A3a.4 FISH AND SHELLFISH

A3a.4.1 Introduction

This section describes the distribution and ecology of fish and commercially important shellfish species in UK waters, with particular reference to spawning and nursery grounds. The section draws on previous fishery studies commissioned for the SEA programme and a range of other technical reports and scientific publications. Information on the seasonal distribution of commercially important fish and shellfish is available from several sources, with the most reliable being the routine research vessel surveys undertaken by European Research Laboratories, co-ordinated by the International Council for the Exploration of the Sea (ICES). These annual surveys target major commercial species but they also record information on the distribution and abundance of the non-target components of the catch.

A3a.4.2 UK context

Over 330 species of fish have been recorded on the UK continental shelf and the deep water regions which lie to the north and west of Scotland are home to many more. The following sections give a brief overview of a selection of abundant and widespread species in UK waters, grouped into pelagic (open water), demersal (bottom dwelling), elasmobranch (sharks and rays), diadromous (migrate to spawn in freshwater) and shellfish species.

A3a.4.2.1 Pelagic species

Mackerel (*Scomber scombrus*) are widely distributed around the northeast Atlantic where they tend to shoal in large schools in waters down to 1000m deep. They usually grow to between 35 and 45cm long although they can reach 60cm. They feed on pelagic crustaceans and other zooplankton and small fish. Mackerel are fast growing and are sexually mature by three years of age (Gordon 2006). Spawning is pelagic and the spawning season prolonged. Eggs are shed in batches and studies of spawning patterns reveal there to be two main mackerel stocks in UK waters: a western stock and a North Sea stock (Coull *et al*. 1998).

Atlantic herring (*Clupea harengus*) are widespread throughout the northeast Atlantic. A number of different spawning grounds around the UK exist, with spawning occurring at different times (although the majority takes place in late summer). Spawning usually takes place at depths of between 15-40m, when herring deposit their sticky eggs on coarse sand and gravel. The dependency of herring on these specific substrates makes the species potentially susceptible to disturbance at these sites. Shoals congregate and spawn simultaneously at traditional spawning grounds, resulting in the formation of an, “egg carpet,” which may extend over an area of one hectare (Blaxter & Hunter 1982). Each female produces a single batch of eggs every year from the age of about 3 years, although the number, size and weight of eggs will vary between spawning populations. Eggs hatch after 1-3 weeks, depending on the water temperature, and pelagic larvae will drift towards important nursery grounds (Coull *et al*. 1998). Young herring occur in dense shoals in inshore waters, and are often found in mixed shoals with varying proportions of sprats (*Sprattus sprattus*).

Sprats are widespread along Atlantic coasts and are usually found in shallow water close to shore, where they can tolerate low salinities. They tend to range in length from 8-12cm and are a short-lived species, the abundance of which is heavily dependent on the strength of the recruiting year class (Gordon 2006). They feed on a range of planktonic crustaceans.

Spawning mainly occurs in the summer months, near the coast or up to 100km out to sea, at depths of 10-20m (Gordon 2006). During spawning, 6,000-14,000 pelagic eggs can be produced and this fecundity, along with the rapid life-cycle, means sprat have a very short population doubling time of less than 15 months.

Horse mackerel (*Trachurus trachurus*) around the UK are split into two stocks; a western stock and a North Sea stock. The North Sea stock spends most of the year in the central North Sea, Skagerrak and Kattegat, but migrates to the southern North Sea in the summer to spawn (Fishbase website). Adults form large shoals in coastal areas with sandy seabeds, where they feed on fish, cephalopods and crustaceans.

Argentines are deep water salmoniformes found over muddy sediment at depths of between 55-550m (Wheeler 1978). Two species of argentine, the greater (*Argentina silus*) and lesser (*Argentina sphyraena*) are present in the northeast Atlantic. The greater argentine is larger and tends to be found in deeper water, closer to the edge of the continental shelf than the lesser argentine. They feed on bottom living worms and molluscs and also predate on pelagic fish, crustaceans and squid at night. They spawn between March and September, producing pelagic eggs and larvae.

Blue whiting (*Micromesistius poutassou*) is a meso-pelagic species, usually found in shoals 30-400m from the surface in water between 150-3000m deep. Shoals move towards the surface at night. They are widely distributed around the northeast Atlantic, typically reach lengths of 25-30cm and live for 5-7 years (Gordon 2006). They feed primarily on small crustaceans such as euphausiids.

A3a.4.2.2 Demersal species

Gadoids

Gadoids are important components of the fish community. The Atlantic cod (*Gadus morhua*) can be found from the shoreline down to depths of 600m and is widely distributed around European coasts. It can reach lengths of 190cm, but more commonly of between 50-80cm. Cod are omnivores, feeding on a variety of invertebrates and fish. Sexual maturity is reached between 4-5 years and spawning occurs over the continental shelf at temperatures between 0-12^{o}C (Gordon 2006). Drumming noises produced by the swimbladder have been found to have an important role in mating of cod, haddock and probably other gadoids (e.g. Rowe & Hutchings 2004).

The haddock (*Melanogrammus aeglefinus*) is found around North-east Atlantic coasts, over rock, sand or gravel bottoms at 10-450m depth, usually between 80-200m (Albert 1994). It can reach 50-75cm long and feeds on small benthic invertebrates and fish. It is known to reach ages of up to 20 years. There is some evidence of a winter migration of adult haddock from the North Sea to North-western Scotland (Gordon 2006).

Whiting (*Merlangius merlangus*) are widespread around European coasts at depths of 10-200m over sandy or muddy ground. They typically grow to 30-40cm in length and may reach 20 years of age, although 7 or 8 is more common (Gordon 2006). Their diet comprises mainly crustaceans and fish, with a greater proportion of fish as they get older. Spawning can take place as early as January in the southernmost areas of its distribution and as late as July in more northerly areas.

Saithe (*Pollachius virens*) are found at depths of between 0-200m around northeast Atlantic coastlines, usually entering coastal waters in spring and migrating back to deeper sea in winter. They grow to 60-90cm and have a diet of fish and small crustaceans. Saithe reach

maturity between the ages of 4-6 years and individuals of 25 years old have been reported (Gordon 2006). They spawn in winter and spring, later in the year for populations further north. Pollack (*Pollachius pollachius*) live inshore over rocky ground at depths of up to 200m, around North-east Atlantic coasts. They can grow to between 60 and 80cm, although individuals of up to 130cm have been found. The oldest recorded pollack was 8 years. The pollack feeds primarily on fish, with cephalopods and crustaceans also forming part of its diet. Juvenile shoals are common inshore but the adults shoal only during the spawning period, which takes place in winter and spring at about 100m depth (Whitehead *et al*. 1986).

A number of smaller gadoid species such as poor cod (*Trisopterus minutus*), Norway pout (*Trisopterus esmarkii*) and bib (*Trisopterus luscus*) can be very abundant in places and may be ecologically important as prey for other species.

Flatfish

Plaice (*Pleuronectes platessa*) live to depths of 200m, mainly on soft sediments. Spawning occurs in water temperatures of approximately 6°C to produce pelagic eggs. Larvae move to coastal regions, and sandy beaches act as nursery grounds, before older individuals venture out to deeper waters (Gordon 2006). Plaice live on mixed substrates at depths up to 200m, with older individuals generally found in deeper water (Whitehead *et al*. 1986).

