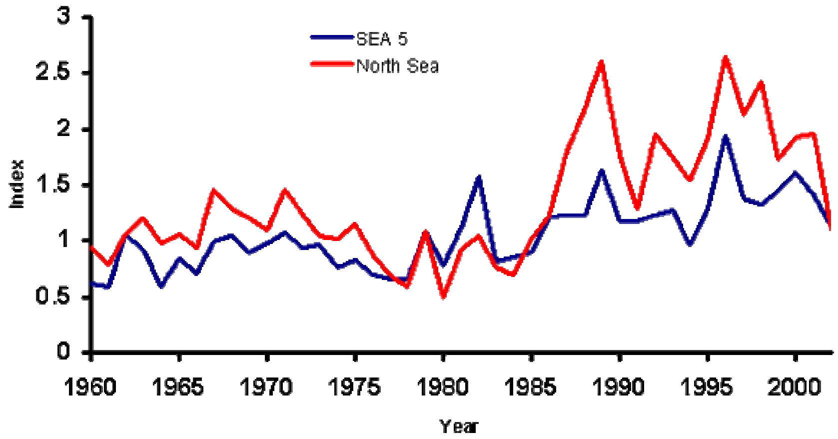
The larger zooplankton, known as megaplankton, including euphausiids (krill), thaliacea (salps and doliolids), siphonophores and medusae (jellyfish) are also present in the SEA 5 area. These gelatinous taxa are poorly sampled as their bodies disintegrate on contact with the CPR although they are known to be more abundant in late summer and autumn.

Euphausiid abundance is greater in the SEA 5 area than in the North Sea as a whole, although in both areas, numbers have been declining. Beaugrand *et al.* (2003) have indicated that the decline could be due to an increase in sea surface temperature in the North Sea. From CPR data, there appears to be a general increase in the occurrence of jellyfish which could be linked to anthropogenic impacts, either by overfishing (removal of finfish competitors, allowing jellyfish to exploit increased prey) or by alien species introductions (Mills 2001).

6.2.3 Plankton blooms

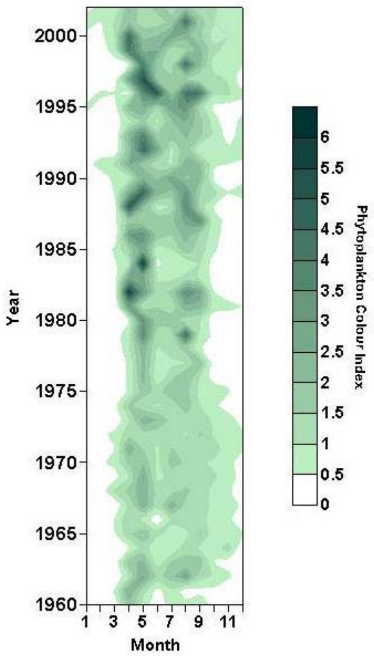
In the North Atlantic a phytoplankton bloom occurs every spring, often followed by a smaller peak in the autumn. In spring, as the day length increases and the water column becomes stratified due to surface warming, there is a bloom of diatoms. As little mixing of the water occurs, nutrients essential for the diatoms become depleted and other groups bloom, such as flagellates, followed later by dinoflagellates. As nutrients become further depleted, primary production slows down. Autumn introduces stronger winds which mix the water, introducing nutrients back to the photic zone, initiating a secondary bloom of dinoflagellates. As light levels reduce through the latter part of the year, primary production is again limited. With little primary production during the winter months, nutrients rise to levels which support the spring bloom.

Figure 6.1 - Phytoplankton Colour values in the SEA 5 area and the North Sea



Over the CPR time series, the Phytoplankton Colour Index, an indicator of primary production, has increased in the SEA 5 area as it has throughout the majority of the North Sea (Figure 6.1).

Figure 6.2 - Seasonal contour plot of Phytoplankton Colour Index in the SEA 5 area



Spring and autumn blooms are evident in the examination of long term seasonality (Figure 6.2), as is an increase throughout the whole year after the mid-1990s; this is possibly due to an increase in the abundance of dinoflagellate species.

Some of the most exceptional phytoplankton blooms recorded by the CPR survey have been associated with ocean climate anomalies and oceanic incursions into the North Sea (Edwards *et al.* 2002).

Under certain conditions (e.g. rapid reproduction, reduced grazing pressures and favourable environmental factors) blooms can occur at other times of the year. Many of these blooms involve nuisance or noxious species and are described as Harmful Algal Blooms (HABs). There are approximately three thousand identified species of marine phytoplankton of which about forty are known to exhibit toxicity. Examples of HABs relevant to the SEA 5 area include those associated with paralytic shellfish poisoning (PSP), such as the discovery of high levels of *Alexandrium tamarense* recorded in shellfish samples in Orkney in 1991. More recently in August 1996 there was a bloom of a dinoflagellate identified as *Gymnodium* cf. *mikimotoi* extending from Orkney to the west coast of Scotland. This outbreak was associated with the death of shellfish, finfish and other invertebrates in the affected area (Kelly & MacDonald 1997). Other HAB forming species such as *Dinophysis* spp. and *Ceratium furca* are also present, with the latter very prevalent in the SEA 5 area.

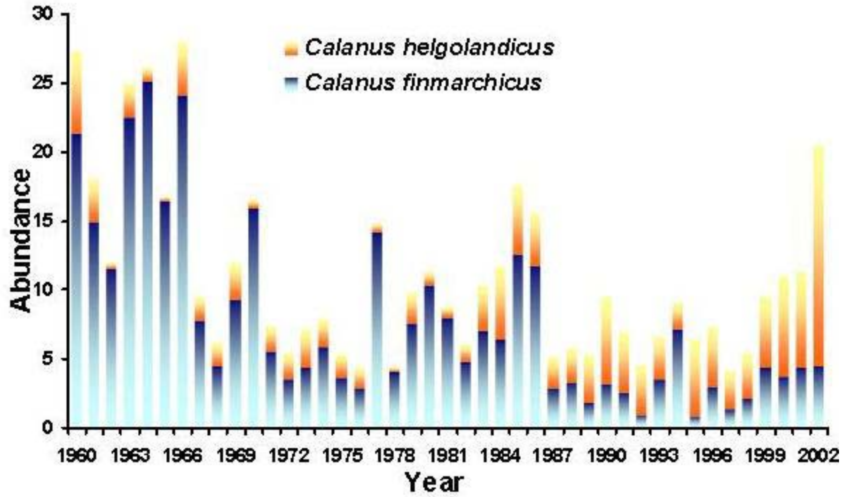
HABs may be related to water surface temperatures in spring, as early seasonal stratification may favour phytoplankton growth in the water column (Joint *et al*. 1997). Observations of seasonal circulation along the northeast coast of England suggest that dinoflagellates originating from the high concentrations of *A. tamarense* cysts in the sediment of the Firth of Forth act to maintain a dinoflagellate population in the coastal region south to Flamborough Head, thereby maintaining the risk of PSP outbreaks (Brown *et al*. 2001). Data suggests that Orkney forms the present-day centre of distribution for this dinoflagellate in northern waters (Tett & Edwards 2002).

6.2.4 The influence of hydro-climatic change

The North Atlantic Oscillation (NAO) is a key influence of North Atlantic weather patterns. During certain conditions, westerly winds increase over the North Sea introducing warmer air and increasing sea surface temperatures. The increase in wind stress also reduces stratification of the surface waters, delaying the onset, or altering the community structure of the spring bloom. These conditions have been more predominant in the last few decades and there is a suggestion that this may be an effect of global warming.

Periods of high and low NAO index are apparent in both phyto- and zooplankton community structure. Analysis of CPR data indicates that phytoplankton biomass, and some species and communities, may be responding to the anomalous atmosphere and climate conditions seen over the last decade. During the 1990s, phytoplankton biomass in the North Sea (and the SEA 5 area) has increased in winter months by over 90% compared to the long-term mean, showing the most pronounced seasonal change and possibly reflecting the milder winter conditions seen throughout the last decade. Some species (e.g. a number of dinoflagellates) have also reached their seasonal peak up to two months earlier in the 1990s compared to the long-term seasonal mean.

Figure 6.3 – Calanus finmarchicus and C. helgolandicus abundance in SEA 5



In the case of zooplankton, the recent increase in the SEA 5 area of *Calanus helgolandicus* and the subsequent decrease in *C. finmarchicus* (Figure 6.3), appears to be due to changes in sea surface temperatures (SSTs) with higher SSTs favouring the more temperate *C. helgolandicus*. Other factors including changes in food availability, inter-species competition, the transport of over-wintering populations onto the shelf, and the flow and temperature of the shelf edge current may also be involved (Reid & Beaugrand 2002). In addition, periods of high NAO may halt or reduce convection in the Greenland Sea, leading to a reduction in the formation of Norwegian Sea deep water which is the overwintering habitat for *C. finmarchicus* (Østerhus & Gammelsrød 1999).

6.2.5 Sensitivity to disturbance/contamination

The *Braer* tanker spill in 1993, which released 84,000 tonnes of oil in the Shetland area, allowed detailed examination of trophic level response to oil contamination, for example on adult, juvenile and larval stages of lobsters (Laurenson & Wishart 1996). Planktonic larval stages and eggs were found to be most susceptible, with higher mortalities, and an enhanced level of premature hatching. A similar result was found in the response of sea urchin eggs to Ekofisk crude oil (Falk-Peterson 1979). Conversely the photosynthesis (and hence primary production) of phytoplankton may be enhanced by low levels of petroleum hydrocarbons (Gin *et al*. 2001).

Despite the detrimental effects that an oil spillage can cause, in less major spills bacteria can play an important role in removing the oil. Davis *et al.* (1979) and Gearing *et al*. (1980) both commented on the increase in bacteria after a spill, and estimated that between 80 and 90% of the oil held in sediments was affected by microbial biodegradation.

In addition to easily identifiable inputs of oil into the marine ecosystem, industrial discharges and urban run-off of oil and other chemicals often amount to a greater volume. Pesticides for example can enter via runoff, and have a deleterious effect on phytoplankton communities (Rajendran & Venugopalan 1983, DeLorenzo *et al.* 2002), particularly organochloride–based products.

6.2.6 Ballast water and invasive species

Ballast water is a recognised vector for the introduction of non-indigenous and potentially harmful organisms into distant areas. Resting stages of both zoo- and phytoplankton can easily be transported in the fine sediments at the bottom of ballast water tanks offering a means of entry into the SEA 5 area.

For example, the non-indigenous diatom *Coscinodiscus wailesii,* is suspected of being introduced to European waters via ballast water. From its initial appearance in 1977 in the English Channel the species has spread throughout European shelf seas to become an established and significant member of the planktonic community (Edwards *et al.* 2001). In the southern North Sea, under certain circumstances *C. wailesii* can reach such a high abundance that it can dominate the phytoplankton biomass (SAHFOS website – http://www.sahfos.ac.uk).

Zooplankton invasion via ballast water is not as well documented as that of phytoplankton (Johns & Reid 2001). A number of species have been recorded in the North Sea for the first time in the last few years (the cladoceran *Penilia avirostris* and the stomatopod *Meisoquilla desmaresti* (Johns, unpublished, cited by Johns & Reid 2001). Whilst these species are most probably responding to a biogeographic change due to a variation in the hydro-climatic conditions (i.e. increased SSTs), in the case of *Penilia*, resting eggs may have 'seeded' the North Sea from ballast water, and responded to favourable conditions (Johns & Reid 2001).

There is a growing concern regarding the risk of alien species and the importance of protecting native biodiversity. Raised awareness of this problem has resulted in the introduction of a variety of operational and technical innovations to reduce the risk of organism transfer via ballast water.

6.3 Benthos

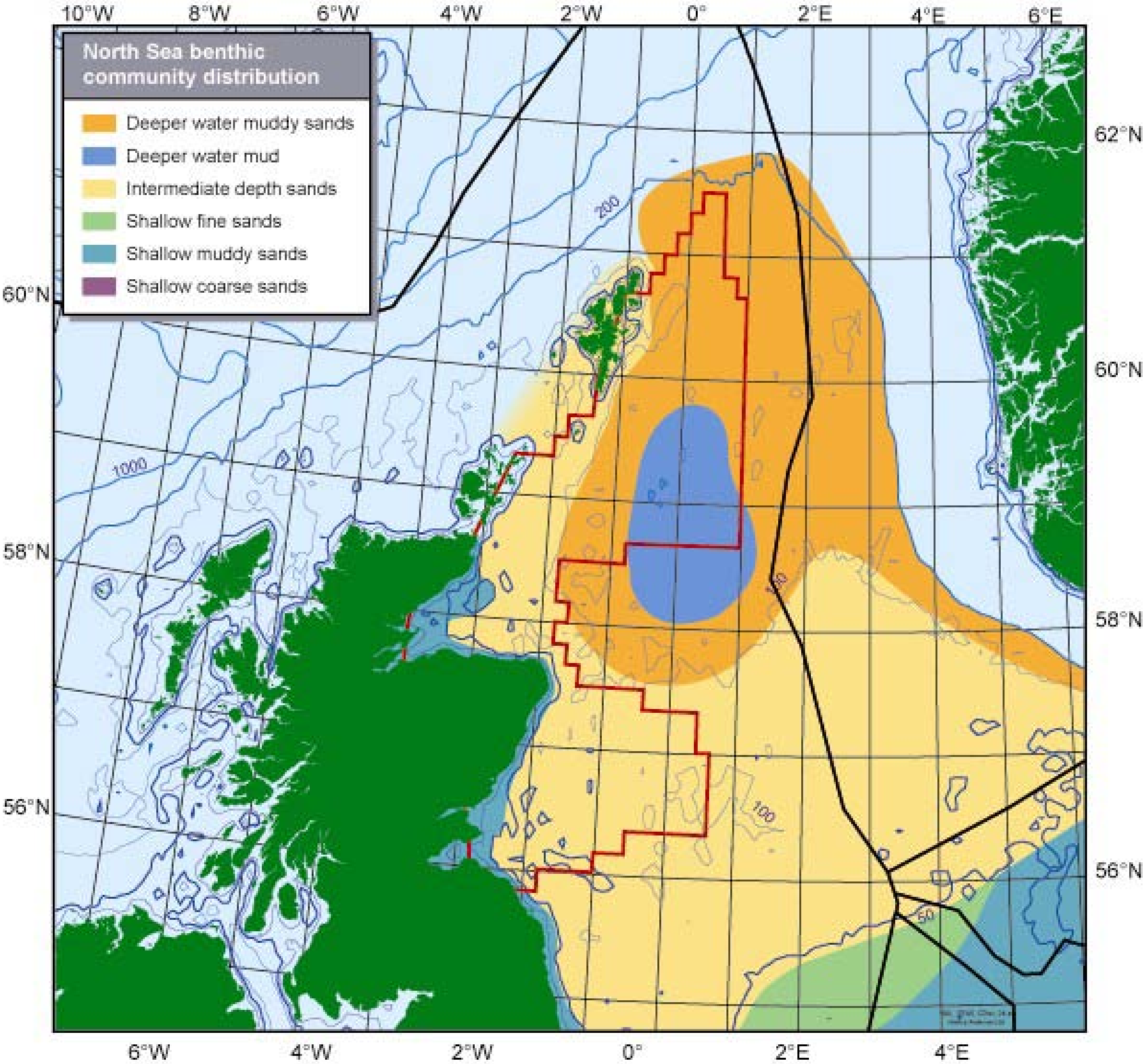
6.3.1 Introduction

In contrast to some previous SEAs, the benthos in the SEA 5 area has been relatively intensively studied over a long period, and is generally well-characterised in terms of community composition and distribution. However, the area includes a complex range of intertidal and seabed habitats and the associated benthic fauna is correspondingly varied. To support SEA 5, a synthesis of current information on the benthic environment and the benthic communities and associations was produced by Eleftheriou *et al*. (2004).

Benthic communities are traditionally considered and presented as three groups: meiofauna, infauna and epifauna. The meiofauna group, the smallest in size (less than 0.5mm), are generally capable of moving between the sediment particles using the natural spaces. Though these animals can be found in very high numbers, they have not been extensively surveyed because of their microscopic size. The infauna (or macrofauna) group (greater than 0.5mm) are usually surveyed using grabs or corers, as they live in the upper layers of the sediment. They represent the most commonly surveyed and well-known benthic grouping. Epifaunal animals, which live on the surface of the sediment, are generally larger in size than infauna and meiofauna and may be encrusting or sessile (usually on rocky substrates), such as sponges, hydroids, bryozoans, corals and anemones; or mobile and sometimes capable of extensive migrations both over the seabed and into the water column, such as crustaceans. Epifaunal communities are surveyed by means of trawls, underwater photography, or diving.

Describing the distributional patterns of benthic communities and species has been a major focus of much work in the SEA 5 and adjacent areas. Stephen's surveys in 1922-1925 represent the first large scale survey of the offshore areas in the northern North Sea with over 1,000 sublittoral samples, as well as littoral sampling and provide a good historical baseline for further studies (Kingston & Rachor 1982). Later, McIntyre (1958) extended the investigations of the benthos of fishing grounds with surveys off the east coast of Scotland, in Aberdeen Bay, St. Andrews Bay, and the Smith Bank at the outer reaches of the Moray Firth. Subsequent studies, including a series of surveys combined to give North Sea wide coverage coordinated by ICES (Künitzer *et al.* 1992), have supported the broad divisions identified by Glémarec. In many cases however, the community groupings distinguished are dependant on the scale of the survey, with smaller scale surveys revealing more localised community types usually reflecting local sediment distribution patterns. It should be noted that such small scale features (e.g. pockmarks) and localised communities may be of conservation interest on account of their local or wider rarity. The broad scale patterns of seabed faunal community distribution in the North Sea are illustrated in Figure 6.4, developed from Glémarec (1973), Basford *et al.* (1990), Duineveld *et al.* (1990), Künitzer *et al.* (1992) and Jennings *et al.* (1999).

Figure 6.4 – Benthic community distributions in the North Sea



6.3.2 Data sources

The SEA 5 supporting document (Eleftheriou *et al*. 2004) provides a comprehensive review of available data, notably:

- Wide area surveys including parts of the SEA 5 area, carried out by the Scottish Department of Agriculture and Fisheries (Eleftheriou & Basford 1989), and subsequently ICES between 1980 and 1985 (Künitzer *et al*. 1992, Heip *et al*. 1992, Duineveld *et al*. 1991).
- A series of surveys (1980-1984) carried out on the benthos of the area of the North Atlantic Flow between Orkney and Shetland (Basford *et al*. 1996).
- Monitoring of thirteen locations in the Moray Firth, the Tay estuary and the Firth of Forth under the UK National Monitoring Plan (NMP).
- Seabed surveys conducted by the oil and gas industry in support of their continued operations in the offshore environment (surveys conducted between 1975 and 1992 collated by Kingston & Harries 2000 for UKOOA): these surveys are all localised in nature, mainly using a cruciform sampling strategy to examine gradients along, and perpendicular to, the residual current. The UKOOA database provides a significant resource towards examining localised impacts of offshore installations, but is too spatially restricted to enable wider interpretation of the general seabed ecology.
- Epifaunal surveys: wide area surveys using headline photography (Dyer *et al*. 1982, 1983) and trawling (Basford *et al*.1989,1990; Frauenheim *et al*. 1989; Jennings *et al*. 1999; Zühlke 2001, Callaway *et al.* 2002).

Scoping for SEA 5 identified a number of gaps in understanding of the benthic habitats and biology of the area, which were addressed by a survey programme in 2003. Preliminary analysis of data from this survey has been carried out, with coverage from the Pobie Bank, Fair Isle, Sandy Riddle, Smith Bank and Southern Trench.

6.3.3 Firths

The major firths of the SEA 5 area – the Moray Firth and Firths of Tay and Forth – together with other significant inlets on the mainland coast (e.g. the Ythan estuary and Montrose Basin) all support habitats which may be characterised as estuarine and sheltered from wave action. These habitats include extensive intertidal sand- and mudflats which are of ecological and conservation importance, and sub-littoral habitats which are distinct from those of adjacent coastal areas. Reed beds and saltmarsh are also characteristic of upper estuary locations

In all of the major firths, a strong community gradient associated with salinity has been described. For example, brackish water species such as *Fabricia sabella, Nereis diversicolor, Pygospio elegans,* tubificids and Nemertea are present at upstream locations. Substrate type is also a significant influence on faunal distribution; for example, within the Firth of Tay, the dynamic nature of the local hydrography leads to a very complex sedimentary regime. The north shore sediments are predominantly fine sediments and the south sands are gravels. There are coarse sand and gravel shoals offshore of the south bank. The channel bed is mainly composed of coarse and medium sand, with gravels and substantial mussel colonies in the main channel giving way to medium and fine sands at the river 'bar'.

Wave exposure in the outer Firth of Forth is a significant influence, particularly on intertidal fauna. For example, Belhaven Bay (near Dunbar) is a high wave energy area, and is biologically "poor" (i.e. low macrofaunal abundance and diversity) with very little input to the sediment of organic matter from any source. Eleftheriou & Robertson (1988) noted the existence on this beach of a species-poor fauna, dominated by amphipods while molluscs and polychaetes were virtually absent.

Following a major sampling exercise in 1979, Elliott & Kingston (1987) classified the subtidal macrofaunal associations within both the estuary and the Firth of Forth. Four clear associations, accounting for six groups were described: the *Abra* community (and two variants) formed the largest group, an *Echinocardium-filiformis* group (Petersen 1914) was found in a broad band curving from Inchkeith into Largo Bay, a *Venus* community formed bands off the north and south coasts of the firth near Largo and Aberlady Bays and a *Crenella* association (characterised by the bivalves *Crenella decussata* and *Venus ovata*, and the amphipod *Metaphoxus fultoni)* occurred in two small areas on the northern and southern sides of the firth, close to its outer limit. A *Modiolus* association with a local but substantial population of adult horse mussels was also present close to the bridges.

The Ythan estuary is a well understood small-scale ecosystem (Raffaelli 1992) and has been the subject of many studies based at the Culterty Field Station of the University of Aberdeen. The scale of the estuary is such that most of the trophic links in the food web for the estuary have been discovered (Gorman & Raffaelli 1993).

Montrose Basin (the estuary of the River South Esk) forms a broad, muddy, predominantly intertidal basin, which supports a rich estuarine fauna, dominated by the gastropod mollusc *Hydrobia ulvae*, the amphipod *Corophium volutator*, the bivalves *Cerastoderma edule*, and *Macoma balthica* and the polychaetes *Manayunkia* spp. and *Fabricia sabella* (McLusky & Roddie 1982). There are extensive mussel (*Mytilus edulis)* beds present, particularly on banks at the eastern end of the basin and along the main drainage channels. Both the Ythan and Montrose Basin (and other coastal inlets such as Loch Fleet, the Cromarty Firth and Findhorn Bay, see section 6.7) support significant populations of resident, wintering and migrant shorebirds which are dependant on the high macrofaunal productivity.

6.3.4 Coastal waters

Open coastlines of the SEA 5 area provide a range of intertidal habitats from bedrock shores, boulders and cobbles, to extensive sandy beaches. Shallow subtidal habitats are predominantly sands, gravels, or a mixture of the two, although extensive areas of exposed rock also occur, with characteristic epifaunal communities.

A broadly similar range of rocky intertidal and subtidal habitats are found in Shetland, Orkney and the east mainland coast. For the greater part, these shores are moderately exposed to wave action, having a northerly or northeasterly orientation and the complex shore geology has created a high diversity of intertidal habitats. On vertical surfaces barnacles and limpets replace fucoid algae as the dominant cover organisms. The communities of plants and animals occurring on hard substrata between the tidal extremes are dependent mainly on a combination of factors: wave exposure, shore topography, geology and geographical location. Sub-littoral communities are also influenced by light availability, producing a depth-related zonation. Within the eulittoral zone, kelp forest provides a complex range of faunal habitats over extensive areas.

Reasonable survey coverage of rocky intertidal and shallow subtidal habitats in the SEA 5 area has been produced, in part due to work related to the MNCR (Hiscock 1998, Bennett & Foster-Smith 1998; see Eleftheriou *et al*. 2004). On a UK-wide basis, this work has been the basis for a classification of biotopes (i.e. distinctive habitat with associated flora and fauna) and regional reports. However, Eleftheriou *et al*. (2004) note that important stretches of hard substrata on the east coast are either scantily surveyed or in some cases there is no information available.

In their extensive survey from Sinclair's Bay to the Firth of Forth, Eleftheriou & Robertson (1988) described the fauna of the east coast sandy beaches and ascribed it to a variation of the north-temperate water community, characterised by the bivalve *Tellina tenuis,* polychaetes and crustaceans, as described and commented on by Stephen (1930) and Eleftheriou & McIntyre (1976). Eleftheriou & Nicholson (1975), using the sediment characteristics of the different beaches, distinguished between exposed and sheltered beaches and described the associated fauna which reflected these conditions. Extreme exposure limits species richness by eliminating or restricting the sedentary forms of many bivalves and polychaetes, which results in a sparse fauna dominated by crustaceans. More sheltered, fine sandy beaches typically have a rich and varied fauna dominated by bivalves such as *Angulus tenuis* and *Donax vittatus*, the polychaetes *Nephtys cirrosa, Spio filicornis, Scolelepis squamata* and the cumaceans *Bodotria pulchella* and *Cumopsis goodsiri*. In those beaches with a flattish profile and a high retention of seawater there may also be incursion of subtidal species well into the intertidal, such as *Tellina fabula*, as well as the amphipod *Bathyporeia guilliamsoniana*, mysids, the polychaete *Nephtys hombergii* and several cumaceans (Eleftheriou & Robertson 1988). These community types are continuous with those found in shallow water sandy sediments, the composition diversity and abundance of which are again influenced by wave and current action.

6.3.5 Offshore waters

Benthic communities in deeper water tend to be spatially distributed over large scales, with distinctive species assemblages associated with particular substrate types and present over large areas of the North Sea (see above). Eleftheriou *et al*. (2004) provide a review of community types described from the SEA 5 area, making major distinctions between areas north and south of 57° 30'N. Broadscale patterns of offshore macrofaunal distribution are summarised in Figure 6.4.

The benthic infauna of the offshore northern North Sea in general is characterised by its tendency towards higher diversities than the central or southern areas (Künitzer *et al*. 1992). While these results may be attributable, in part, to the use of finer sieves (0.5mm in the northern area as opposed to 1mm elsewhere), the gradual increase in diversity northward through the southern and central areas would suggest that this gradient does exist. There may be a relationship between this increase and changes in depth and productivity in the area, but the variability of the data makes it difficult to discern clear divisions on smaller scales.

Early studies of benthic epifauna recovered in fishing trawls have been followed by photographic surveys (using a camera attached to the headline of a demersal trawl) (Dyer *et al.* 1982, 1983; Cranmer *et al.* 1984); while Basford *et al*. (1989, 1990) investigated epifaunal community assemblages using a 2m Agassiz trawl, at 38 stations in the SEA 5 area north of Peterhead. Statistical analysis of the latter data distinguished two groups of stations in the SEA 5 area:

- Fauna inhabiting moderately sorted, coarse sediments with relatively low silt and organic carbon levels characterised by sponges, the bryozoan *Flustra foliacea*, the anemone *Bolocera tuediae*, and the crab, *Hyas coarctatus,* typically in the sandy areas extending south of Fair Isle to off Peterhead.
- The deeper, finer sediments, of the Fladen Ground area where the fauna was typified by the echinoids; *Asterias rubens, Astropecten irregularis*, and *Bryssopsis lyrifera*.

The latter group was further sub-divided giving a deeper mud-dwelling group in the Fladen area characterised by the seapen (*Pennatula phosphorea*) and a shallower group typified by the hermit crab (*Pagurus bernhardus*), the brown shrimp (*Crangon allmanni*), the purple heart urchin (*Spatangus purpureus*) and the snail (*Colus gracilis*) in the surrounding area. Similarly, further divisions of the first group separated a shallower (70m) and coarser sediment group inhabiting the sediments between Orkney and Shetland and off the Buchan coast typified by the presence of sponges; and a deeper (100m), finer sediment group typified by tunicates and the shrimp (*Spirontocaris lilljeborgi*) in the intermediate flat offshore area. South of 57° 30'N, analysis grouped the majority of the stations together based on the presence of sponges, tunicates, *Spirontocaris lilljeborgi* and *Pagurus bernhardus*.

In recent years, ROV and drop-camera surveys carried out by the oil and gas industry, either for environmental purposes or for operational reasons (e.g. pipeline route inspections), have provided extensive and high quality data on epifaunal distributions. Several initiatives are ongoing to optimise survey design and collate available information from ROV surveys.

Infaunal community distribution in the broad area is relatively well described. From 1980 to 1985, Eleftheriou & Basford took macrofaunal and sediment samples every 15 miles in a grid extending across the North Sea from just north of Shetland to the Firth of Forth. Analysis of this data produced two distinct groups according to the amount of silt present in the sediments. Stations containing less than 20% silt were sub-divided into a fine sand group, inhabited by *Abra prismatica, Ophelina neglecta, Travisia forbesi, Bathyporeia elegans* and *Eudorellopsis deformis*; an inshore, coarser sandy sediment group (near Shetland) with *Hesionura elongata, Protodorvillea kefersteini, Protomystides bidentata* and *Moerella pygmea* and a finer (medium to very fine sand) group, which was characterised by *Spiophanes kroyeri, Myriochele heeri, Harpinia antennaria* and *Aricidea wassi*. A group of Fladen Ground stations with more than 20% silt is outwith the SEA 5 area.

Basford *et al.* (1990) reported on additional sampling, extending from off Orkney to the inner Moray Firth. These samples indicate a gradient of infaunal density from less than 3,000 individuals/m^2 offshore increasing up to 6,000 in the outer Moray Firth. Species richness varied from 30 to 60 species per station with no detectable pattern. The initial division shown in the analysis of the data revealed an inshore group and an offshore group. These groups were sub-divided into a siltier group characterised by the polychaete, *Pisione remota*, and a coarser silt group typified by the lamellibranch, *Nucula tenuis*. The offshore group was further sub-divided with the polychaete, *Spiophanes bombyx,* representative of the shallower, less silty group and the amphipod, *Eriopisa elongata*, lamellibranchs, *Thyasira spp* and the polychaetes, *Lumbrineris gracilis* and *Ceratocephale loveni* representative of the deeper siltier samples.

6.3.6 DTI 2003 survey

The epifauna and macrofauna of several specific features within the SEA 5 area were investigated by studies commissioned by the DTI to support the SEA process, with field sampling carried out in late summer 2003. Analysis of the benthic communities of the targeted areas is summarised in Figures 6.5 to 6.10.

Figure 6.5 – Benthic communities described by DTI 2003 survey – Fair Isle

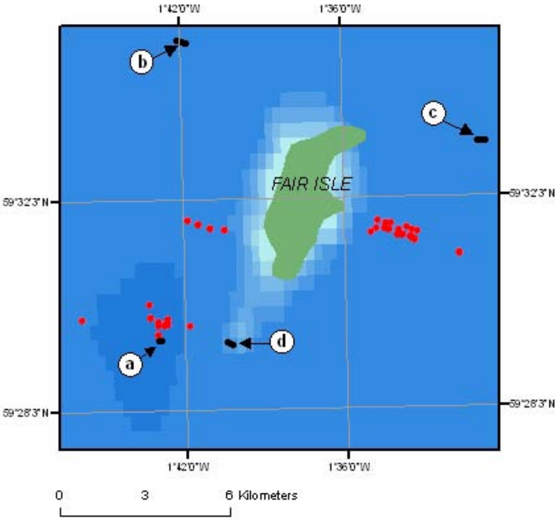
FAIR ISLE

Bedrock and boulder intertidal and sub-littoral habitats (previously surveyed in 1986-87 by OPRU/MNCR), with exposure ranging from sheltered to highly exposed, support typical sessile and mobile epifauna. Surrounding sedimentary habitats were surveyed in 2003 during the SEA 5 survey and samples were retrieved from three areas:

- sand ridge to the east of the island
- sand ridge to the west of the island
- seabed depression to the southwest of the island

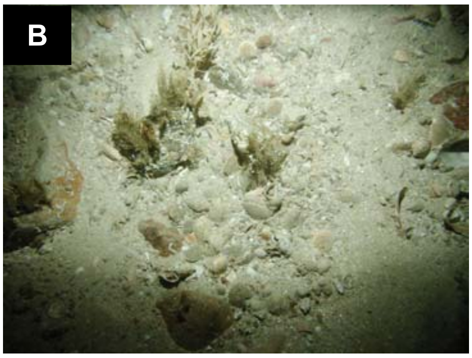
The sediments typically comprise coarse-very coarse calcareous sand and gravel. Numerically dominant taxa include typical coarse-sediment polychaete worms (*Glycera lapidum, Pisione remota, Polygodius spp., Hesionura elongata, Protodorvillea kefersteini*), bivalve molluscs (*Modiolula phaseolina, Moerella pygmaea, Gari tellinella*), amphipod crustacea (*Liljeborgia kinahani*), echinoids (*Echinocyamus pusillus*) and ophiuroids (*Ophiura affinis*).