Dab (*Limanda limanda*) and long rough dab (*Hippoglossoides platessoides*) are spring and summer spawners which mature at 2-3 years to produce pelagic eggs and larvae. Dab larvae were the most abundant to be found in the North Sea and Irish Sea during ichthyoplankton surveys. Dab are typically found in shallower water, where they feed on small benthic invertebrates (Amara *et al*. 1998). The long rough dab tends to be found in deeper waters, up to 500m, over muddy substrates. Other important flatfish include the lemon sole (*Microstomus kitt*), mainly on coarser sediments to 200m, and the sole (*Solea solea*), especially on finer sandy and muddy seabeds to around 120m, including estuarine areas. Both are widespread in British waters, but sole is much more abundant in the southern half of the British Isles than in the north as it is generally confined to warmer waters.

Other species

Monkfish (*Lophius piscatorius*) are typically found in northern UK waters ranging from shallow, inshore waters down to depths of up to 1,100m. Spawning takes place in deep water, with each female thought to produce just one batch of eggs between January and June. Juvenile monkfish descend to the seabed after 3-4 months spent in the water column and are generally found in shallower water than adults. Female monkfish do not mature until they are at least seven years old and so the species is particularly vulnerable to overfishing. Monkfish are ambush predators, enticing prey towards their mouths with a lure that extends from the top of their head (Rogers & Stocks 2001).

Gurnards such as red and grey gurnards are abundant in UK waters. The grey gurnard (*Eutrigla gurnardus*) is very abundant in shallow, sandy areas and migrates inshore during summer (Wheeler 1978). Spawning takes place between January and June, with juveniles moving into deeper water as they mature. Red gurnards (*Aspitrigla cuculus*) tend to be found in shallow water and spawn over the summer months. Gurnards are predators, feeding on a range of fish, crustaceans and benthic invertebrates. The rays of their pectoral fins are modified into sensory organs with which they detect prey (Wheeler 1978).

The scorpionfish include bullrout (*Myoxocephalus scorpius*), sea scorpions (*Taurulus bubalis*) and pogge (*Agonus cataphractus*). These species tend to favour coarse sediments

in shallow waters and may enter estuaries and river mouths (Power & Attrill 2002). They feed on crustaceans and small fish and pogge have sensory barbels to detect prey (Wheeler 1978). Most scorpionfish will spawn between October and April, with exact periods dependent on the species. They produce benthic eggs which they deposit on a secure holdfast.

Dragonets are typically found inshore on sand and gravel sediments. Of the three main species found in UK waters, the common dragonet (*Callionymus lyra*) is the most abundant (Russell 1976). This species spawns in depths of less than 50m from early spring to August, producing pelagic eggs and larvae (Russell 1976). Other species found in the region are the spotted (*Callionymus maculatus*) and reticulated (*Callionymus reticulatus*) dragonets. Dragonets feed primarily on polychaetes, crustaceans and molluscs (King *et al*. 1994).

Sandeels (Ammodytidae, principally *Ammodytes* spp. and *Hyperoplus* spp.) are shoaling species which lie buried in the sand at night and feed in mid-water during daylight (Winslade 1974). Spawning usually takes place between November and February, on sandy sediments. The eggs are demersal and are laid in sticky clumps on sandy substrates. Larvae remain pelagic for between 2-5 months after which they are thought to over-winter buried in the sand (Wright & Bailey 1996). There is little movement between spawning and feeding grounds, and so fishing activity may have a direct effect on spawning (Kunzlik *et al*. 1986, cited by Rogers & Stocks 2001). As well as being a major component of the industrial fishery, sandeels are an important food item for predatory fish and seabirds. Of the five species of sandeels in the North Sea, the lesser sandeel *Ammodytes marinus* is the most abundant and comprise 90% of commercial landings (FRS 2008d).

There are 19 species of goby found in UK waters (Wheeler 1992). They are found in inshore waters and estuaries where they feed on a wide range of food from planktonic organisms to crustaceans. Gobies spawn on the seabed in summer, with males guarding eggs that have been left under rocks or in shells.

Bass (*Dicentrarchus labrax*) are attracted to warm water discharges and so are common inshore, close to the mouths of rivers, particularly around the southern coasts of the UK. Bass move inshore to spawn from March to June and form large shoals during this migration, making them a target for fisheries.

A3a.4.2.3 Elasmobranchs

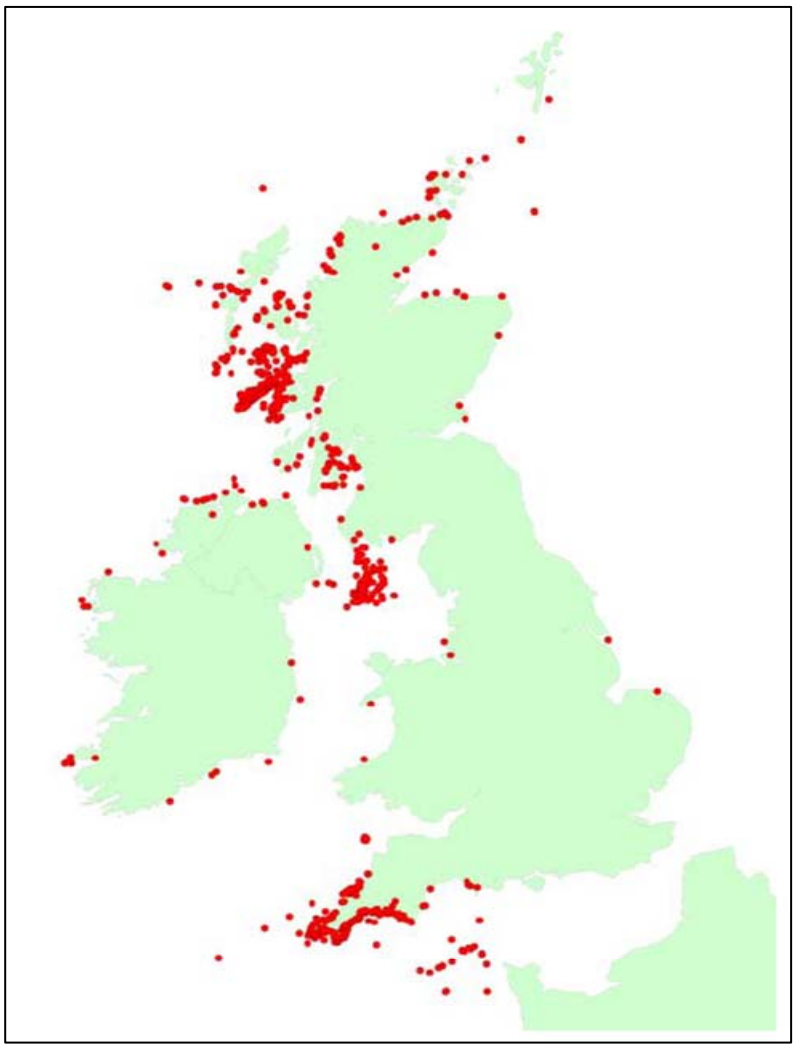
The most abundant sharks found in UK waters are the lesser and greater spotted dogfish (*Scyliorhinus canicula* and *Scyliorhinus stellaris*), the spurdog (*Squalus acanthias*) and the tope (*Galeorhinus galeus*). Dogfish show a wide but patchy distribution in the North Sea. They feed on crustaceans, cephalopods and fish (Ellis *et al*. 1996) and are egg layers, with the peak of breeding in June and July. Tope are also widespread and juveniles are often found in large bays and estuaries. They are long-lived, reaching an age of at least 36 years (Peres & Vooren 1991). They are viviparous and young are generally born during the summer, after a year-long gestation period. Large open water species such as the porbeagle (*Lamna nasus*) may occasionally occur around the coast of the UK.