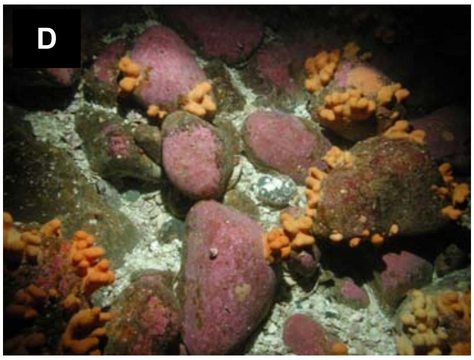
Stations Map



Most abundant seabed animals

	total number	%
Ophiuroid juveniles	1453	17.8
Glycera lapidum	676	8.3
Pisione remota	536	6.6
Oligochaeta indet.	393	4.8
Polynoidae indet.	368	4.5
Modiolula phaseolina	277	3.4
Polygordius spp.	259	3.2
Echinocyamus pusillus	224	2.7
Echinoidea juveniles	199	2.4
Nemertea indet.	191	2.3





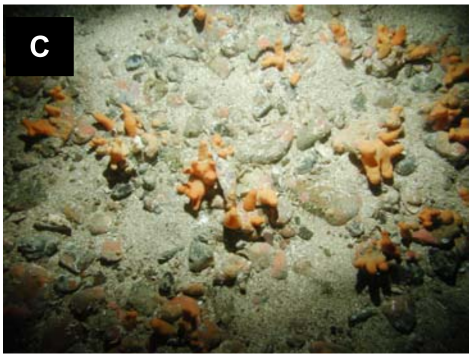


Figure 6.6 – Benthic communities described by DTI 2003 survey – Outer Moray Firth

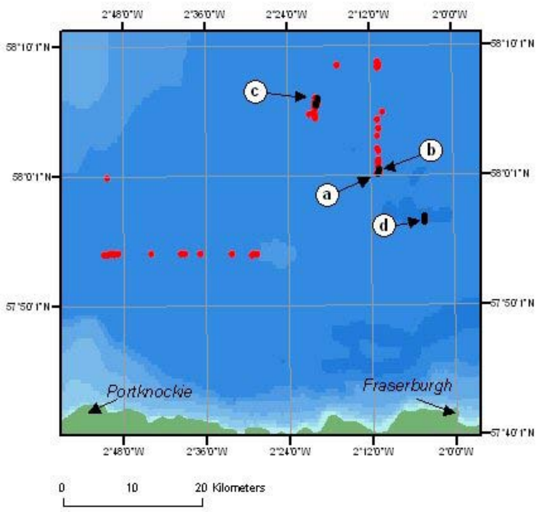
OUTER MORAY FIRTH

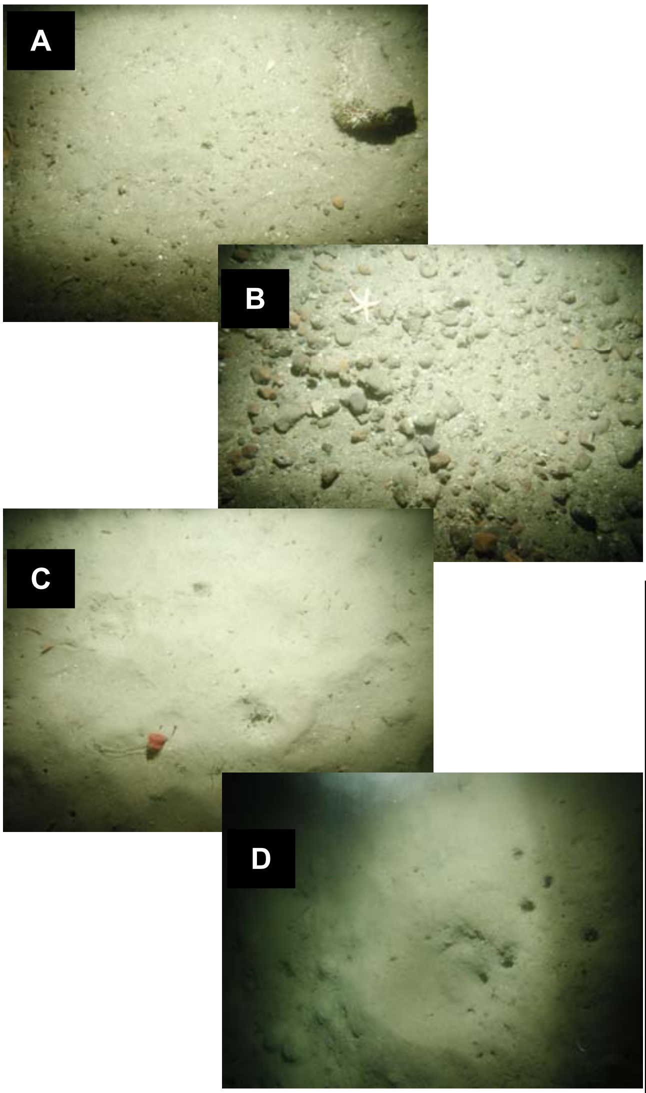
Samples were retrieved from two areas in the Outer Moray Firth:

- Area A, a rectangular block extending 58°-58°29'N, 2°04'-2°11'W
- Area B, a second rectangular block extending 50°50'-58°N, 3°-1°48'W (including gas pockmark feature)

Sediments were variable, ranging from generally coarse sediment cover to muddy, very fine to fine sands becoming finer with depth (Outer Moray Firth, gas pockmark feature). The macrofauna was relatively consistent, with numerically dominant taxa including species characteristic of stable fine sands (e.g. the polychaete worm *Galathowenia oculata* agg., the amphipods *Ampelisca tenuicornis* and *Harpinia antennaria*, and echinoid *Echinocyamus pusillus*). The capitellid polychaete *Peresiella clymenoides* was widely distributed in both areas.

Stations map





Most abundant seabed animals – Area A

	total number	%
Galathowenia oculata agg.	947	8.2
Ampelisca tenuicornis	813	7.0
Echinocyamus pusillus	337	2.9
Spiophanes cf. wigleyi	327	2.8
Harpinia antennaria	323	2.8
Lumbrineris latreilli	257	2.2
Polynoid indet.	242	2.1
Mysella bidentata	241	2.1
Peresiella clymenoides	238	2.1

Most abundant seabed animals – Area B

	total number	%
Echinocyamus pusillus	137	6.5
Peresiella clymenoides	124	5.9
Glyceridae juveniles	87	4.1
Harpinia antennaria	74	3.5
Amphiura filiformis	62	2.9
Nemertine indet.	57	2.7
Galathowenia oculata agg.	55	2.6
Pisione remota	51	2.4
Eudorella emarginata	51	2.4

Figure 6.7 – Benthic communities described by DTI 2003 survey – Pobie Bank

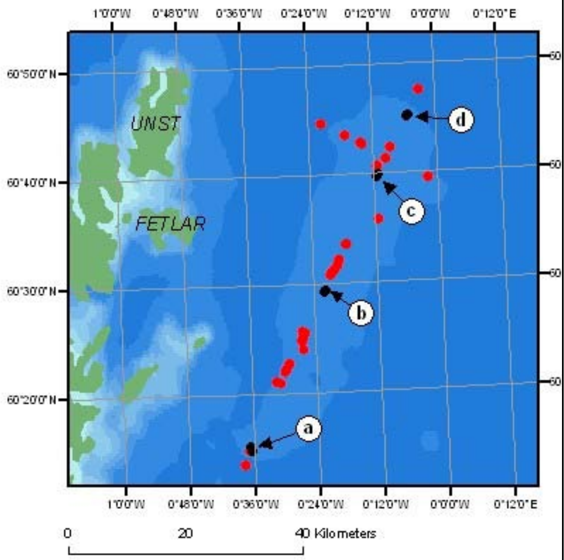
POBIE BANK

Pobie Bank is a large submarine rocky bank, defined broadly by the 100m contour, about 15km east of the Shetland Islands. Exposed bedrock supports a relatively sparse epifauna including bryozoans and hydroids.

Sediment samples were retrieved from across the bank, principally in the form of a northeast-southwest transect but some samples were obtained from a west-east transect on the northern area of the Bank.

The sediments comprise very coarse sand and gravel (mean gravel content 18.27%). Occasional finer samples (medium sand) were also observed. Samples from the flanks have characteristic polymodal grain size distributions, which may explain the widespread distribution of fine-medium sand infaunal species (e.g. the polychaetes *Pisione remota*, *Galathowenia oculata* agg. and *Aonides paucibranchiata*) co-occurring with species more characteristic of coarser sediment (*Sphaerosyllis*, *Protodorvillea kefersteini*).

Stations map



Most abundant seabed animals

	total number	%
Echinoidea juveniles	585	11.5
Pisione remota	453	8.9
Echinocyamus pusillus	301	5.9
Sphaerosyllis indet.	265	5.2
Galathowenia oculata agg.	245	4.8
Ophiuroid juveniles	240	4.7
Protodorvillea kefersteini	237	4.7
Aonides paucibranchiata	236	4.6
Polygordius spp.	159	3.1
Bivalve juveniles	140	2.7

Figure 6.8 – Benthic communities described by DTI 2003 survey – Smith Bank

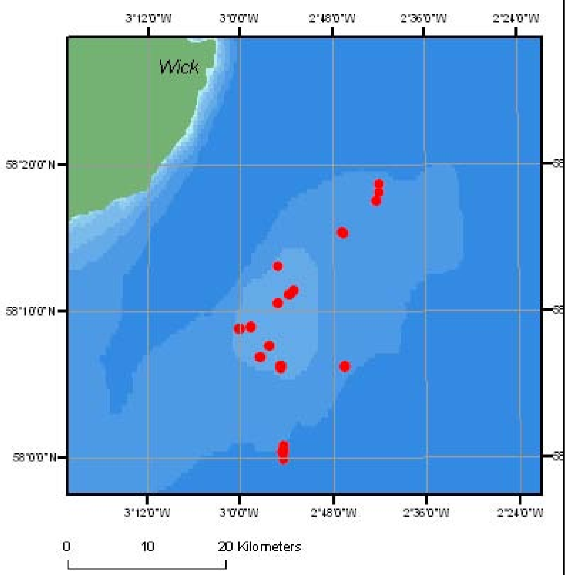
SMITH BANK

Smith Bank is an extensive sand bank located in the inner Moray Firth with a mean depth of about 40m.

The sediments across the bank comprise unimodal or multi-modal fine to medium sands. Occasional samples comprising shell gravel were also recorded, and these samples were noted to display high values also for carbonate and percent total carbon.

Numerically dominant infaunal taxa were consistent across the area and characteristic fine sand species: the amhipods *Bathyporeia elegans* and *B. guilliamsoniana*, the polychaetes *Spiophanes bombyx* and *Ophelia borealis*, the bivalve molluscs *Moerella pygmaea* and *Abra prismatica* and echinoid *Echinocardium cordatum*.

Stations map



Most abundant seabed animals

	total number	%
Bathyporeia elegans	1258	8.0
Spiophanes bombyx	1126	7.1
Moerella pygmaea	928	5.9
Amphiura filiformis	857	5.4
Ophelia borealis	627	4.0
Bivalve juveniles	458	2.9
Bathyporeia guilliamsoniana	435	2.8
Abra prismatica	428	2.7
Echinocardium cordatum	327	2.1
Aonides paucibranchiata	324	2.1

Figure 6.9 – Benthic communities described by DTI 2003 survey – Sandy Riddle

SANDY RIDDLE

The Sandy Riddle is a linear sand feature associated with the Pentland Skerries, rocky islands east of the Pentland Firth.

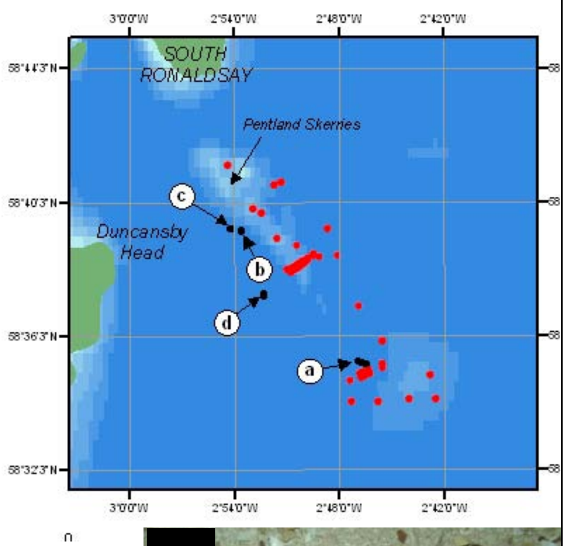
Samples were retrieved from four areas:-

- Transects across crest main body of the bank and the tail at the southern end
- Distal sand flat area (tail region)
- Between the skerries
- Additional sites

The Bank proper (i.e the ridge to the tail) consists of carbonate rich, very coarse shelly sand, mineral sand and gravel. Gravel contents commonly exceeded 50% by mass, and comprised broken as well as whole shells. The sediments of the surrounding seabed tend to be less well sorted, and typically contained medium and coarse sand fractions, as well as pebbles and stones. The region between the skerries is entirely biogenic shell gravel.

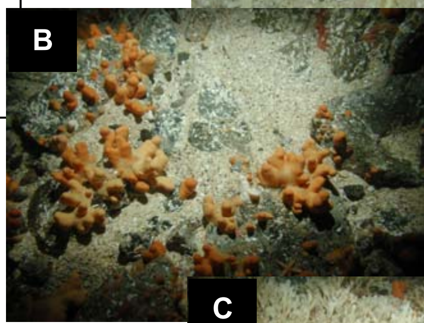
The numerically dominant animals include two interstitial archiannelid worm species *Saccocirrus indet.* and *Polygordius lacteus*, together with the sand-characteristic polychaetes, *Pisione remota* and *Glycera lapidum*; and the bivalves, *Moerella pygmaea* and *Spisula subtruncata*. *Saccocirrus* had a patchy distribution, with overall abundance largely due to very high numbers at one station (T4.6) on the bank crest (18.3m water depth). Other species were distributed more evenly, although considerable variability in species richness and individual abundance was evident, reflecting the small-scale variability in the sediment and habitat.

Stations map



Most abundant seabed animals

	total number	%
Saccocirrus indet.	8051	45.1
Pisione remota	1633	9.1
Ophiuroid juveniles	1033	5.8
Glycera lapidum	707	4.0
Moerella pygmaea	408	2.3
Polynoid indet.	387	2.2
Glyceridae juveniles	378	2.1
Exogone verugera	367	2.1
Spisula subtruncata	307	1.7
Polygordius lacteus	287	1.6



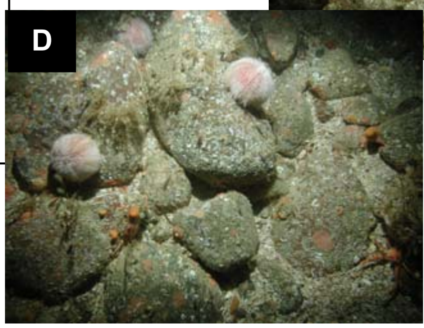


Figure 6.10 – Benthic communities described by DTI 2003 survey – Southern Trench

SOUTHERN TRENCH

The Southern Trench is a large linear submarine valley located in the southern part of the outer Moray Firth.

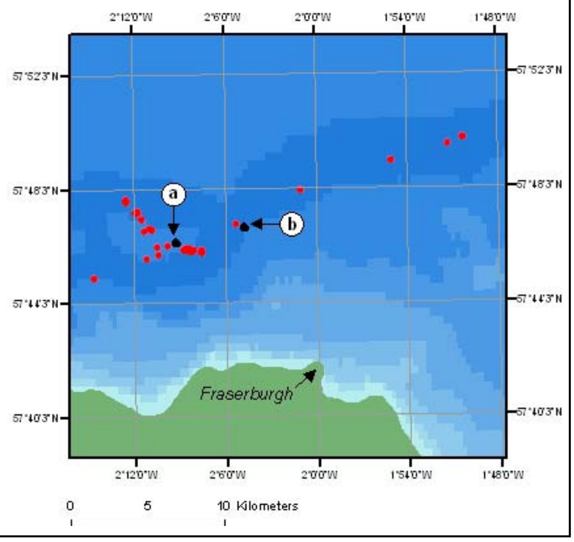
Samples were retrieved from two areas:

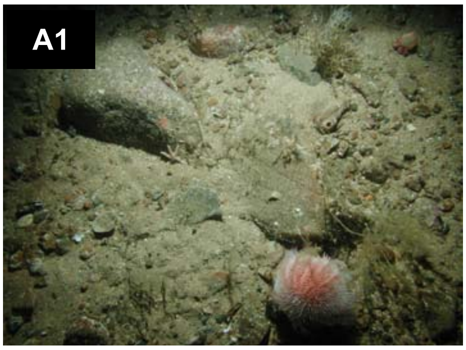
- a paired transect running from 200m up and over a shallow plateau (~50m)
- along the length of the trench axis at a constant depth (~200m)

The sediments sampled from the flanks of the shallow plateau comprise mainly muddy fine sand; toward the top of the plateau (ca. 75-80m) the sediment become coarser and include a significant gravel fraction. The sediments forming the bottom of the trench are very similar to those on the slope and comprise primarily slightly muddy fine to medium sand with a mud fraction typically <5% by mass.