A number of skates and rays are also present in UK waters, with the most abundant being the thornback ray (*Raja clavata*) and the cuckoo ray (*Raja naevus*). The common skate (*Leucoraja batis*), listed as endangered on the IUCN Red List, is also present, but rare.

Basking shark

The basking shark (*Cetorhinus maximus*) is the largest fish in the North Atlantic and the second largest in the world. It is widespread and feeds by filtering plankton from the water with its gill rakers. The shark is commonly seen at the surface in the summer months, particularly around the western coasts of the UK, but it is less clear where they spend the winter. Recent work (Sims *et al*. 2003) suggests that they make extensive migrations both vertically and horizontally to locate high concentrations of plankton that will often be associated with fronts, and that they principally migrate north to south during the winter months along the continental shelf of Europe (Sims *et al*. 2005a, b). However, in the summer of 2007 one of two sharks tagged in the Irish Sea was found to migrate more than 9,500km over a period of ca. 2.5 months to a point off Newfoundland, Canada, reaching depths of over 1,200m on the way (Rowe *et al*. 2008). Figure A3a.4.1 shows basking shark observations to be centred on three main areas: the Minch, the Isle of Man and Cornwall.

Figure A3a.4.1 – UK basking shark sightings reported by the general public in 2006



Source: Bloomfield & Soldant (2007)

A3a.4.2.4 Diadromous species

Diadromous species are those which migrate between marine and freshwater as part of their lifecycle.

Lampreys are eel-like, jawless fish. Both the river lamprey (*Lampetra fluviatilis*) and the sea lamprey (*Petromyzon marinus*) migrate up rivers to spawn (anadromy) and spend the larval stage buried in muddy substrates in freshwater. Both species need clean gravel for spawning, and silt or sand for the burrowing juveniles (JNCC website a). Once metamorphosis takes place, the adults migrate to the sea where they live as a parasite on various species of fish (UK Marine SACs Project website). Sea lampreys are thought to venture further out to sea and spawn in lower reaches of the rivers than the river lampreys (Carmarthen Bay and Estuaries SAC website). The sea lamprey is uncommon in the UK, while the river lamprey or lampern is widespread with substantial populations in some rivers and streams. The main populations of both species are found in the Bristol Channel and adjacent offshore waters (UK Marine SAC website).

The allis and twaite shads (*Alosa alosa* and *A. fallax*) and the Atlantic salmon (*Salmo salar*) also display an anadromous lifecycle. The shads are clupeids, or herring-like fish. They are rare, but are most abundant around the west coast, where they feed in estuaries before moving upstream to spawn in between April and July. Significant spawning populations of the twaite shad are still found in the UK, while the allis shad, displays little spawning activity in the UK. Juveniles are thought to remain in freshwater for up to two years, before returning to the sea (Maitland & Hatton-Ellis 2003).

Salmonids, including Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta*) undertake extensive migrations out to sea to feed, before returning to "home" rivers to spawn. Spawning takes place in shallow excavations (redds), in shallow gravelly areas in clean rivers and streams. After a period of 1-6 years the young salmon migrate downstream to the sea as smolts. Salmon have a homing instinct and spawn in the river of their birth after 1-3 years in the sea (JNCC website b).

For both species, there have been general declines in the numbers of fish returning to UK rivers. The reasons for these declines are complex but may include pollution, predation, by-catch, parasites and climate change. There are also concerns about salmon farm escapees interbreeding with wild salmon and causing fitness reduction and potential extinction of wild stocks (McGinnity *et al.* 2003).

Extensive research on the freshwater phase of the salmon life cycle has revealed much about the factors affecting juvenile production, but much less is known about the salmon's life at sea. Atlantic salmon leave their home rivers in spring and early summer as smolts, and migrate towards feeding areas in the Nordic Seas and West Greenland. New information is elucidating the smolt migration routes and food resources (Haugland *et al.* 2006).

Recapture data from tagged adult salmon strongly suggest that the oceanic homing migration, opposite to the smolt migration, is independent of currents with homing fish often moving along the shortest distance from tagging site to the coast (Hansen *et al.* 1993). Returns of salmon to western rivers are confined largely to the summer months.

In contrast, sea trout appear to remain within nearshore waters rather than undergoing extensive migrations leading to concerns about their greater risk of exposure to sea lice infections from salmon farms in these areas as well as declines in stocks of their main prey species, sandeels (FRS website).

Salmonids play a critical role in the life cycle of the freshwater pearl mussel *Margaritifera margaritifera*. The freshwater pearl mussel is long lived with records of individuals over 100 years old (Bauer 1992). The larval stage (or glochidia) of the mussel is inhaled by juvenile Atlantic salmon and brown or sea trout and where it attaches to the gills and encysts. Encysted larvae live and grow in the hyper-oxygenated environment on the gills before dropping off in the following spring.

The European eel (*Anguilla anguilla*) spends most of its life in freshwater or inshore coastal waters, before migrating across the Atlantic to the Sargasso Sea to spawn in late summer (McCleave & Arnold 1999). The Leptocephalus larvae drift northeast with the Gulf Stream and return to European coastal waters during the spring where they transform into transparent elvers (glass eels). Glass eels gather in river estuaries and wait for the river water to reach 10-12°C, before swimming upstream and migrating into inland waters. Peak migration take place on the increasing tides in April and May. Eels which successfully reach fresh water acquire green and brown pigments and become yellow eels. Yellow eels spend between 2 and 20 years in rivers and other inland waters although there are records of longer lived animals. Mature fish migrate seawards as silver eels and are thought to migrate westwards at depth to the Sargasso Sea, where they spawn and die. Some eels remain in coastal waters where they feed and grow in the sea, while others may continue to migrate between freshwater and the sea (Fishbase website).

Very large declines in eel populations since the 1970's have been reported throughout Europe, including Britain. The number of new glass eels entering European rivers declined to 10% of former levels and recent figures show that this has now dropped to 1% (ICES website). The biological cycle of the European eel has not yet been replicated under artificial conditions and elvers are removed from the natural environment to supply the aquaculture sector (FAO 2008). Council Regulation (EC) No 1100/2007 establishing measures for the recovery of the stock of European eel entered into force in September 2007. The regulation requires the development of Eel Management Plans which include measures to reduce anthropogenic mortalities to allow the escapement to sea of at least 40% of the silver eel biomass. Under the regulation, during 2009, 35% of the eel catches with a body length <12 cm (increasing to 60% by 2013) will have to be used for restocking European eel river basins.

Bark *et al.* (2007) concluded that eel stocks in some English west coast rivers are probably still at or near to carrying capacity, with male-dominated populations. In other rivers, particularly those towards the southeast of England, current and historical data indicate declining female-dominated stocks.

A3a.4.2.5 Shellfish

The benthic fauna of the UK waters is rich and diverse. An important component of this benthic fauna is a collection of molluscs and crustaceans loosely referred to as shellfish. This section considers shellfish of commercial importance, with other species considered in detail in the Benthos section. Detail on the fisheries for these species may be found in the Fisheries section.