Typical muddy sand and fine sand species were numerically dominant: the echinoid *Echinocyamus pusillus*, bivalve *Mysella bidentata*, polychaete *Galathowenia oculata* agg., and ophiuroid *Amphiura filiformis*. The fauna was generally similar to that from outer Moray Firth sites, with the capitellid polychaete *Peresiella clymenoides* again numerous at some stations. No dominant taxa showed a clear trend in abundance in relation to water depth.

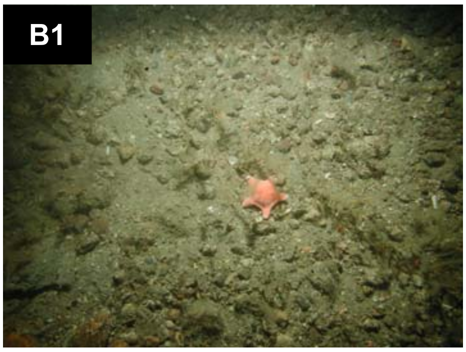
Stations map





Most abundant seabed animals

	total number	%
Echinocyamus pusillus	784	14.0
Mysella bidentata	370	6.6
Galathowenia oculata agg.	294	5.3
Amphiura filiformis	228	4.1
Peresiella clymenoides	224	4.0
Ophiura affinis	214	3.8
Lumbrineris latreilli	168	3.0
Minuspio cirrifera	163	2.9
Pholoe synophthalmica	158	2.8
Ophiuroid juveniles	154	2.8



Wrecks and artificial substrates

The deliberate and accidental placement of hard substrates in the North Sea where the seabed is predominantly sand and mud will allow the development of "island" hard substrate communities. Such "islands" occur naturally, for example on glacial dropstones and moraines but a substantial expansion of the number of hard surfaces has a number of potential implications for seabed fauna. Firstly, the additional surfaces can provide "stepping stones" allowing species with short lived larvae to spread to areas where previously they were effectively excluded from. The rapid colonisation of new oil and gas platforms has been documented a number of times (e.g. Forteath *et al.* 1982) and such colonising species can have very rapid growth rates (e.g. the horse mussel (*Modiolus modiolus*), Anwar *et al*. 1990), and cause slight enrichment at the seabed through dislodged animals and settlement of the wastes produced (Southgate & Myers 1985).

6.3.8 Rare species/communities and conservation significance

Most species recorded from benthic communities in the SEA 5 area have broad distributions, and large individual populations (in comparison to, say, terrestrial species of known conservation significance). Although new species continue to be described, it is broadly true that macrofaunal biodiversity in the SEA 5 area is well-characterised in comparison to deep water areas of SEAs 1 and 4. Conservation significance in relation to the benthos therefore tends to be associated with specific habitat types, rather than designated species. Species and habitats of potential conservation interest were reviewed by SEA 2:

- The large, long-lived bivalve mollusc *Arctica islandica*, with individuals in excess of 100 years old reported from the Fladen Ground (Witbaard *et al*. 1997). *A. islandica* was nominated for inclusion on the OSPAR list of threatened and/or declining species and habitats with particular reference to decline.

- The coral (*Lophelia*) is also a potentially long-lived species, which in some areas forms massive reefs. *Lophelia* is a deeper water Atlantic species, but has been recorded as a dead fragment from the southeastern Moray Firth (Wilson 1979), possibly as a fishing discard. The species has recently been recorded alive from fixed installations in the North Sea e.g. in the Beryl and Brent fields (Bell & Smith 1999), and may occur alive on suitable hard substrates in the outer Moray Firth and northern North Sea. However, there is no historical or recent evidence that the species has established large colonies of potential conservation interest in the North Sea, including the SEA 5 area.

- The horse mussel (*Modiolus modiolus*) is a widely distributed species which in suitable conditions can establish dense and persistent beds. These beds influence the seabed topography, sediment type and fauna present and can be considered as biogenic reefs. In the North Sea such beds are typically found in fully marine coastal areas down to about 70m, including areas in Shetland, Orkney and the Firth of Forth, although they have not been recorded alive in the central and northern North Sea (Seaward 1982). Individual *Modiolus* can live for about 50 years (Anwar *et al.* 1990) and the species has a Biodiversity Action Plan for it in the UK. Although the species is not listed in the Annexes to the EU Habitats and Species Directive, it may be afforded protection under the Directive by virtue of forming biogenic reefs.

- Another large and relatively long lived bivalve mollusc, *Pinna (Atrina) fragilis*, occurs in the North Sea. McKay and Smith (1979) record the presence of the species off Wick and Kinnaird Head; Seaward (1982) indicates the species is of southern and western distribution not extending further into the North Sea than Orkney and the Moray Firth; and, the UK Biodiversity Group notes six specimens being recovered on fishing lines off Aberdeen in 1841/2 (UKBG 1999). Earll (1983) notes the trawling of half a ton of *Pinna* to the east of Duncansby-Wick. *Pinna* is a large and long lived species which is susceptible to physical damage and a Biodiversity Action Plan has been developed for it in the UK, although the species is not listed in the Annexes to the EU Habitats and Species Directive.

- Glacial moraines can be interpreted as reefs under the EU Habitats and Species Directive and moraines are abundant in the area of continental shelf to the northeast and northwest of Shetland. Such moraines consist of mixed boulders, cobbles and finer material and can develop rich and spectacular epifaunal communities. Some topographic features such as Pobie Bank and the Sandy Riddle may also qualify as reefs and sandbanks (see Section 5.2), although available data suggests that benthic communities are not unusual.

- Pockmarks are a widespread feature in muddy sediments in the central and northern North Sea and are discussed in more detail in SEA 2. The macrofaunal ecology of an active Fladen Ground pockmark (in block 15/25, within the SEA 2 area) was described by Dando *et al.* (1991), who found that the fauna of sediments within the pockmark was characterised by the bivalve, *Thyasira sarsi,* (which is known to contain symbiotic sulphur-oxidising bacteria) and a mouthless and gutless nematode, *Astomonema southwardorum*, which also contains symbiotic bacteria. The carbon isotope compositions ($\delta^{13}C$) of the tissues of benthic animals from in and around the pockmark indicated that little methane derived carbon was contributing to their nutrition. Macrofaunal analysis of samples from the DTI commissioned survey of pockmarks in the Fladen and Witch Grounds indicates that potentially characteristic species (e.g. *Thyasira sarsi*) were not present at any of the pockmarks sampled (Graham Oliver, pers. comm.).

6.3.9 Data gaps

Although the general level of understanding of seabed fauna communities of the area is considered to be adequate for the purposes of SEA, there are a number of areas in which further research would improve confidence in the assessment:

- Long-term temporal studies – current understanding of long-term variability in benthic community structure and trophic interactions is limited. Natural variability in recruitment and productivity may be substantial and unpredictable, with significant implications for the design and interpretation of monitoring studies. Similarly, although several initiatives are in progress to investigate long-term recovery of areas affected by exploration drilling and large cuttings piles, understanding of the processes and rates of successional recovery remains limited.

- The tools to allow the distinction between species (taxonomic resolution) are poor for several macrofaunal, and most meiofaunal groups, and understanding of the ecological differences between species separated on the basis of morphological or molecular studies is extremely limited. This has implications for the understanding of biodiversity and its conservation monitoring, including the colonisation and spread of exotic species.

- The distribution and ecology of specific habitats (e.g. pockmarks, deepwater hard substrates, and shallow water coarse deposits such as those off the Spey estuary) are relatively poorly known. In many cases this is due to the limitations of "traditional" sampling techniques, and the use of camera and ROV surveys together with experimental studies should provide better understanding of such habitats and communities.

- The effects of fishing – in terms of direct physical damage, mortality of target and incidental species, and effects on ecosystem functioning – remain poorly understood despite their obvious importance. In particular, regulation of fishing effort remains based on short-term stock assessment of target species, despite a wide recognition that ecosystem effects may be equally important to long-term prospects for sustainable fishing. Improved understanding of benthic impacts of fishing, and of trophic interactions between benthos and fish communities, is fundamental to effective management at an ecosystem level.

6.4 Cephalopods

6.4.1 Introduction

To support the SEA 5 process, the University of Aberdeen's Department of Zoology was commissioned to provide an overview of cephalopod ecology and distribution in the SEA 5 area, the fisheries which exploit them and their sensitivity to environmental contaminants (Stowasser *et al.* 2004).

Cephalopods are short-lived molluscs, characterised by rapid growth rates. They can range in size from 1.5cm in pygmy squid (*Sepiolidae*) to 20m in giant squid (*Architheutidae*) and exhibit the highest degree of development of invertebrate nervous systems, expressed through complex behaviour patterns such as the ability to learn and the display of complex colour changes. In contrast to other molluscs, most cephalopods lack an external shell, are highly mobile as adults and occupy similar ecological niches to predatory fish.
They are active predators at all stages of their life-cycle and generally regarded as opportunistic, taking a wide variety of prey. Cephalopods also sustain a number of marine top predators such as fish, birds and marine mammals. Many species are powerful swimmers and carry out feeding and spawning migrations, thus influencing prey and predator communities strongly on a seasonal and regional basis.

6.4.2 Cephalopods in the SEA 5 area

Ecology and distribution

The main commercial cephalopod species in Scottish waters is the long-finned squid (*Loligo forbesi*) (Boyle & Pierce 1994, Pierce *et al.* 1998). Research trawling surveys record *L. forbesi* in the SEA 5 area in all seasons. However, the spatial pattern of abundance varies with season with the majority of squid being caught in the Long Forties/North Dogger Bank grounds in winter, the outer Moray Firth in spring and in and around the Moray Firth and Firth of Forth in summer and autumn (Pierce *et al.* 1998). Recent analysis of long-term trends in abundance points to the possible influence of oceanographic conditions, as proxied by the NAO index, on squid abundance (Zuur & Pierce 2004).

L. forbesi in Scottish waters spawns mainly from December to February, although breeding animals are also recorded in May. Two main pulses of recruitment are found in April and November, with a small numbers of recruits present throughout most of the year (Lum-Kong *et al.* 1992, Boyle & Pierce 1994, Pierce *et al.* 1994b, Collins *et al.* 1997, 1999). Mature squid are recorded throughout Scottish waters in winter and eggs of *L. forbesi* have been recorded in trawls off Shetland (Lum-Kong *et al.* 1992) and are regularly found on creel lines.

Although spawning grounds have not yet been documented, it is thought that *L. forbesi* move from the west coast of Scotland into the North Sea to spawn (Waluda & Pierce 1998, Pierce *et al.* 2001).

In general, squid catches in the UK, as in most northern European countries, are as a bycatch of demersal trawl and seine net fisheries (Boyle & Pierce 1994). In the SEA 5 area, however, there is a small directed fishery close inshore in the Moray Firth between Nairn and Macduff. The fishery is strongly seasonal (September to November) and used to be undertaken by around 20 small trawlers, although within the last two years the number of trawlers taking part in this fishery has increased dramatically up to 100 vessels (Ian Young, pers. comm. 2004, cited by Stowasser *et al.* 2004).

Approximately 480 tonnes of loliginid squid was landed from catches in the SEA 5 area in 2002, around 21% of the UK total. Squid catches from the Moray Firth may contribute over 90% of the total cephalopod landings from ICES Area IVa (Northern North Sea) (Pierce *et al.* 1994c).

Another loliginid squid frequently occurring in hauls alongside *L. forbesi* is the species *Alloteuthis subulata*. It is of no commercial value but may have an important ecological role in coastal food webs since it is the most commonly recorded cephalopod species in stomach contents of demersal fish in UK waters (Daly *et al.* 2001).

Other species of commercial interest, present in the SEA 5 area are squid species, *Todarodes sagittatus, Todaropsis eblanae,* and the octopus (*Eledone cirrhosa*), though in much smaller numbers. Both *T. sagittatus* and *T. eblanae* were part of a substantial fishery off Shetland and Norway in the 1980s (Joy 1989, Hastie *et al.* 1994) but are currently only occasionally landed. *E. cirrhosa* is often taken in Scottish waters as bycatch in demersal fishing mainly for cod and haddock, but rarely landed due to the absence of a domestic market in Scotland. Towards the most northern edge of SEA 5, specimens of species *Gonatus fabricii* may also sporadically occur in fishing hauls. This species is of considerable ecological interest as the main prey of large predators such as sperm whales (Santos *et al.* 1999, 2002) and is attracting interest as a potential commercial resource in Norway and Greenland.

Trophic interactions

Cephalopods are active predators and take a wide variety of prey including crustaceans, cephalopods and fish. They are also heavily preyed upon by a large number of marine predators including fish, birds and most importantly marine mammals, especially whales.

Although cephalopods are routinely eaten by many fish, they are major components of the diet in relatively few species such as monkfish (*Lophius piscatorius*) and some shark species. *Loliginid Alloteuthis* spp. comprised the main cephalopod prey of North Sea whiting (Hislop *et al.* 1991, Pedersen 1999).

Stomach content analysis of seabirds in the northeast Atlantic has shown that birds primarily feed on ommastrephid squid rather than loliginid species (Boyle & Pierce 1994, Furness 1994). Numbers of squid taken by seabirds in the northeast Atlantic was low compared with seabird populations from the Southern hemisphere.

Although primarily a fish eater, the most common cetacean species in the SEA 5 area, the harbour porpoise (*Phocoena phocoena*), has often been found with remains of sepiolids and the small loliginid squid (*Alloteuthis*) in its stomach (Santos *et al.* 2004). Most cetacean species found in northeast Atlantic waters show remains of at least some cephalopods (e.g.

Loligo sp.) in their stomach contents, e.g. bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*), white-beaked dolphin (*Lagenorhynchus albirostris*), pilot whale (*Globicephala melas*) and Risso's dolphin (*Grampus griseus*) (Boyle & Pierce 1994, González *et al.* 1994, Santos *et al.* 1994, 1995).

Cephalopods also play an important part in the diet of seals. Both the grey seal (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*) seem to prefer octopus (*Eledone cirrhosa*) to any other cephalopod prey. Studies carried out in Scottish waters showed that octopus formed an important part of the summer diet of harbour seals in the Moray Firth (Tollit & Thompson 1996) as well as appearing in the diet of harbour seals in Orkney (Pierce *et al.* 1990) and Shetland (Brown *et al.* 2001).

6.4.3 Sensitivity to environmental contamination and disturbance

Like many other molluscs, cephalopods naturally accumulate high levels of a number of trace metals including cadmium, copper and zinc (Martin & Flegal 1975, Finger & Smith 1987). Heavy metal accumulation rates in cephalopod species appear to be rapid (Craig 1996) and various studies on cephalopods report high levels of cadmium (Caurant & Amiard-Triquet 1995, Bustamente *et al.* 1998, Koyama *et al.* 2000) and mercury (Frodello *et al.* 2000). Since cephalopods represent an essential link in marine trophic chains, the concentration of heavy metals in their tissues will consequently also play an important role in the bioaccumulation of these pollutants in their predators (Koyama *et al.* 2000).

The concentration of anthropogenic and naturally occurring radionuclides is relatively low in squid. The accumulating effect of radionuclides along the food chain, however, can have damaging effects on higher trophic levels. Toxicity for both anthropogenic and naturally occurring radionuclides is highest the closest to the source. Thus, a more toxic effect of radionuclides could probably be found for more benthic cephalopod species (i.e. octopods, sepiolids) or eggs and juveniles in spawning areas should they be identical with areas of drilling and reprocessing operations.

The only serious impacts involving cephalopod species in the SEA 5 area would be the disturbance of spawning grounds due to displacement of bottom sediments. Loliginid squid aggregate to spawn and although no actual spawning grounds have been positively identified in the SEA 5 area, squid in spawning condition are caught every year in the area, especially during January to March (Pierce *et al.* 1994a). However, since spawning most likely occurs over an extended area the population is less dependent on any single spawning site and localised disturbance would not affect breeding success of the whole population.

6.5 Fish

6.5.1 Data sources

The North Sea fish and fisheries report produced by CEFAS (2001) for SEA 2 provides a comprehensive review of information on the commercial fish resources of the North Sea and the main fisheries which impact upon them. The shellfish resource and fisheries of the SEA 5 area are described by Chapman (2004) in a report specifically commissioned for SEA 5.

This section provides a summary of the distribution of the main finfish and shellfish species within the SEA 5 area. Further ecological information on the main commercial species including details of their spawning and nursery grounds adapted from Coull *et al.* (1998) can be found in Appendix 4.

6.5.2 Fish resource in the SEA 5 area

The SEA 5 area supports a range of fish and shellfish species and communities. The composition and distribution of these communities is dynamic and dependent on a range of biological and physical factors, including the pelagic or demersal nature of individual species; age and reproductive status; water depth, temperature and salinity, and the nature of the seabed. Spawning and nursery grounds are also dynamic features and are rarely fixed in one location from year to year. Thus, while some species have similar patterns of distribution from one season to the next, others show greater variability.

Fish species also undergo natural variation in population size, largely as a result of variation in year to year success in recruitment. Broad scale patterns of climate change and human exploitation also impact upon the fish populations (CEFAS 2001).