Crustaceans

The Norway lobster (*Nephrops norvegicus*), commonly known as *Nephrops*, lives in burrows dug into muddy and sandy sediments, at depths between 20-800m. They range in body length from 8-24cm. *Nephrops* feed mainly on detritus, small crustaceans and worms and are most active at night (FAO website). Eggs hatch in spring or summer after being carried

by females for 9 months. The relative inactivity of females during this period, when they remain hidden in burrows, means that males are more heavily exploited in the fishery through most of the year (FRS website a). There is considerable variation in the life-histories of *Nephrops* at different locations. In part, this is linked to sediment type, with higher population densities found at sandier sites, resulting in a reduction in the rate of growth and maximum size (FRS website). *Nephrops* is more abundant in northern UK waters, although significant populations exist in the Irish and Celtic Seas and on the Dogger Bank.

The brown (or edible) crab (*Cancer pagurus*) is most abundant on rocky grounds, where it hides in holes and crevices. The crab is generally found in shallow water close to shorelines, particularly along the east coast and the southwest of England, although it can be found in water as deep as 100m (FAO website). It is both an active predator and a scavenger. The species spawns between November and February, during which time the females remain in deeper waters offshore (Edwards 1979). Other crabs that are abundant around UK coasts include the green crab (*Carcinus maenas*) and velvet crab (*Necora puber*). The European lobster (*Homarus gammarus*) is found from the shoreline to depths of 150m, usually on a hard substrate such as rock or hard mud, growing to lengths of 60cm. Lobsters are most active at night, remaining in crevices during the day. Females lay eggs in July and carry them for 10 or 11 months (FAO website). The related crawfish *Palinurus elephas* is another valuable crustacean but catches are much reduced since the 1970s. It is most abundant on hard bottoms off the extreme southwest of England and Wales and the west of Scotland. Crawfish feed on a variety of benthic organisms but are thought to have a preference for echinoderms such as urchins. Long distance migrations are a feature of many crabs and lobsters, particularly the edible crab, European lobster, crawfish and spider crab (*Maja squinado*) (Edwards 1979).

A number of valuable shrimp species are found around the UK. The three most important are the brown shrimp (*Crangon crangon*), the pink shrimp (*Pandalus montagui*) and the deep-water shrimp (*Pandalus borealis*). The brown and pink shrimps are typically found in shallow waters, in bays and estuaries along the east coast of England. The brown shrimp generally favours areas with soft, sandy sediments, in which it can burrow, while the pink shrimp is more common over hard substrates. Eggs are carried by females over the winter months, before hatching in spring (Lee & Ramster 1981). The deep-water shrimp is larger and longer lived than the other species. It has a more northerly distribution in UK waters and the North Sea represents the southern edge of its range. It is a detritivore, found as deep as 900m, typically over muddy sediments and in areas of slow moving water where detritus accumulates (Lee & Ramster 1981).

Molluscs

The most commercially valuable molluscs are scallops (*Pecten maximus*). Scallops are found predominantly to the south and west of the UK on sandy, muddy, shell and gravel substrates, down to depths of over 100m. They occupy depressions in the sediment and are able to escape danger by swimming using jet propulsion (Chapman 2004). Their shells are lined with eyes and sensory tentacles, allowing them to detect light levels and even to form rudimentary images (FRS website b). Scallops are filter feeders, sieving the water for phytoplankton and suspended detritus. They first spawn in autumn, at two years old. Older scallops also spawn in spring (Mason 1983). Queen scallops (*Aequipecten opercularis*) are a much smaller shellfish, without the upward facing flat valve characteristic of *P. maximus*. Habitats and distributions of the two species are similar, but queen scallops are able to live on harder gravel and shell substrates (Chapman 2004) and have a much greater ability to swim.

Cockles (*Cerastoderma edule*) live on inter-tidal beaches of sand, muddy sand and fine gravel, where they burrow into the sediment. They use a siphon tube to feed on material suspended in the water column and can be found in very high densities (several 100/m2) (Chapman 2004). Cockles mature after 2 years and spawn in spring, with each female producing up to a million eggs. The eggs spend about a month in the water column, meaning that settlement of spats and subsequent recruitment can be highly variable (Chapman 2004).

Mussels (*Mytilus edulis*) are suspension feeders generally found attached to hard substrates within the inter-tidal zone, although they also attach to reefs and man-made structures in shallow waters (Chapman 2004). Mussels reach maturity after one year and each female can release over 5 million larvae (Bannister 1998, cited by Chapman 2004), with spawning taking place in late spring. The settlement of spat is influenced by a range of factors, including tidal currents, water temperature and predation and so can be variable (Bannister 1998, cited by Chapman 2004). Other bivalve molluscs common in UK waters include the horse mussel (*Modiolus modiolus*) although these are little exploited and razor clams (*Ensis arcuatus* and *Ensis siliqua*).

The most harvested gastropod molluscs in UK waters are whelks (*Buccinum undatum*) and periwinkles (*Littorina littorea*). Whelks are carnivorous, mobile species found close to the coast along rocky shores and on soft sediments. They spawn in November, with eggs attaching to the seabed (Chapman 2004). Winkles are herbivorous, typically found attached to rocks in the inter-tidal zone. They spawn between January and July, releasing planktonic egg capsules (Chapman 2004).

A3a.4.2.6 Spawning grounds

Most fish display external fertilization and therefore need to aggregate in large groups to coordinate spawning. Figures A3a.4.2 - A3a.4.3 (overleaf) show the spawning sites of 13 key fish species (and *Nephrops norvegicus*, a commercially important shellfish) around the UK coast. These maps are based on a wide-ranging study by Coull *et al*. (1998). In some instances (particularly herring, in which spawning is very site specific) they may be broad in their overview and areas indicated should be regarded as areas in which spawning may occur, rather than well defined zones. Table A3a.4.1 indicates the main spawning periods of selected fish species around the UK. These periods are estimates, based mainly on plankton trawls and spawning periods are likely to vary with location. This is particularly notable in herring, which has a number of separate spawning sites, in use at different times of the year.

A3a.4.2.7 Nursery grounds

Juvenile fish are vulnerable to predators and harsh conditions in the open water. Therefore it is typical for juvenile fish to stay in sheltered nursery grounds which provide an abundance of food. Selected nursery grounds are shown in Figures A3a.4.4 - A3a.4.5 (overleaf), with the information taken from Coull *et al*. (1998). These figures should be referred to where nursery sites are mentioned in this baseline.

At nursery and spawning grounds, fish aggregate in large numbers and so are particularly vulnerable to disturbance.