Finfish

Commercial species

In general, the juvenile stages of many commercial fish species remain within coastal nursery areas for a year or two before moving offshore. Juvenile plaice, dab and long rough dab occur in coastal areas of SEA 5 on sandy seabed, gradually moving to deeper water as they grow. Cod, whiting and haddock are found in coastal areas of SEA 5 particularly during summer and autumn months. Mackerel are widely distributed and growing juveniles and adults migrate to coastal waters after spawning, where they remain until autumn. Herring are also locally abundant in the summer and autumn in coastal feeding areas and discrete banks of clean gravel throughout the area are utilised by autumn spawning herring.

Sandeels are present in the SEA 5 area and their distribution is closely associated with well-oxygenated, medium to coarse sand. They provide an important source of food for many predators, including fish such as cod and haddock, marine mammals including grey seals and harbour porpoises, and seabirds. Many of the large coastal seabird colonies in SEA 5 appear to be reliant on sandeels during the breeding season leading to fishing restrictions in certain areas.

Offshore areas are characterised by fish communities dominated by haddock, whiting and cod (Daan *et al.* 1990). Saithe are common in deeper northern areas, although juveniles migrate into, and remain in, coastal areas for up to 3-4 years. Norway pout are also associated with deeper areas of the central and northern North Sea. Juvenile monkfish are found over most of the northern North Sea to depths of about 150m, while spawning adults are found at all depths but are generally scarce in coastal waters. Herring and mackerel are migratory species and are found throughout the central and northern North Sea, although their distribution is seasonal.

Diadromous species

Salmon and sea trout migrate from the sea to breed in freshwater. Important salmon and sea trout rivers are found along the Scottish east coast with rivers such as the Spey, Dee, Tay and Tweed of notable significance.

As a result of various environmental pressures, the numbers of both species have declined in recent years leading to increased concerns over fish stocks. International and national legislation, as well as a number of management initiatives have been introduced in an effort to halt declines and improve stocks. In Scotland, the management of the salmon fishery is entrusted to District Salmon Fishery Boards (DSFBs) whose responsibilities include the protection and improvement of the salmon fisheries within their districts.

Both the river lamprey (*Lampetra fluviatilis*) and sea lamprey (*Petromyzon marinus*) migrate from the sea up rivers in the SEA 5 area to spawn. The River Spey supports important numbers of sea lamprey and they are listed as a primary reason for site selection of the River Spey cSAC. Both lamprey species are listed as present but not the main reason for site selection for the River Tay cSAC, the Tweed Estuary cSAC and the River Tweed cSAC (JNCC website – http://www.jncc.gov.uk/idt/).

Eels are thought to be present in most, if not all, river systems along the SEA 5 coast. Although highly vulnerable to over-exploitation, there is no tradition of exploiting eels in Scotland (Fisheries Research Services website – http://www.marlab.ac.uk). However, concern about their status at a European level has led the European Commission to begin development of a Community Action Plan to improve eel stocks.

Non-commercial species

The estimated numbers of exploited and non-exploited fish species from coastal areas of SEA 5 are presented in Table 6.1. The information is taken from the British Marine Fishes Database (after Potts & Swaby 1993, cited by Swaby & Potts 1996, 1997a, b, c) which lists a total of 336 marine and estuarine fish species in UK waters.

Table 6.1 – Number of marine and estuarine fish species recorded in the SEA 5 area

	Number of fish species	Jawless fish	Sharks & rays	Bony fish	Protected species
Shetland	159	1	26	132	5
Orkney	108	1	19	88	3
North east	166	3	27	136	7
South east	154	3	23	128	7

Source: After Potts & Swaby 1993, cited by Swaby & Potts 1996, 1997a, b, c

The numbers are not definitive and in the case of Orkney, where the fish fauna has not been well documented some groups, such as skates and rays (*Rajidae*) and dragonets (*Callionymidae*), have not been identified to species level and the list must be considered incomplete (Swaby & Potts 1997b). Protected fish species in the SEA 5 area are described in the following section but in general, records of these species are rare.

Information on the distribution and abundance of non-commercial species comes from records made during routine groundfish surveys, landings data, historical records as well as scientific studies. Some fish species have been recorded in reports of the diet of other animals. On Shetland, for example, fish that featured in the diet of otter (*Lutra lutra)* included the viviparous blenny (*Zoarces viviparous*), the butterfish *(Pholis gunnellus)*, the five-bearded rockling *(Ciliata mustela)* and, less commonly, the northern, shore and three-bearded rocklings (*Ciliata septentrionalis, Gaidropsarus mediterraneus* and *Gaidropsarus vulgaris* respectively), together with the sea scorpion *(Taurulus bubalis)*, bull rout *(Myoxocephalus scorpius)* and eel *(Anguilla anguilla)* (Kruuk *et al.* 1987, cited by Swaby & Potts 1997a). The most abundant species found in near surface surveys in areas from Aberdeen to off Shetland were rocklings (*Gadidae*), members of the herring family (*Clupeidae*) and three-spined sticklebacks (*Gasterosteus aculeatus)* (Hislop 1979, cited by Swaby & Potts 1996).

The Firth of Tay is one of the few Scottish estuaries to be used as a spawning ground by smelt and they are now known to be returning to the Firth of Forth in increasing numbers as a result of improving water quality. At least 34 species of fish use the Forth estuary at some time during the year, including the lumpsucker *(Cyclopterus lumpus)* as well as commercially important species such as cod and herring (Buck 1993).

Threatened and protected species

A number of fish species present in the SEA 5 area have been included in the OSPAR Initial List of Threatened and/or Declining Species and Habitats. Details of the relevant species and the threats they face are described in Table 6.2.

Table 6.2 – OSPAR threatened and/or declining fish species in the SEA 5 area

Fish species	Decline	Threat
Cod	Stocks have declined substantially in the OSPAR area and the status of many individual stocks is poor.	Overfishing in directed fisheries as well as bycatch in mixed fisheries where juvenile cod in particular may be caught and then discarded.
Common skate	Status in the North Sea has changed from a species that was relatively common and commercially important, to being quite rare.	Directed and bycatch fishing mortality. Vulnerable life history makes the threat to population status posed by even only bycatch mortality potentially serious.
Spotted ray	Not particularly rare in SEA 5 area but has declined significantly in other parts of the OSPAR area.	Taken as bycatch in demersal fisheries and it is landed for consumption along with a number of other rays.
Basking shark	The decline in many of the basking shark fisheries, including the NE Atlantic fishery is believed to indicate a decline in the population. Occasionally recorded from SEA 5 area.	Very low fecundity and late age at maturity make them sensitive to additional mortality.
Common sturgeon	Significant decline throughout the OSPAR area. Very rarely recorded from SEA 5 area.	Obstruction of migration routes, pollution of lower river reaches, targeted commercial fisheries, and damage to spawning grounds.
Allis shad	Sporadic distribution around UK coasts, where it is considered to have declined in abundance since the mid-19th century.	Obstruction of migration routes, pollution of lower river reaches, targeted commercial fisheries, and damage to spawning grounds.
Sea lamprey	Declined in many parts of Europe and particularly in the last 30 years. Important numbers in the SEA 5 area (e.g. River Spey).	Poor water quality, obstructions in rivers, and degradation of spawning grounds.
Salmon	Status assessment of salmon populations concluded that 43% categorised as healthy. The remainder are vulnerable, endangered, critical or extinct. Important numbers in the SEA 5 area.	Degradation of freshwater habitat by human activity. Commercial fishing in the marine environment. Salmon farm escapees.

Source: OSPAR Commission (2004).

At a European level, a number of fish species, including the sturgeon, are listed on Annex IV of the Habitats Directive (92/43/EEC). Under this Annex, the deliberate capture, killing or disturbance of such species is banned, as is their keeping, sale or exchange. Salmon are listed under Annex II of the Directive as a species of community interest whose conservation requires the designation of Special Areas of Conservation. A number of rivers within the SEA 5 area including the Spey, Dee, South Esk, Tay and Tweed have been designated as cSACs for their salmon populations.

As mentioned above, the River Spey supports important numbers of sea lamprey which are listed as a primary reason for site selection of the River Spey cSAC.

Several fish species are also protected in UK waters under Schedule 5 of *The Wildlife and Countryside Act, 1981* including the sturgeon, allis shad, twaite shad and basking shark. The basking shark has also recently been given protection by the Convention on International Trade in Endangered Species (CITES).

Commercial shellfish species

Commercially exploited crustacean species within the SEA 5 area include *Nephrops* (Norway lobster), pink shrimp, European lobster, edible crab, velvet crab and shore crab. Molluscan species include king scallop, cockles, mussels, whelk and periwinkles.

Nephrops is by far the most important shellfish species exploited in Scottish waters and occurs over a broad-depth range in Scottish waters, from 10-200m. The species is found on a range of muddy sand sediments, varying from fine mud to muddy sand, in which the lobsters construct and inhabit burrows extending down to about 300mm below the sediment surface. The burrows offer some protection from predation, including the capture by mobile fishing gear. Major predators on *Nephrops* are various species of fish, principally cod, lesser spotted dogfish and thornback rays (Chapman 1980). Within or adjacent to the SEA 5 area, important stocks are found to the west of Orkney (Noup), within the Moray Firth, Firth of Forth and offshore on the Fladen Ground. Within the SEA 5 area, pink shrimps are commercially exploited only on the Fladen ground where their distribution overlaps with *Nephrops* (Chapman 2004).

Lobsters, shore crabs and velvet crabs are mostly found in shallow reef, rock and boulder habitat. Edible crabs share a similar habitat, but may also occur on less coarse sediments, such as gravel, sand and even mud down to 100m. The king scallop is the most important exploited mollusc within the SEA 5 area and is found mainly on sand, muddy sand and shell gravel substrates at all depths from the sub-littoral down to over 100m. Cockles and mussels are found inter-tidally on sandy beaches or rocky shores respectively. Whelks are widely distributed around the Scottish coast on all types of substrate, from rocky shores to soft sediments, ranging in depth from shallow subtidal to 100m. Winkles are also common around the Scottish coast and are found on all rocky, boulder and pebble shores, except in the most exposed areas (Chapman 2004).

6.6 Marine reptiles

6.6.1 Distribution and abundance

The TURTLE (Pierpoint & Penrose 1999) database holds records of sightings at sea, bycatch and strandings for marine turtles drawn from numerous published and unpublished sources. Bycatch data has been analysed by Pierpoint (2000) in relation to Biodiversity Action Plan and Habitats Directive obligations of the UK.

Five species of marine turtle have been recorded in UK waters (Pierpoint 2000). Only one species however, the leatherback turtle *(Dermochelys coriacea)* is reported annually and is considered a regular and normal member of UK marine fauna (Godley *et al.* 1998). Loggerhead turtles *(Caretta caretta)* and Kemp's ridley turtles *(Lepidochelys kempii)* occur less frequently, with most specimens thought to have been carried north from their usual habitats by adverse currents (Carr 1987, Mallinson 1991). Records of two other vagrant species, the hawksbill turtle *(Eretmochelys imbricate)* and the green turtle *(Chelonia mydas)* are very rare (O'Riordan *et al.* 1984, Branson 1997).

Leatherback turtles have been sighted all around the UK & Irish coasts. Records are concentrated to the west and south of Ireland, southwest England and the west coast of Scotland, Orkney and Shetland. There are far fewer recorded sightings from the North Sea coasts of England and east Scotland. Of 257 leatherback turtle sightings recorded around the UK, 24 were made to the north and northeast of Scotland with 10 sightings off southeast Scotland and east England (Piepoint 2000). A total of 13 dead leatherbacks were recorded from the northern North Sea and to the west of Orkney and Shetland, with 12 dead animals from the central North Sea area (Pierpoint 2000).

The peak month for sightings in all regions, except for the central and southern North Sea, is August. However, data showing the months in which 75% of sightings are made suggest that in general, leatherbacks occur later in Scottish waters (August–October) than further south (July–September). Sightings in the central and southern North Sea and the eastern English Channel occur later still, with 75% of sightings made in October and November. The data imply that leatherbacks move into British and Irish waters from the south and west, and pass northwards up western coasts and the Irish Sea. Some leatherbacks enter the central North Sea in autumn. A paucity of sightings in the southern North Sea earlier in the year, suggest that it is unlikely that many turtles enter the North Sea via the English Channel.

Loggerhead turtles have also been recorded in UK and Irish waters, albeit less frequently than leatherbacks. Loggerheads are most frequently reported as strandings (81%) and have been predominantly found on the west coast of Ireland, southwest England and the west coast of Scotland. Unlike leatherbacks, the presence of loggerheads is thought to be the result of animals having been carried by currents from their normal habitat.

The TURTLE database also contains a record of a green turtle found dead on the shore of Loch of Stenness, Orkney in 1980. Like the loggerhead, the presence of green turtles is thought to be accidental and they are not considered regular visitors to the area (Pierpoint & Penrose 1999).

6.6.2 Conservation issues

The leatherback turtle is included on the OSPAR Initial List of Threatened and/or Declining Species and Habitats. Information justifying its inclusion indicates a significant decline in turtle numbers over recent years (OSPAR Commission 2004). The global population of adult female leatherback turtles was estimated to be around 115,000 in the early 1980s. A more recent estimate gives a figure of around 34,500 (with confidence limits giving lowest and highest estimates between 26,200– 42,900) of which the eastern Atlantic population of nesting females was estimated to be around 4,638 (±763) (Spotila *et al.* 1996, cited by OSPAR Commission 2004). These figures point to a possible decline of around 60% in the intervening period. There are no estimates of the likely population size in the OSPAR area. The main threats to this species in the OSPAR area come from fisheries activity and marine litter (OSPAR Commission 2004).

In UK waters marine turtles face a range of threats, including incidental capture in fishing equipment; ingestion of plastics and marine debris; boat collision and oil spills (Pierpoint 2000).

Incidental capture in fishing gear poses a widespread threat to marine turtles. Most records of leatherback bycatch around the UK implicate entanglement in ropes (n=50 records), particularly those used to tether marker buoys in pot fisheries for lobster, crab and whelk. Since 1980, these fisheries have accounted for 62% of reported bycatch (for which gear type is known). Most bycatch in pot fisheries occurs in the west and southwest, north and northwest, from July to September; reflecting the areas and months in which most live sightings of leatherbacks are made. There is little bycatch reported from the eastern coasts of Britain which leatherbacks visit less frequently (Pierpoint 2000).

The Sea Mammal Research Unit (SMRU) has employed observers in several UK fisheries. For data collected since 1996, no turtle bycatch has been recorded in bottom-set gill nets targeting cod and monkfish in the North Sea and off western Scotland, or in salmon drift nets off the central North Sea coast. No turtles have been observed during a recently initiated monitoring programme for pelagic trawls in Scottish waters (S Northridge, SMRU, pers. comm., cited by Pierpoint 2000).

The Scottish Executive's Marine Laboratory, Aberdeen, has operated a discard monitoring programme for approximately 25 years, and aims to observe 60-70 trips on demersal trawlers each year in the North Sea and west of Scotland. Non-fish bycatch is not recorded systematically, but there have been no reports of turtle bycatch in 2,045 fishing trips since 1975 (P Kunzlik, Marine Laboratory, pers. comm., cited by Pierpoint 2000).

All five species of turtle are listed in Appendix I of the Convention on the International Trade in Endangered Species of Flora and Fauna (CITES) 1975, Appendix II of the Bern Convention 1979, Appendices I and II of the Bonn Convention 1979 and Annex IV of the EC Habitats Directive. The loggerhead is also listed as a priority species in Annex II of the EC Habitats Directive. All five species are protected under Schedule 5 of the *Wildlife and Countryside Act 1981* and the *Conservation (Natural Habitats &c.) Regulations 1994*. A grouped species action plan for marine turtles has been published as part of the UK Biodiversity Action Plan (UKBAP website – http://www.ukbap.org.uk).

A UK Turtle Code website (http://tofino.ex.ac.uk/euroturtle/turtlecode/default.htm) has been set up through collaboration with the national conservation agencies, research groups and NGOs, including the Marine Conservation Society and Wildlife Trusts. The Code provides information on marine turtle conservation and a recording system for sightings.

6.7 Birds

A coastal margin overview and a brief summary of important areas for seabirds and waterbirds as well as the sensitivities and vulnerabilities for these groups of birds are provided here. A more detailed description is provided in Appendix 5.

Information on seabird populations and numbers at colonies within the SEA 5 area was obtained from the recently published results of the Seabird 2000 Census (1998-2002) (Mitchell *et al* 2004). Various publications from the Seabird at Sea Team (SAST) and the European Seabirds at Sea database (ESAS) provided information concerning seabird distribution throughout the year (Tasker *et al.* 1986, Stone *et al.* 1995).