Table A3a.4.1 – Spawning periods of selected species and groups

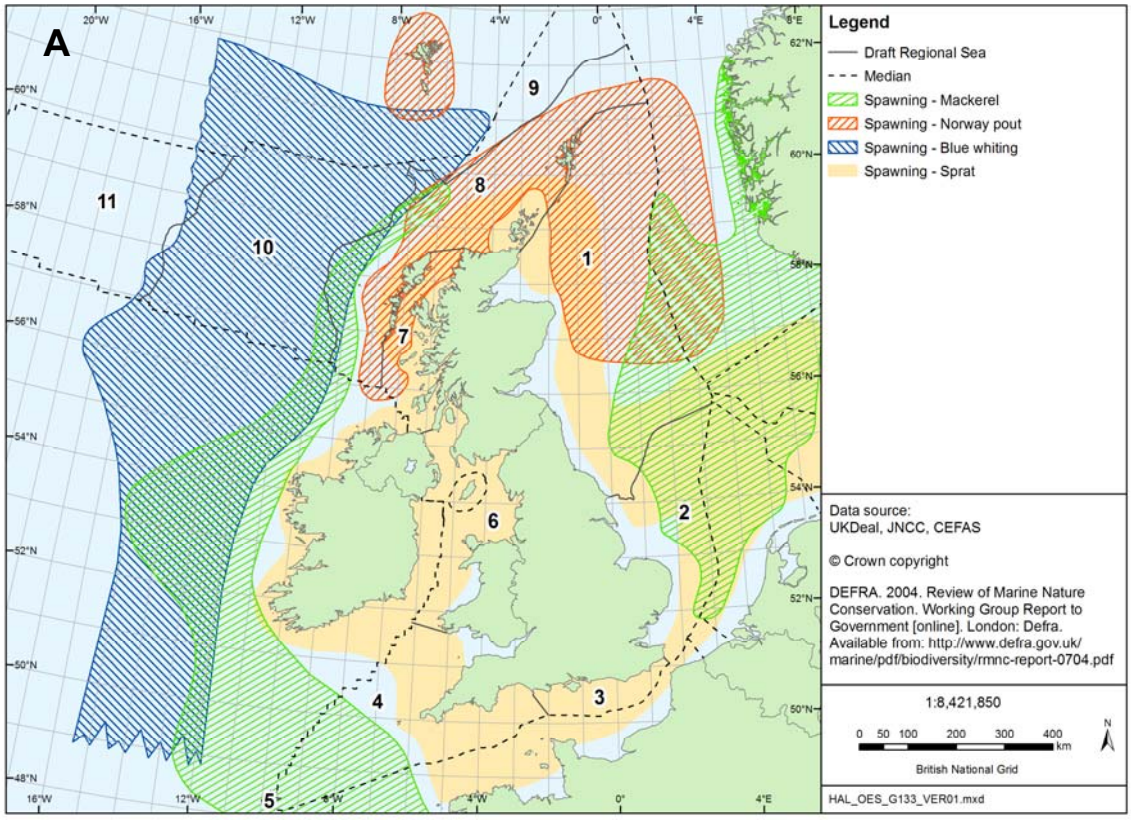
Group	J	F	M	A	M	J	J	A	S	O	N	D
Dab, long rough dab & solenette												
Plaice												
Sole												
Lemon sole												
Turbot & megrim												
Gurnards												
Scorpionfish												
Dragonets												
Bass												
Haddock												
Whiting												
Cod & saithe												
Norway pout & poor cod												
Dogfish & tope												
Monkfish												
Sandeels												
Argentines												
Blue whiting												
Northern North Sea herring												
Southern North Sea & English Channel herring												
Western stock herring												
Sprat												
North Sea mackerel												
Western stock mackerel												

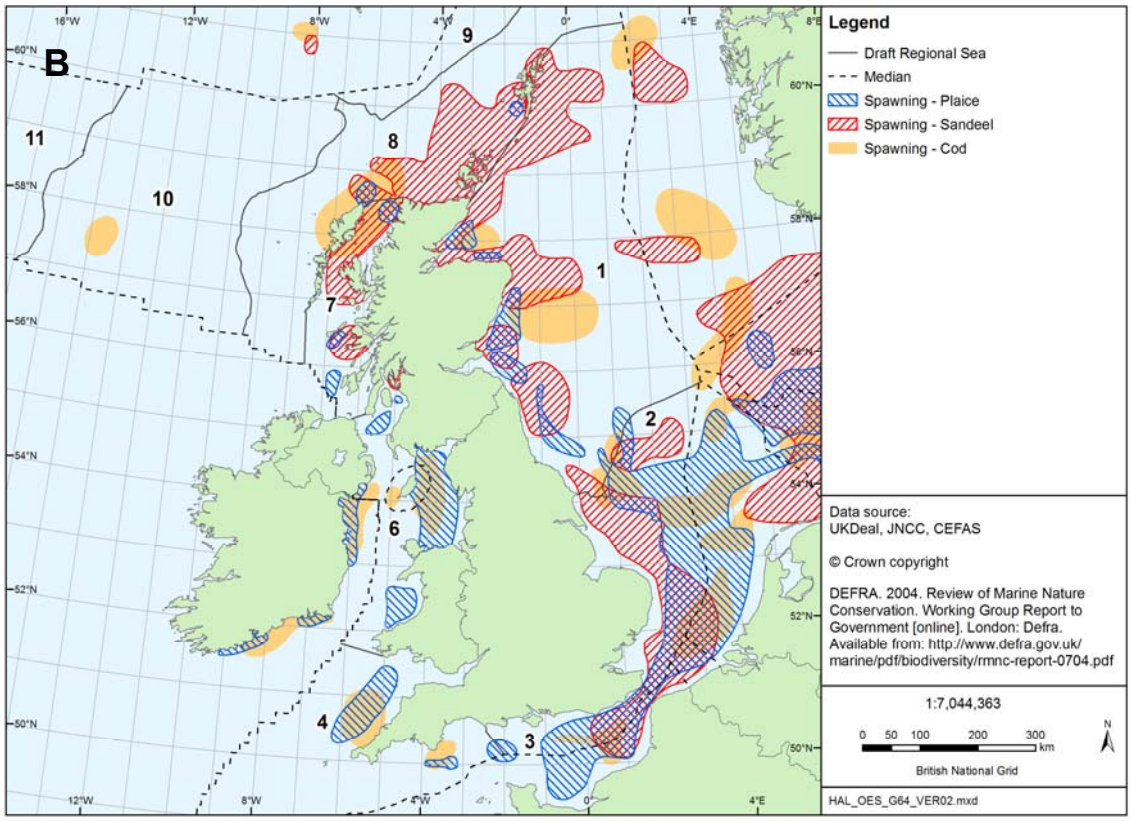
Source: Information taken from Coull et al. (1998) and CEFAS (2007)

A3a.4.3 Ecological context

Fish and shellfish are important components of marine ecosystems, operating at a number of trophic levels. They utilise a variety of feeding strategies, including filter feeding for plankton and detritus suspended in the water column, scavenging for detritus on the seabed, and both pelagic and demersal predation of plankton, small fish, cephalopods, crustaceans and other benthic organisms. Pelagic fish such as mackerel and herring primarily feed on planktonic crustaceans, other zooplankton and small fish. Demersal fish such as gadoids and flatfish often consume a wide range of benthic invertebrates including crustaceans, polychaetes, molluscs and echinoderms, along with cephalopods and fish. Sandeels main prey is calanoid copepods, but other planktonic prey including fish larvae are also taken; larger individuals may also take benthic prey such as polychaetes. Most benthic crustaceans are scavengers to some extent, feeding on detritus, although many species are also active predators of a variety of benthic organisms. Many molluscs such as scallops, cockles and mussels are filter feeders of material suspended in the water column.