The annual Wetland Bird Survey, 2000-01: wildfowl and wader counts (Pollitt *et al.* 2003), provided information on the population size, distribution and the most important sites for non-breeding waterbirds in the UK. A DTI commissioned report (Barton & Pollock 2004) reviewed the distribution and abundance of thirteen species of diver, grebe and seaduck in the SEA 5 area while the Joint Nature Conservation Committee also published the results of aerial winter surveys (2000/01 and 2001/02) of winter aggregations of seaduck, divers and grebes (Dean *et al.* 2003).

6.7.1 The Scottish east coast and coastal margin overview

Seabirds

Seabirds are a group of birds that depend mainly on the sea, beyond the tide-line for their food. While this group includes species such as black-headed and common gulls, which often breed and feed inland, the group does not include other species that spend only part of the year at sea such as divers, seaducks and phalaropes (Lloyd *et al.* 1991). These latter groups will be discussed under waterbirds.

Much of the SEA 5 coastline is colonised by seabirds, particularly in the north. The region is of importance to several species of breeding seabird, all of which are present in numbers equal to or exceeding 1% of their European population, while other species exceed nationally important levels (Table 6.3).

Table 6.3 - Seabird species which occur in important numbers in the SEA 5 area

Equal to or exceeding 1% of European population	
Gannet (*Sula bassana*)	Common tern (*Sterna hirundo*)
Fulmar (*Fulmarus glacialis*)	Roseate tern (*Sterna dougalli*)
Cormorant (*Phalacrocorax carbo*)	Guillemot (*Uria aalge*)
Shag (*Phalacrocorax aristotelis*)	Black Guillemot (*Cepphus grille*)
Lesser black-backed gull (*Larus fuscus*)	Razorbill (*Alca torda*)
Greater black-backed gull (*Larus marinus*)	Puffin (*Fratercula arctica*)
Herring gull (*Larus argentatus*)	Arctic Skua (*Stercorarius parasiticus*)
Kittiwake (*Rissa tridactyla*)	Great Skua (*Stercorarius skua*)
National importance	
Black-headed gull (*Larus ridibundus*)	Sandwich tern (*Sterna sandvicensis*)
Arctic tern (*Sterna paradisaea*)	Little tern (*Sterna albifrons*)

Source: Tasker 1996, Tasker 1997a, Tasker 1997b, Tasker 1997c

Many colonies along the Scottish east coast have been afforded protection status as Special Protection Areas (SPAs) for the species breeding there and the numbers they support. Some of these areas also support seabird assemblages of international importance during the breeding season, with some areas regularly supporting between 95,000 (Buchan Ness to Collieston Cliffs) and 300,000 (East Caithness Cliffs) individual seabirds (JNCC website http://www.jncc.gov.uk/).

Feeding areas utilised by seabirds are as important as the colonies themselves (Tasker 1997). Seabird prey varies from zooplankton to small fish and waste from fishing fleets and habitats that concentrate any of these foods are preferred. Important feeding areas in SEA 5 include the waters of the Greater Moray Firth (Smith Bank), the nearshore waters off eastern Aberdeenshire and the Firth of Forth (Isle of May – two important feeding grounds, one near Bell Rock and another at Wee Bankie (Tasker *et al.* 1986)).

Waterbirds

Breeding birds

Waterbirds are a group that include divers and grebes, bitterns and herons, rails, crakes and coots, wildfowl (JNCC refer to this group as waterfowl) and waders. The two latter groups are further subdivided: wildfowl is a large group which includes ducks, shelducks, geese and swans, while waders include oystercatcher, whimbrel, snipe, plovers sandpipers, godwits, curlews, snipe and phalarope (Hulme 2002). Seaducks will also be discussed in this section.

The collective coastal wetlands of the Moray Basin are of international importance for breeding waterfowl and waders (Craddock & Stroud 1996). The Cromarty Firth, which has one of the largest areas of intertidal flats within the Moray Basin, the inner Moray Firth and Dornoch Firth support breeding oystercatcher (*Haematopus ostralegus*), and ringed plover (*Charadrius hiaticula*) (Craddock & Stroud 1996). Curlew (*Numenius arquata*), although not a predominantly coastal breeding wader, is found on saltmarshes in these firths at densities which are amongst the highest in Britain (Craddock & Stroud 1996), while small numbers of dunlin (*Calidris alpina*) also breed on the Dornoch and Cromarty Firths.

The Ythan Estuary (Sands of Forvie) and Don Mouth to Blackdog are important for breeding eider (*Somateria mollissima*), the former of which supports one of the largest breeding populations of eider in Britain (Scottish Natural Heritage, Forvie National Nature Reserve information booklet).

Further south along the Scottish coast is Montrose Basin - a tidal basin which contains a varied mixture of mudflats, fresh, sea and brackish waters, saltmarsh, reedbed, unimproved grassland and arable land. Species characteristic of shingle, sand dunes and dry coastal grassland such as ringed plover, oystercatcher and shelduck (*Tadorna tadorna*) utilise the sand dunes and bays along this coastline including those at Montrose Basin and the Forth Estuary.

The Forth Estuary is of national importance for breeding shelduck and the muddy shores of the eastern Firths of Moray (including Cromarty, Dornoch and Beauly Firth and Findhorn Bay), Forth and Tay support the main concentrations of this species in Scotland (Gibbons *et al.* 1994).

Wintering and migratory birds

The SEA 5 region lies on a major migratory flyway and many birds winter in the region and others pass through and stage here during onward migration between wintering and breeding grounds.

Shetland and Orkney, while relatively less important for migratory species than other key areas within SEA 5, still support internationally important populations of eider, great northern diver (*Gavia immer*) and Slavonian grebe (*Podiceps auritus*), as well as nationally important populations of other waterbird species.

During winter, the Moray Firth supports internationally important flocks of red-breasted merganser (*Mergus serrator*) amounting to approximately 15% of the national total for this species as well as a further eight species which reach nationally important levels (red-throated diver (*Gavia stellata*), black-throated diver (*Gavia arctica*), scaup (*Aythya marila*), long-tailed duck (*Clangula hyemalis*), common scoter (*Melanitta nigra*), velvet scoter (*Melanitta fusca*), goldeneye (*Bucephala clangula*) and goosander (*Mergus merganser*)) (Tasker 1996, Barton & Pollock 2004). The Dornoch Firth and Loch Fleet, as well as the

Cromarty Firth and the Moray and Nairn coast, support internationally important levels of bar-tailed godwit (*Limosa lapponica*) and greylag goose (*Anser anser*) during winter, with each of the three areas representing on average 1% of these species total biogeographical populations (2.7% of the greylag goose biogeographical population for the Moray and Nairn coast) (JNCC website http://www.jncc.gov.uk/).

Further south along the Scottish coast between Montrose and Eyemouth, the four coastal wetland sites (Montrose Basin, Tay, Eden and Forth Estuaries) support nationally important numbers of one or more over-wintering waterfowl species, some of which occur in internationally important numbers (May & Law 1997).

The Tay Estuary supports the largest flock of wintering eider in the UK as well as notable numbers of other autumn passage species. The Eden Estuary supports a notable number of passage bar-tailed godwits and the most northerly wintering flock of black-tailed godwit (*Limosa limosa*) in Britain.

One of the most important estuarine areas for wintering birds in Scotland is the Firth of Forth. At least three species of waterbird occur at internationally important numbers in the Firth with at least a further twelve at nationally important numbers. Scarce and rare migrants are often recorded at Aberlady Bay to the east of Edinburgh, and in recent years these have included a female king eider (*Somateria spectabilis*). The Bay also supports internationally important numbers of roosting pink-footed geese (*Anser brachyrhynchus*).

Other bird species

Breeding peregrines (*Falco peregrine*), while neither a seabird or waterbird, occur along most of the northeast coast of Scotland in numbers which are significant in both national and Scottish contexts. The peregrines prey on seabirds and rock doves (*Columba livia*). The Dornoch, Cromarty and inner Moray Firth are important feeding areas for locally breeding osprey (*Pandion haliaetus*) and are sites of European importance for this species, as is the Moray and Nairn coast (JNCC website). Further south along the coast, the Firth of Tay and Eden Estuary are sites of European importance for breeding marsh harrier (*Circus aeruginosus*).

6.7.2 Importance of individual coastal areas

Within the SEA 5 region there are eighteen areas which support Seabird Assemblages of International Importance as defined by the qualifying criteria under Article 4.2 of the Council Directive on the Conservation of Wild Birds (79/409/EEC) by regularly supporting at least 20,000 seabirds (Table 6.4).

Table 6.4 - Areas in and around SEA 5 which support breeding seabird assemblages of international importance

Area	Approximate numbers during breeding season and species
Hermaness, Saxa Vord & Valla Field	Regularly supports 152,000 individual seabirds including: guillemot, kittiwake, shag, fulmar, puffin, great skua, gannet
Fetlar	Regularly supports 22,000 individual seabirds including: arctic skua, fulmar, great skua, arctic tern
Noss	Regularly supports 100,000 individual seabirds including: puffin, kittiwake, fulmar, guillemot, great skua, gannet
Sumburgh Head	Regularly supports 35,000 individual seabirds including: guillemot, kittiwake, fulmar, arctic tern

Area	Approximate numbers during breeding season and species
Fair Isle	Regularly supports 180,000 individual seabirds including: puffin, razorbill, kittiwake, great skua, arctic skua, shag, gannet, fulmar, guillemot, arctic tern
Foula	Regularly supports 250,000 individual seabirds including: leach, storm-petrel, razorbill, kittiwake, arctic skua, fulmar, puffin, guillemot, great skua, shag, arctic tern
Marwick Head	Regularly supports 75,000 individual seabirds including: kittiwake, guillemot
Rousay	Regularly supports 30,000 individual seabirds including: guillemot, kittiwake, arctic skua, fulmar, arctic tern
West Westray	Regularly supports 120,000 individual seabirds including: razorbill, kittiwake, arctic skua, fulmar, guillemot, arctic tern
Calf of Eday	Regularly supports 30,000 individual seabirds including: guillemot, kittiwake, great black-backed gull, cormorant, fulmar
Copinsay	Regularly supports 70,000 individual seabirds including: guillemot, kittiwake, great black-backed gull, fulmar
Hoy	Regularly supports 120,000 individual seabirds including: puffin, guillemot, kittiwake, great black-backed gull, arctic skua, fulmar, great skua
East Caithness Cliffs	Regularly supports 300,000 individual seabirds including: puffin, great black-backed gull, cormorant, fulmar, razorbill, guillemot, kittiwake, herring gull, shag
Troup, Pennan & Lion's Heads	Regularly supports 150,000 individual seabirds including: razorbill, kittiwake, herring gull, fulmar, guillemot
Buchan Ness to Collieston Coast	Regularly supports 95,000 individual seabirds including: guillemot kittiwake, herring gull, shag, fulmar
Fowlsheugh	Regularly supports 170,000 individual seabirds including: razorbill, herring gull, fulmar, guillemot, kittiwake
Firth of Forth Islands	Regularly supports 90,000 individual seabirds including: razorbill, guillemot, kittiwake, herring gull, cormorant, fulmar, puffin, lesser black-backed gull, shag, gannet, arctic tern, common tern, roseate tern, sandwich tern
St. Abb's Head to Fast Castle	Regularly supports 79,560 individual seabirds including: razorbill, guillemot, kittiwake, herring gull, shag

Source: JNCC website, Mitchell et al 2004.

There are nine wetlands of international importance for over-wintering species, as defined by the qualifying criteria under Article 4.2 of the Council Directive on the Conservation of Wild Birds (79/409/EEC), as regularly supporting at least 20,000 waterfowl (Table 6.5).

Table 6.5 - Coastal wetlands of international importance in the SEA 5 area

Wetland of international importance	Approximate over-wintering numbers and species
Dornoch Firth & Loch Fleet	Regularly supports 34,000 individual waterfowl including: curlew, dunlin, oystercatcher, teal, wigeon, greylag goose, bar-tailed godwit.
Cromarty Firth	Regularly supports 34,000 individual waterfowl including: redshank, curlew, dunlin, knot, oystercatcher, red-breasted merganser, scaup, pintail, wigeon, greylag goose, bar-tailed godwit, whooper swan

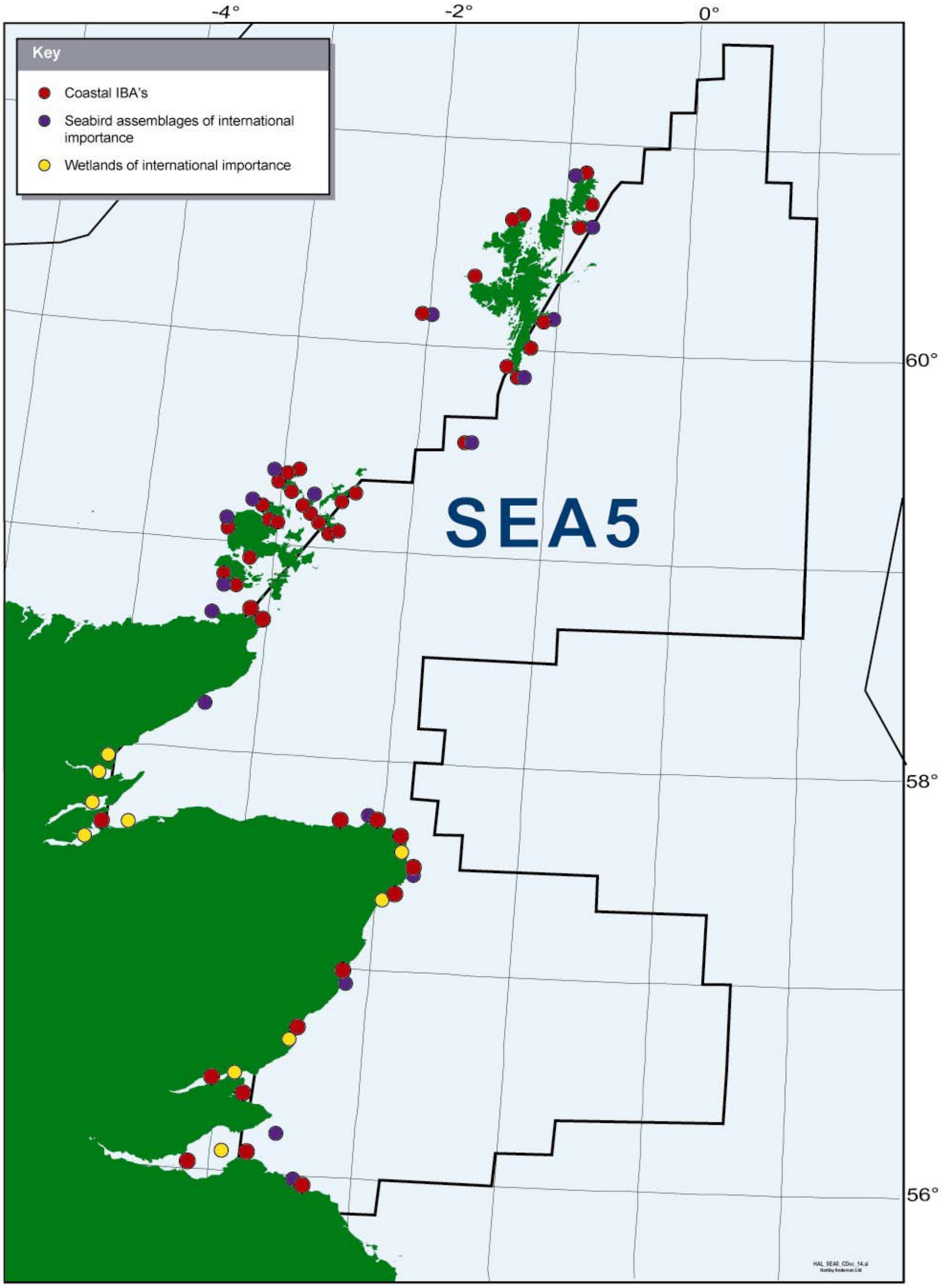
Wetland of international importance	Approximate over-wintering numbers and species
Inner Moray Firth	Regularly supports 33,000 individual waterfowl including: scaup, curlew, oystercatcher, goosander, goldeneye, teal, wigeon, redshank, red-breasted merganser, greylag goose, bar-tailed godwit
Moray & Nairn Coast	Regularly supports 20,250 individual waterfowl including: pink-footed goose, dunlin, oystercatcher, red-breasted merganser, velvet scoter, common scoter, long-tailed duck, wigeon, redshank, greylag goose, bar-tailed godwit
Loch of Strathbeg	Regularly supports 49,000 individual waterfowl including: teal, greylag goose, pink-footed goose, barnacle goose, whooper swan
Ythan Estuary, Sands of Forvie & Meikle Loch	Regularly supports 51,000 individual waterfowl including: redshank, lapwing, eider, pink-footed goose
Montrose Basin	Regularly supports 54,000 individual waterfowl including: dunlin, oystercatcher, eider wigeon, shelduck, redshank, knot, greylag goose, pink-footed goose
Firth of Tay & Eden Estuary	Regularly supports 34,000 individual waterfowl including: velvet scoter, pink-footed goose, greylag goose, redshank, shelduck, eider, bar-tailed godwit, common scoter, black-tailed godwit, goldeneye, red-breasted merganser, goosander, oystercatcher, grey plover, sanderling, dunlin, long-tailed duck
Firth of Forth	Regularly supports 86,000 individual waterfowl including: scaup, slavonian grebe, golden plover, bar-tailed godwit, pink-footed goose, shelduck, knot, redshank, turnstone, great crested grebe, red-throated diver, mallard, curlew, eider, long-tailed duck, common scoter, velvet scoter, goldeneye, red-breasted merganser, oystercatcher, ringed plover, grey plover, lapwing, dunlin, wigeon

As well as these wetlands of international importance, other areas within SEA 5, such as Shetland and Orkney, the Aberdeenshire coast, Aberlady Bay and the Tweed Estuary support populations of international and national importance of several species of waterbird including great northern diver slavonian grebe, eider, pink-footed goose and mute swan (*Cygnus olor*).