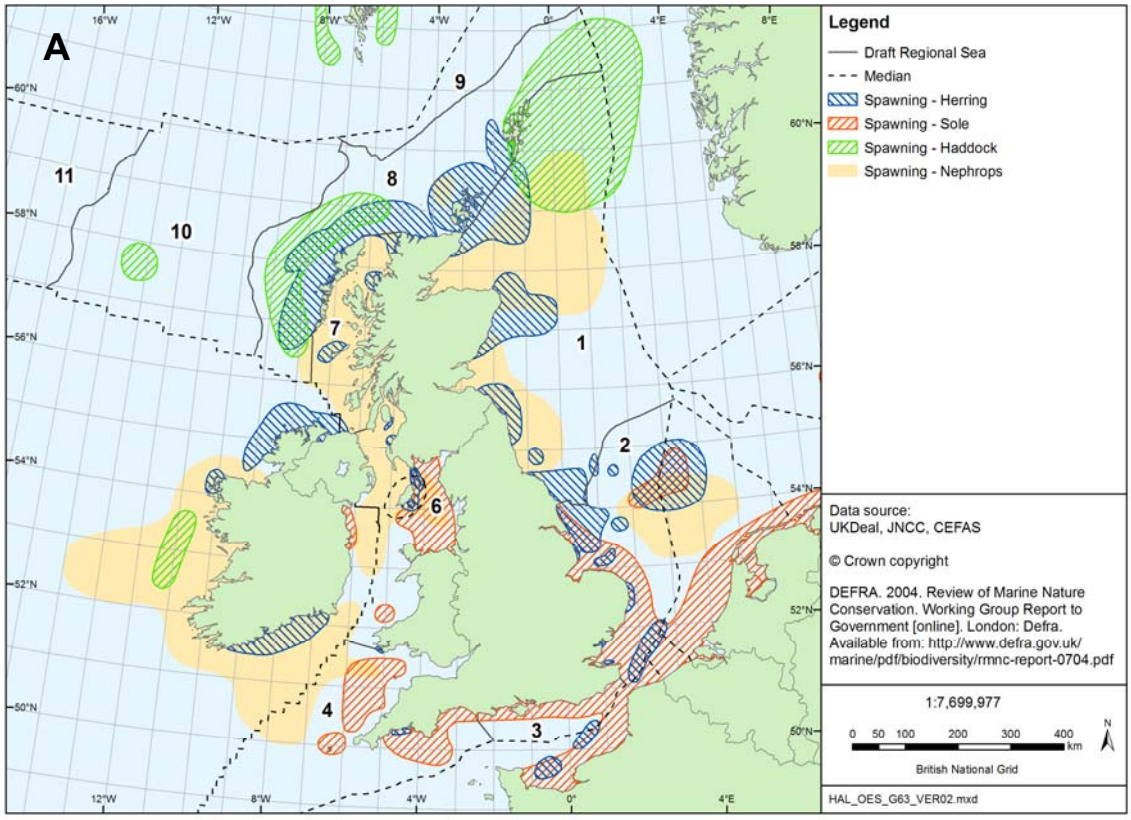
Figure A3a.4.2 – UK spawning grounds

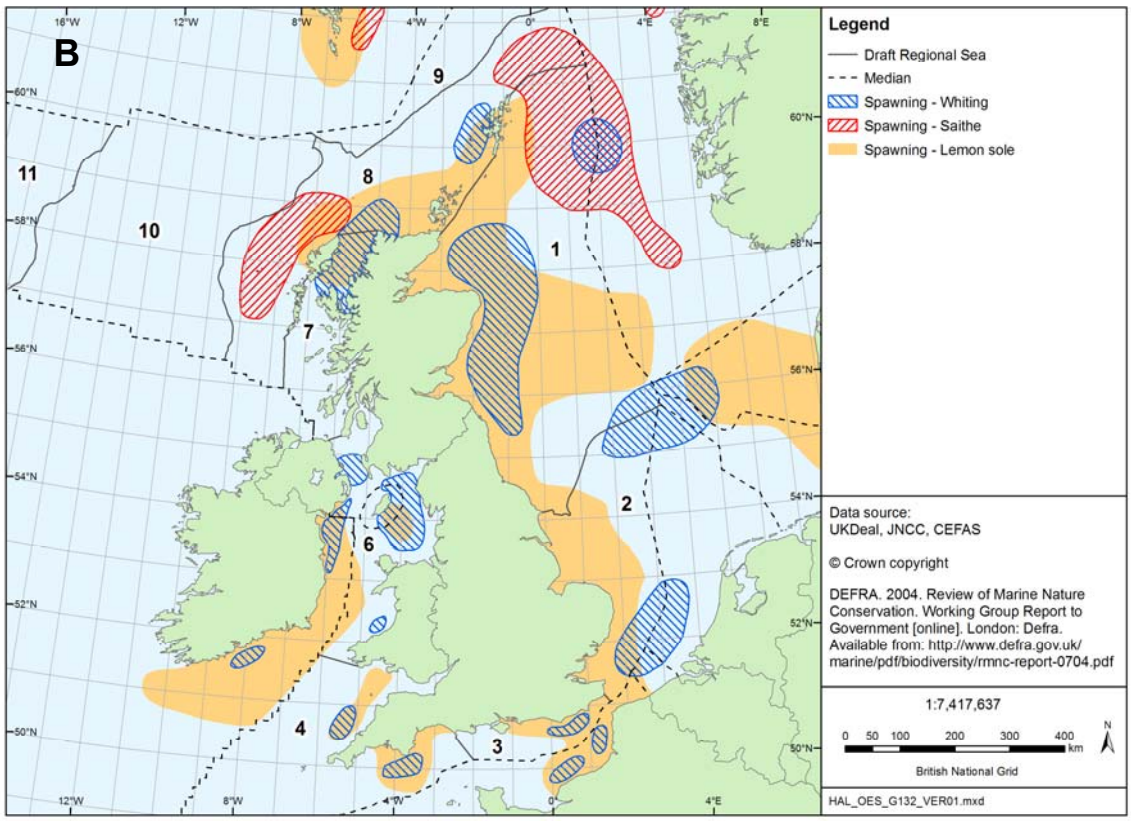




A: Mackerel, Norway pout, blue whiting & sprat
B: Plaice, sandeel and cod.

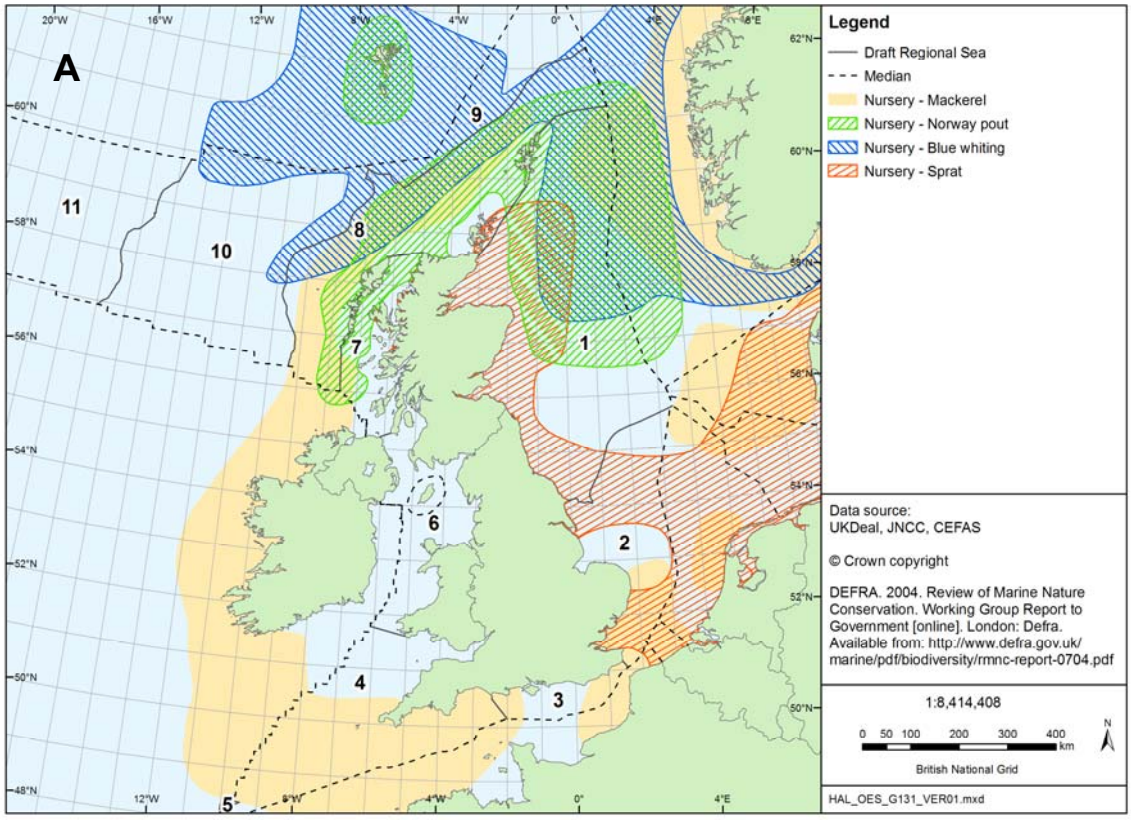
Figure A3a.4.3 – UK spawning grounds

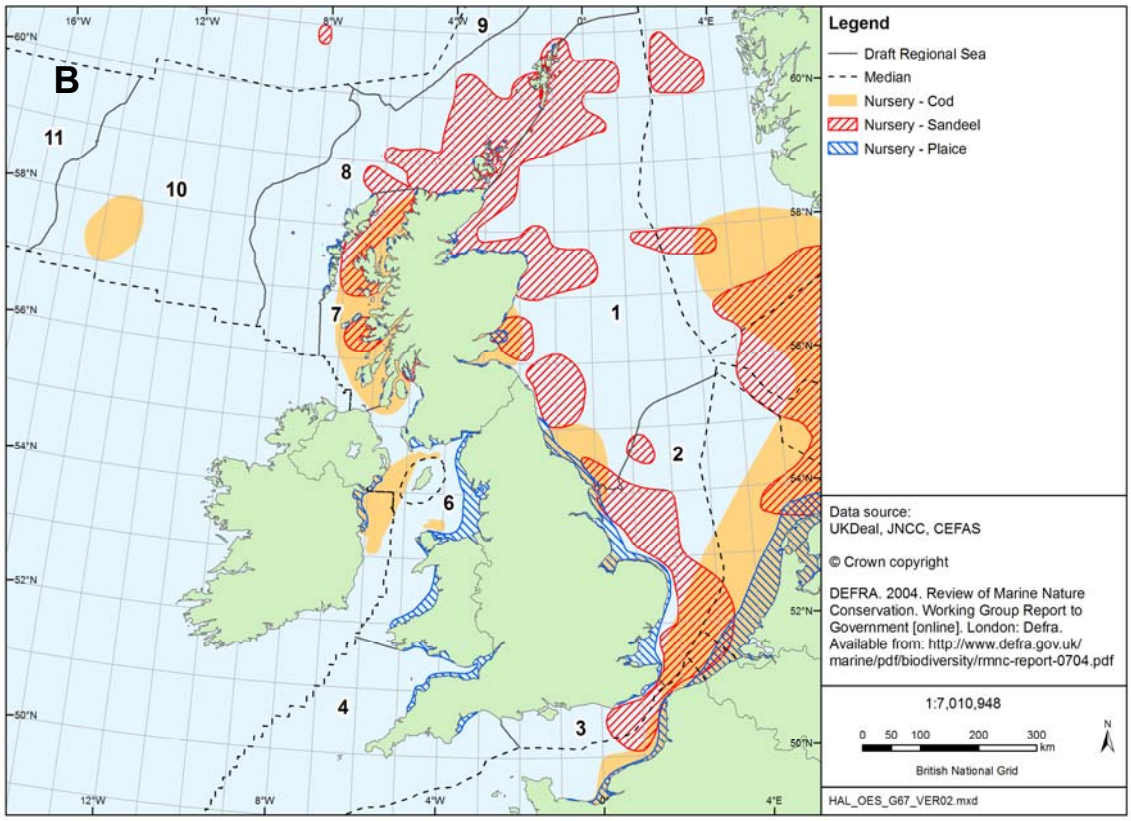




A: Herring, sole, haddock and *Nephrops*.
B: Whiting, saithe and lemon sole.