There are forty-five coastal Important Bird Areas (IBAs) within SEA 5. Eleven of these coastal IBAs are found on Shetland, twenty are found on Orkney with the remaining fourteen found along Scotland's east coast from the Caithness Cliffs in the north to St. Abb's Head to Fast Castle in the south.

Seabird assemblages of international importance, wetlands and IBAs are shown in Figure 6.11.

Figure 6.11 – Important sites for seabirds and waterbirds within SEA 5



6.7.3 Sensitivities and vulnerabilities

Seabirds

The breeding population size of seabirds is most affected by factors such as senescence, disease, reduced food availability, predation, hunting/culling and stochastic events such as oil spills and severe storms that influence adult survival (Mitchell *et al.* 2004).

There is very little or no direct competition between commercial fisheries and seabirds over fish. Fishing trawlers are in fact an important source of food for many species of seabird which scavenge at trawlers, but the decline in commercial fishing and changes in fishing practice have seen this food source for seabirds decline in recent years. The collapse in stocks and subsequent poor recruitment of sandeels over the last 20 years has also led to a reduction in breeding success for seabird species which rely on sandeels, particularly kittiwakes. The extent to which fishing has affected the availability of small prey species such as sandeels and their subsequent effect on the seabird populations, remains poorly understood. Nonetheless, since 2000 a ban has been imposed on sandeel fishing in the eastern North Sea, with re-opening dependent on kittiwake success.

The bycatch of seabirds in fishing gear is of great concern, particularly the numbers being caught in the longline fisheries, which is a growing industry off Norway and Britain. A joint study was carried out by the UK's Royal Society for the Protection of Birds (RSPB), the Norwegian Ornithological Society, Birdlife International and the JNCC to give impetus to the development and implementation of FAO National Plans of Action (NPOAs) for Reducing Incidental Catch of Seabirds in Longline Fisheries. The report made recommendations for the content of the NPOA that Norway is currently undertaking (Dunn & Steel 2001).

Potential hazards to birds from offshore windfarms include mortality following collision with turbines, loss of habitat and the turbines creating a barrier between feeding and/or roosting areas or migration routes. Current available evidence suggests appropriately positioned windfarms do not pose a significant hazard for birds (RSPB 2004). Nonetheless, data on the effects large offshore windarms have on birds is relatively scarce and further work is needed in order that potential impacts can be fully understood and addressed.

A potential major cause of seabird mortality is pollution of the sea by oil, predominantly from merchant shipping. While oil spills from tankers on the UKCS have resulted in the death of locally important numbers of birds, population recovery has generally been rapid. Little or no direct mortality of seabirds has been attributed to exploration and production activities on the UKCS including incidences of incineration by flaring. While there have been reports of large numbers of migratory birds being killed by offshore flares, incidents of this kind are considered rare (Jones 1980, Wallis 1981, Marquenie & van de Laar 2000). The effect of light offshore and the "holding effect", where birds circle the platform during migration is also of potential concern. However, like the incidents of birds and flaring the possible detrimental effects of lights and "holding" on birds have not been quantified (Jones 1980, Wallis 1991, Wiese *et al.* 2001).

The vulnerability of seabird species to oil pollution at sea is dependant on a number of factors – the amount of time spent on the water; total biogeographical population; reliance on the marine environment and potential rate of population recovery – and varies considerably throughout the year. Of those species commonly present offshore in the SEA 5 area, the most vulnerable to oil pollution are gannet and auk species as these spend a great deal of time on the sea surface. In contrast, the least vulnerable, due to their aerial habits, large populations and widespread distribution, are the fulmar and gulls.

Using the vulnerability scores for individual UKCS licence blocks calculated by JNCC, overall vulnerability to surface pollutants is very high in Quadrants 11, 12, 17, 18, 25 and 26 (those north of the Scottish mainland and along the entire Scottish east coast). Much of the seabird vulnerability is seasonal and vulnerability is very high for between 9 and 11 months in some blocks of Quadrants 6, 7, 11, 12, 17, 18, 19, 25, 26, 33 and 34. Within the SEA 5 area, vulnerability data are relatively comprehensive. However, data gaps are present for two or more consecutive months in blocks within Quadrants 210, 20, 26, 27 and 28.

Waterbirds

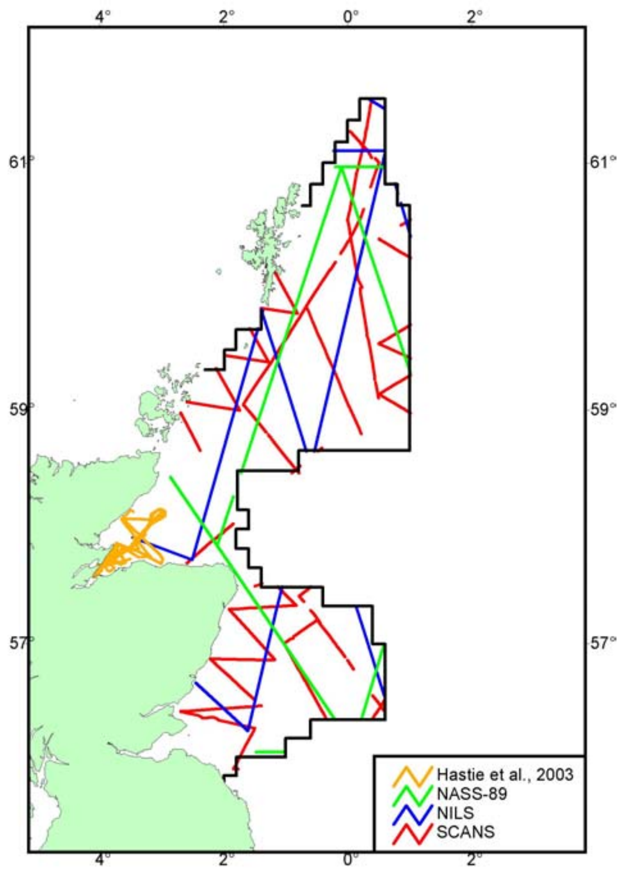
The major breeding areas for most wildfowl and wader species are outwith the UK, therefore population dynamics are largely controlled by factors outwith the scope of SEA 5 – including breeding success and migration loss. Populations of some wintering waders and wildfowl have shown steady increase over the last thirty years, however since a peak in 1996/97 numerous species have shown short term declines. The exact reasons for these species' declines remain unknown.

6.8 Marine mammals

6.8.1 Introduction

The Sea Mammal Research Unit (SMRU), University of St. Andrews, was commissioned to review the distribution and ecological importance of marine mammals of relevance to the SEA 5 area. The review also described the sensitivity of marine mammals to disturbance from potential activities arising from SEA 5 licensing. Other issues including fisheries bycatch and conservation frameworks were also discussed (Hammond *et al.* 2004).

Figure 6.12 – Survey tracks in the SEA 5 area



Quantitative information for the SEA 5 area comes from a variety of sightings surveys (Figure 6.12) including the Small Cetacean Abundance in the North Sea (SCANS) survey in July 1994, the North Atlantic Sightings Surveys (NASS) in July 1989, and the Norwegian Independent Line transect Surveys (NILS) in July 1995 and 1998. Published cetacean observations made during seismic surveys in 1996 to 1999 have also been utilised as has analysis of acoustic recordings from the US Navy's SOSUS hydrophone array and low frequency sonobuoys.

Cetacean sightings data from SCANS 1994 have been combined with those from the European Seabirds at Sea database (maintained by JNCC) and those of the Seawatch Foundation into a Joint Cetacean Database, from which has been generated an atlas of cetacean distribution around the British Isles using sightings per standardised unit of time (Reid *et al.* 2003). Extensive studies of bottlenose dolphins by the University of Aberdeen and SMRU provide detailed information about this species.

Information on the distribution and abundance of grey and harbour seals comes from SMRU annual aerial surveys of breeding colonies and satellite-tracking studies.

6.8.2 Distribution and abundance

Cetaceans

The six most frequently recorded cetacean species in the SEA 5 area are the harbour porpoise, white-beaked dolphin, Atlantic white-sided dolphin, killer whale, bottlenose dolphin and minke whale.

Harbour porpoise

The SEA 5 area is an important area for harbour porpoises, at least in summer (Hammond *et al*. 2004). SCANS 1994 estimated the summer abundance of harbour porpoises around Shetland and Orkney at around 61,000, estimating a density in the waters immediately adjacent to the islands of 0.784 porpoises/km^2, one of the highest observed in the whole survey area. The SCANS estimate for the whole North Sea was 268,500 (approximate 95% confidence interval 210,000–340,000). Bjørge & Øien (1995) estimated the number of porpoises in the North Sea, north of 56ºN at 82,600.

Figure 6.13 – Harbour porpoise sighting rates

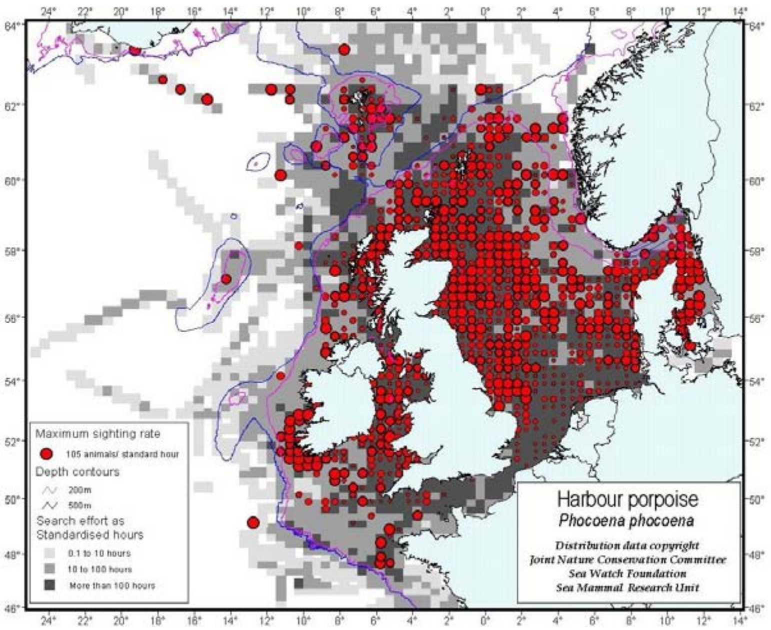


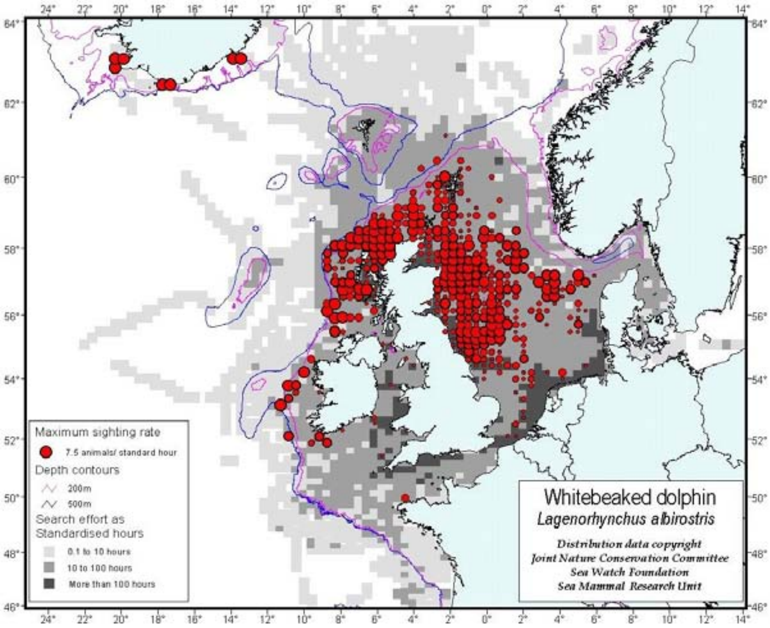
Figure 6.13 (Reid *et al.* 2003) shows sightings rates of harbour porpoises (numbers sighted per hour), corrected for probability of detection under different sea states around Britain. These data represent several thousand sightings made on hundreds of different platforms over a 20 year period.

SAST data show the highest rate of porpoise sightings in the northern North Sea including the SEA 5 area in April to June (the calving season), and July to September.

Harbour porpoise have been included on the OSPAR Initial List of Threatened and/or Declining Species and Habitats. Declines in abundance have been reported since the 1940s as well as in more recent studies in various parts of its range. The harbour porpoise has become scarce in the southernmost North Sea, English Channel and Bay of Biscay, and has declined in the Skagerrak & Kattegat (Evans 2000, Berggren & Arrhenius 1995, cited by OSPAR Commission 2004). The main threat to this species in the OSPAR area is incidental capture and drowning in fishing nets. Other threats include marine pollution, for example from toxic substances that bioaccumulate and are known to reduce reproductive fitness, as well as acoustic disturbance (from shipping traffic, oil exploration, military activities etc.) which may reduce available habitat. A reduction in prey species may also be a threat as the diet of harbour porpoises includes herring, mackerel and sandeel which are also targeted by commercial fisheries in the North Sea (OSPAR Commission 2004).

White-beaked dolphin

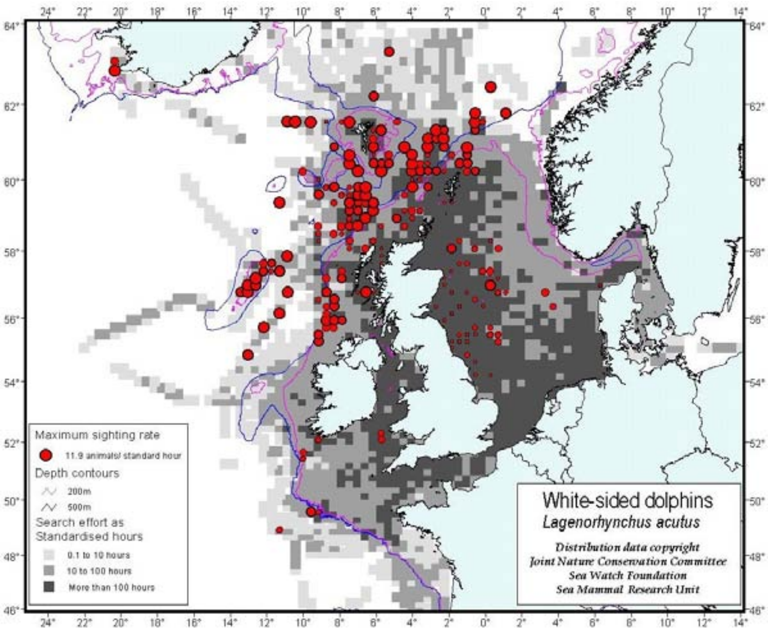
Figure 6.14 – White-beaked dolphin sighting rates



White-beaked dolphins are mainly distributed over the continental shelf and in the North Sea are much more numerous within about 200nm of the Scottish (and north-eastern English) coasts than anywhere else (Northridge *et al.* 1995). White-beaked dolphins are present year round in the North Sea and are commonly sighted in the SEA 5 area (Figure 6.14, Reid *et al.* 2003). The summer abundance of white-beaked dolphins in the North Sea was estimated from the SCANS survey as 7,856 (approx. 95% confidence interval 4,000–13,300). This estimate includes shelf waters around Shetland and Orkney in which there were an estimated 1,157 animals.

Atlantic white-sided dolphin

Figure 6.15 – Atlantic white-sided dolphin sighting rates



Atlantic white-sided dolphins share most of their range with the white-beaked dolphin, but in the eastern North Atlantic they adopt a mainly offshore distribution.

At sea, the two species can be difficult to distinguish and there is sometimes a tendency for them to be recorded simply as *Lagenorhynchus spp*. Around Britain, Atlantic white-sided dolphins have been recorded mainly in the north and there are very few observations actually in the SEA 5 area, with Atlantic white-sided dolphins being generally distributed further northwest in deeper waters (Figure 6.15, Reid *et al.* 2003). In the North Sea, their presence is seasonal, with the majority of sightings occurring between May and September (Northridge *et al.* 1997).

The SCANS survey estimated 11,760 *Lagenorhynchus* dolphins (white-beaked plus white-sided) in the North Sea (approx. 95% confidence interval 5,900 - 18,800). This estimate includes shelf waters around Shetland and Orkney in which there were an estimated 1,569 animals. Atlantic white-sided dolphins are occasionally involved in mass stranding events. 1,097 were taken in the Faroese drive fishery in the period 1995 to 1999.

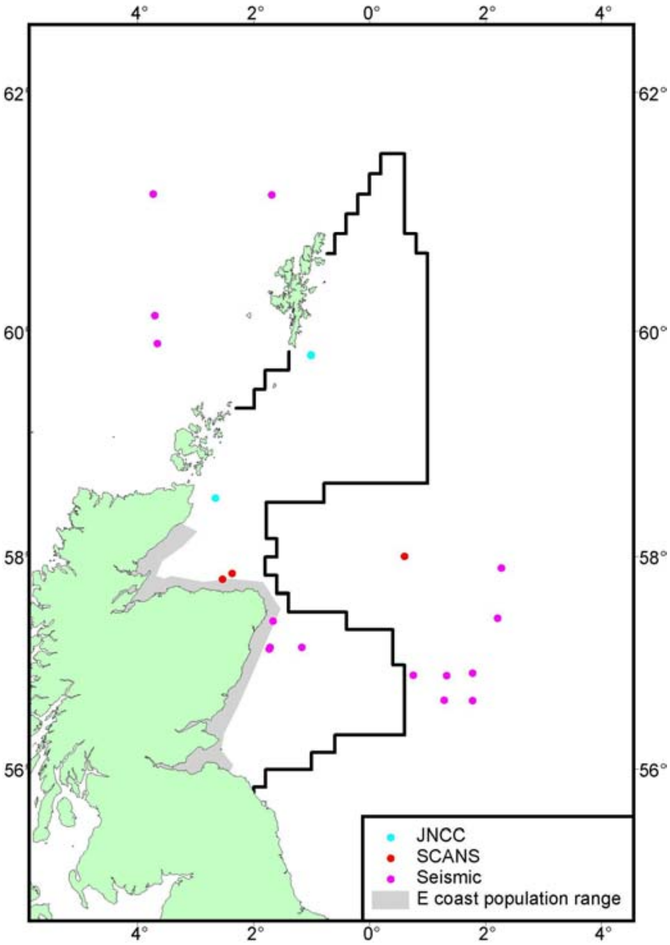
Killer whale

In the eastern North Atlantic, killer whales occur in most areas from coastal fjords to oceanic waters and movements appear to be driven by prey abundance. Killer whales have been observed throughout the northern North Sea including around commercial trawlers during discarding of fish. There have been sightings north of approximately 58ºN (Reid *et al.* 2003) in all months except October. There are relatively few records within the SEA 5 area itself, except around Shetland.

Bottlenose dolphin

The bottlenose dolphin is a cosmopolitan species occurring in warm and temperate waters throughout much of the world. It is not particularly common in the northeastern North Atlantic, although a resident population of bottlenose dolphins inhabits coastal waters of eastern Scotland from north of the Moray Firth to the Firth of Forth, and other resident populations are present in the Celtic Sea and west of Scotland.

Figure 6.16 – Bottlenose dolphin sightings

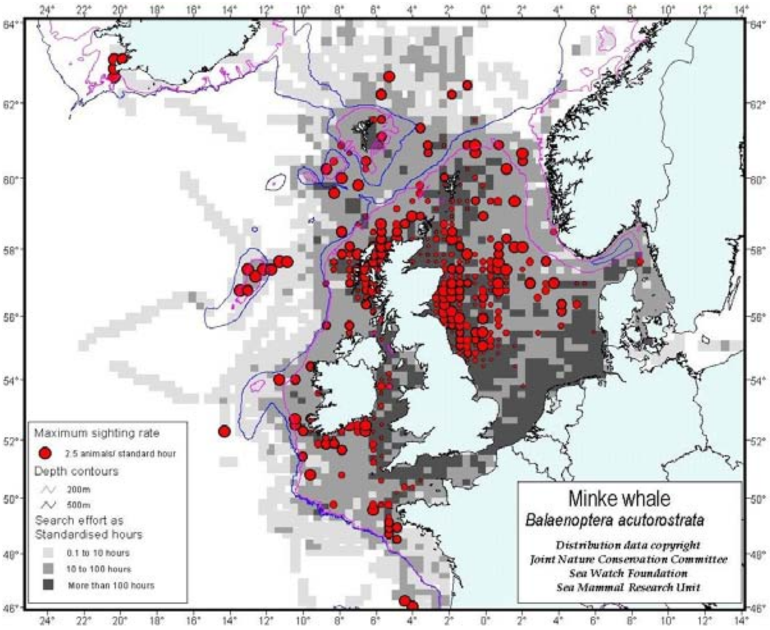


The few observations offshore in the North Sea may indicate that these animals are also distributed offshore at least for part of the year (Figure 6.16). In the 1980s, the core of the eastern Scottish population's range was in the Inner Moray Firth but since the mid-1990s, in particular, the population's range has expanded south to waters off Aberdeen, St. Andrews Bay and the Firth of Forth (Wilson *et al.* in press). Dolphins are seen year round off Aberdeen but the rate of sightings is highest in November-May. Peak sightings occur in June-August in St. Andrews Bay. Within the inner Moray Firth, there are three areas where sightings are concentrated: the Kessock Channel, Chanonry Narrows, and around the mouth of the Cromarty Firth.

A baseline estimate of abundance using mark-recapture analysis of photo-identification data collected during 1992 was calculated as 129 individuals (95% confidence interval: 110-174) (Wilson *et al.* 1999). Data collected up to 1997 was analysed to estimate rates of survival and reproduction, which were incorporated in a population viability analysis (PVA) to predict likely future population trends (Sanders-Reed *et al.* 1999). These models predicted that, if conditions remained the same, the Scottish east coast population was likely to decline at a rate of around 5% per annum. However, recently calculated annual estimates of abundance from 1990 to 2002 show no clear trend and the effect of the recently documented range expansion on the PVA results is currently being investigated.

Minke whale

Figure 6.17 – Minke whale sighting rates



Minke whales appear to move into the SEA 5 area at the beginning of May and are present throughout the summer until October (Figure 6.17, Reid *et al.* 2003).

SCANS estimates of the summer abundance of minke whales around Shetland and Orkney, and the whole North Sea were 2,920 (approximate 95% confidence interval **=** 630-5,210) and 7,200 (approximate 95% confidence interval = 4,700-11,000), respectively. Schweder *et al.* (1997) put the number of minke whales in the North Sea, north of 56°N at 5,430 (SE=1,870) for 1989 and 20,300 (SE=5,240) for 1995. These estimates represent approximately 8-18% of the estimated size of the northeast Atlantic stock of 67,000 whales in 1989 and 112,000 whales in 1995. The NILS 1998 survey provided North Sea estimates of 11,700 (SE=3,460) (Skaug *et al.* 2003). Clearly, the SEA 5 area is an important area for minke whale in summer (Hammond *et al*. 2004).

Other species

Long-finned pilot whales and Risso's dolphins are also regularly seen in waters around Shetland. There are also occasional at-sea records of at least a further five cetacean species (humpback whale, fin whale, sperm whale, striped dolphin and short-beaked common dolphin) in the SEA 5 area. For most of these species, the SEA 5 area is only a marginal part of their habitat, and is likely to be inhabited only during a restricted part of the year.

Pinnipeds

Grey seal

Grey seals are restricted to the North Atlantic and adjacent seas with three recognised populations; the northwest Atlantic, the Baltic Sea and the northeast Atlantic (breeding primarily on offshore islands around the British Isles but also in Iceland, the Faroe Islands, France, the Netherlands, central and northern Norway, and around the Kola peninsula in Russia). The British grey seal population has been increasing by around 6% annually since the 1960s. Its current size is estimated at around 110,000 individuals, of which approximately 60,000 are associated with the colonies in Orkney, Shetland, and the east coast of Scotland (Table 6.6).

Table 6.6 - Estimated grey seal population size in the SEA 5 area			
Area	**Population size (not including pups of the year)**	**Year(s) information obtained**	**Population status**
Mainland Scotland and Shetland	12,000	1998-2002	Possibly increasing
Orkney	44,300	2002	Increasing but rate may be slowing
Scottish North Sea coast	5,900	2002	Increasing

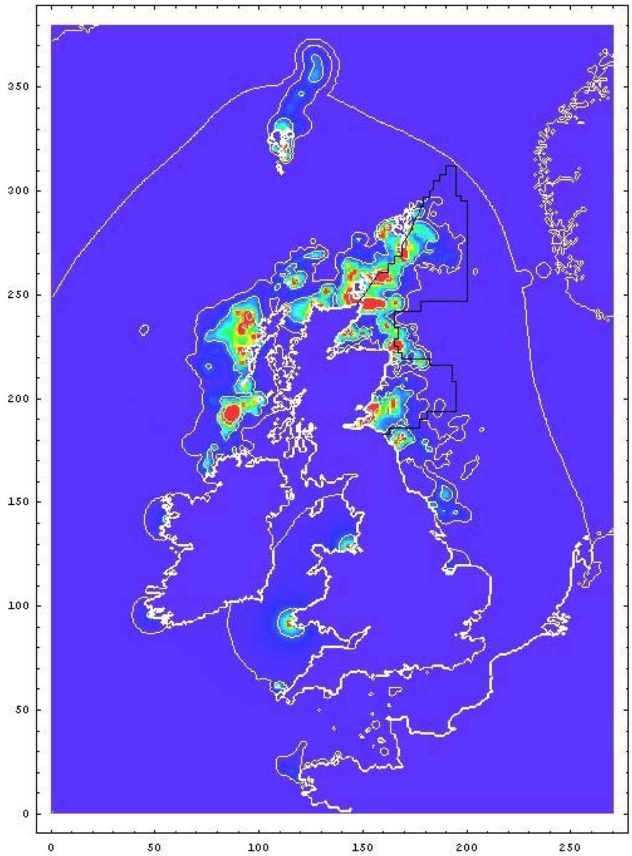
Source: Hammond et al. (2004), adapted from SCOS (2003).

Most animals spend the majority of time on land for several weeks from October to November during the pupping season, and again from February to April during the moult. Densities at sea are therefore lower during this period than at other times of the year.

Extensive information on the distribution of British grey seals at sea is available from studies of animals fitted with satellite relay data loggers. In a study of animals captured at the Farne Islands and Firth of Tay, McConnell *et al.* (1999) found that movements were on two geographical scales: (a) long and distant travel (up to 2,100km away); and (b) local, repeated trips to discrete offshore areas. Long-distance travel included visits to Orkney, Shetland, the Faroes and far offshore into the Eastern Atlantic and the North Sea.

In 88% of trips to sea, individual seals returned to the same haul-out site from which they departed. The durations of these return trips were short (typically 2-3 days) and their destinations at sea were often localised areas characterised by gravel/sand seabed. This is the preferred burrowing habitat of sandeels, an important component of the grey seal diet.

Figure 6.18 – Grey seal density around the UK



This is confirmed by recent SMRU modelling work that used satellite-linked telemetry and other data to generate predicted distributions of where grey seals spend their time foraging around the British Isles (Figure 6.18, Matthiopoulos 2003a, b, in press). All the major grey seal activity off the coast of northeast Scotland is contained within the SEA 5 area. The model estimates that approximately 50% of foraging effort by the UK grey seal population occurs in the SEA 5 area.

In summary, the SEA 5 area is clearly an extremely important area for UK grey seal foraging activity (Hammond *et al.* 2004).

Harbour seal

Only the eastern Atlantic harbour seal (*Phoca vitulina vitulina)* occurs around Britain with approximately 20% of this sub-species breeding in Orkney and Shetland and along the east coast of Scotland. In the North Sea, harbour seals haul out on tidally exposed areas of rock, sandbanks or mud. Pupping occurs on land from June to July during which time females and pups spend a high proportion of their time ashore. The moult is centred around August and extends into September. Moulting seals also spend a high proportion of their time ashore, so from June to September harbour seals are ashore more often than at other times of the year.

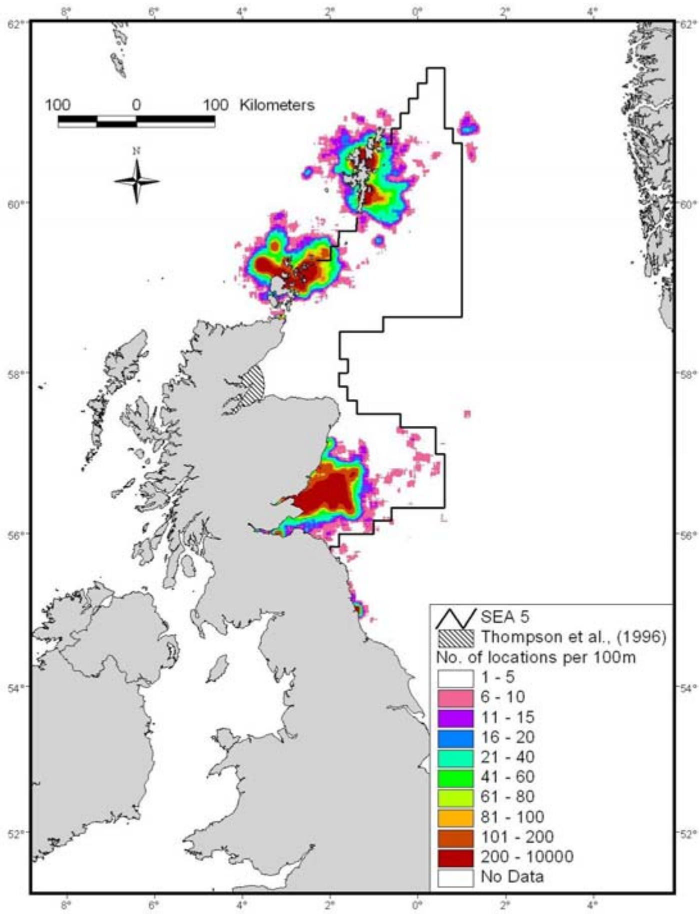
Approximately 15,000 harbour seals are associated with the SEA 5 area, around 50% of the UK total (Table 6.7). Counts of seals hauled out on land during the moulting season (August) represent no more than about two-thirds of the total population, so the true population size is likely to be at least 50% greater than these counts.

Table 6.7 - Estimated harbour seal population size in the SEA 5 area

Area	Count	Year(s) information obtained	Population status
Shetland	4,900	1996-2001	Possibly decreasing
Orkney	7,800	1996-2001	Possibly decreasing
Scottish East coast	1,800	1996-1997	Stable

Source: Hammond et al. (2004), adapted from SCOS (2003).

Figure 6.19 – Harbour seal density in the SEA 5 area



Harbour seals are widely distributed around the coasts of Orkney and Shetland and along the east coast of Scotland. Recent unpublished data on harbour seal distribution obtained through satellite telemetry have found that this species is distributed far more widely offshore than previously thought. As a result, further telemetry work on the populations of harbour seals found in Orkney and Shetland is being conducted. These data, combined with those obtained previously from seals hauling out in St. Andrews Bay and the Moray Firth, show that harbour seals are found across much of the SEA 5 area (Figure 6.19).

There is dense foraging activity in the southern part of the SEA 5 area from the population of harbour seals hauling out in St. Andrews Bay and animals tagged in Orkney and Shetland are foraging around the northwest boundary of the SEA 5 area. When the modelling methods described above for grey seals are applied to these data, the predicted usage of this northwestern part of the SEA 5 area will be much greater than the density shown in Figure 6.19 because of the large number of seals associated with haul-out sites throughout Orkney and Shetland. The Moray Firth is also an area where there is dense foraging activity, although the data is yet to be integrated into Figure 6.19.

In summary, the SEA 5 area is clearly an area of particular ecological importance for UK harbour seals.

Other species

There are occasional records of hooded seal, bearded seal, ringed seal and walrus in the SEA 5 area and adjacent waters.

6.8.3 Bycatch and other non-oil management issues

The accidental capture (bycatch) of marine mammals in fishing gear is an issue of current concern throughout EU waters and beyond. Bycatch in gill and tangle nets represents a significant source of mortality for harbour porpoises in many areas. The bycatch in the SEA 5 area and adjacent areas has not been explicitly assessed, but gillnet fishing effort is not thought to be particularly high in this region. Bycatch of other cetacean species in the area has only rarely been recorded and is not known to be an issue of concern.

A potential source of mortality to cetaceans in this and other areas is through collisions with shipping. In other areas, where ships are numerous and cetacean numbers are depleted, this is a serious cause for concern. The frequency of such events in the northeastern Atlantic is unknown and consequently this has not been identified as a significant source of additional mortality in this region (Hammond *et al*. 2004).

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