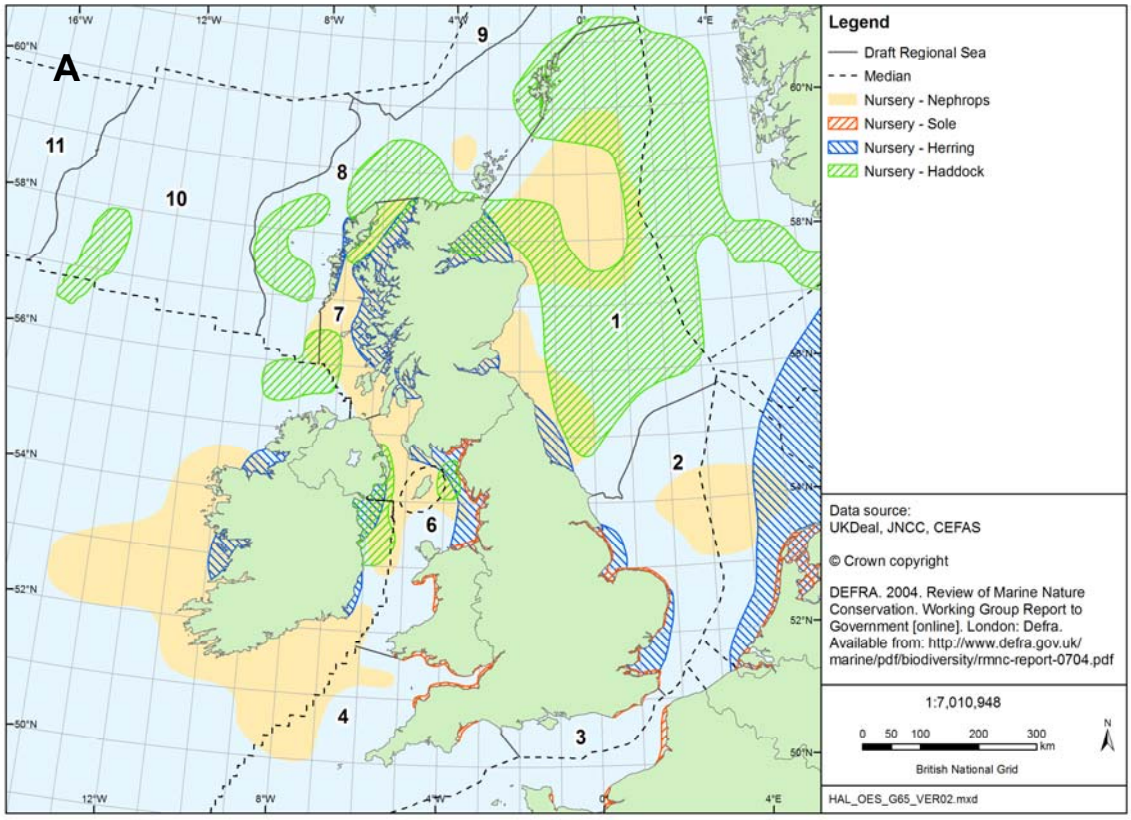
Figure A3a.4.4 – UK nursery grounds

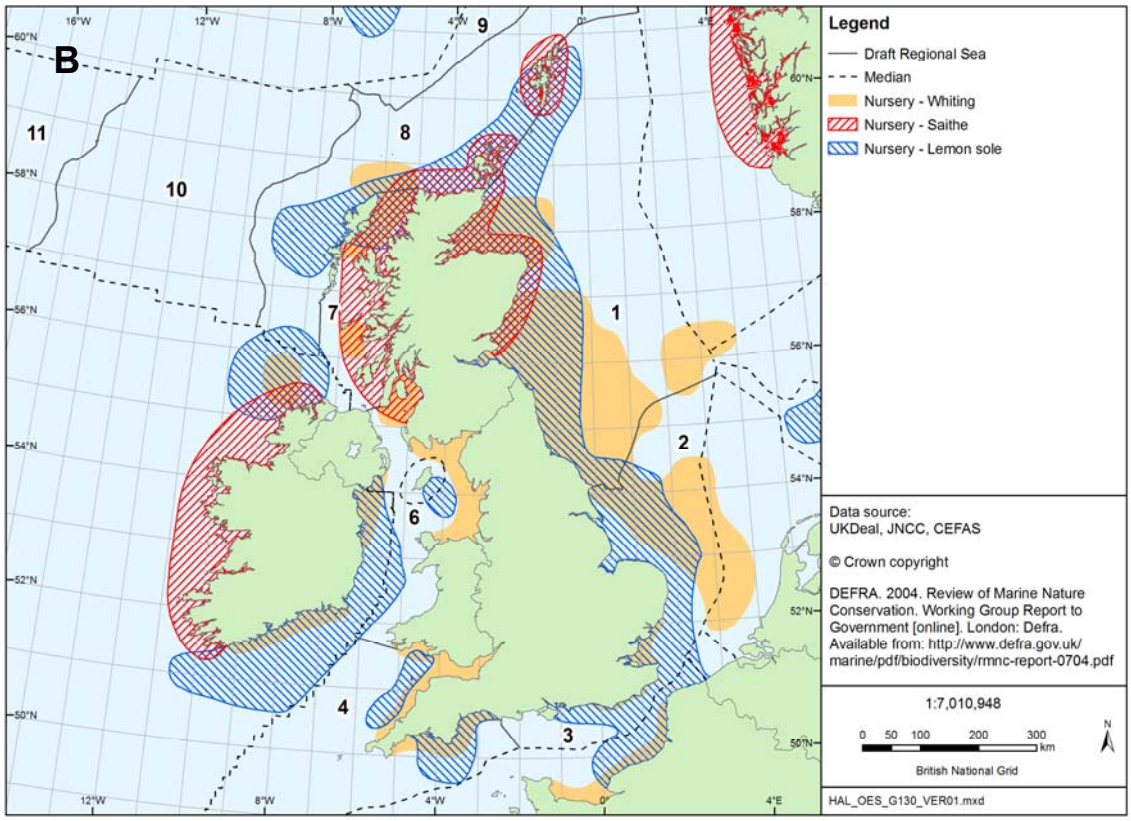




A: Mackerel, Norway pout, blue whiting and sprat.
B: Plaice, sandeel and cod.

Figure A3a.4.5 – UK nursery grounds





A: Herring, sole, haddock and *Nephrops*.
B: Whiting, saithe and lemon sole.

Fish and shellfish play a pivotal role in the transfer of energy from some of the lowest to the highest trophic levels within the ecosystem, and also through the recycling of nutrients from higher levels through the consumption of detritus. Consequently, their populations will be determined by both top-down factors, such as predation, and bottom-up factors, such as ocean climate and plankton abundance. Fish and shellfish are an important prey item for top marine predators including elasmobranchs, seabirds, cetaceans and humans, and small planktivorous species such as sandeels and herring act as important links between zooplankton and top predators (Frederiksen *et al*. 2006). The influence that fish abundance can have on predators is best illustrated by sandeels, which have declined in abundance dramatically in recent years, with sandeel landings in the North Sea decreasing by over 50% since 2003 (Frederiksen *et al*. 2006). This decline has coincided with a series of breeding failures amongst sandeel dependent seabirds such as puffins (*Fratercula arctica*) and kittiwakes (*Rissa tridactyla*). Declines in sandeel populations have also been linked with increased rates of starvation in harbour porpoise (*Phocoena phocoena*) (MacLeod *et al*. 2007), although the quality of the evidence that supports this suggestion has been questioned (Thompson *et al*. 2007). Sandeel recruitment and interactions with higher predators are complex and poorly understood. Further information on the ecological importance of fish and shellfish species to seabirds and marine mammals is provided in Appendices A3a6 and A3a7 respectively.

A3a.4.4 Features of Regional Sea 1

Fish community

The northern North Sea is an ecosystem characterised by oceanic inflows from the Norwegian Sea and Atlantic Ocean and by seasonal stratification in the water column. Species diversity within the fish community is not as great in the central and northern North Sea as in the southern North Sea, with the exception of some areas of the Scottish coast (Callaway *et al*. 2002). The highest richness of northerly species is found in waters off the northeast of Scotland, including Orkney and Shetland (Daan 2006). A study of North Sea fish assemblages carried out by Callaway *et al*. (2002) using data collected in groundfish surveys found that the 50m depth contour that separates the southern North Sea from the central and northern regions acts as a conspicuous boundary between different fish assemblages. Within the northern North Sea, a number of assemblages were identified, with divisions typically occurring at the 100m depth contour. At depths between 50-100m, the benthic community was dominated by dab and long rough dab. Of species more loosely associated with the seabed, haddock, whiting, herring and plaice were dominant. At depths of between 100-200m, the community was characterised by long rough dab, hagfish (*Myxine glutinosa*) and Norway pout. In the deepest areas of the region, below 200m, assemblages were notable for the low abundances of demersal fish and the prevalence of silvery pout (*Gadiculus argenteus*).

Pelagic species

In the North Sea, there are three sub-populations of herring which spawn at different times. These groups are mixed for the majority of the year, but migrate to different spawning grounds during the breeding season (Daan *et al*. 1990). One of these populations is of importance in the northern North Sea - Buchan / Shetland herring, which spawns off the northeast coasts of Scotland and Shetland in August and September (Coull *et al*. 1998). Juveniles migrate into nursery grounds in coastal areas such as the Moray Firth and the Firth of Forth. North Sea mackerel overwinter in deep water to the east and north of Shetland, before migrating south to spawn between May and August (Coull *et al*. 1998). Spawning may take place as far south as the Dogger Bank. Juvenile fish remain in nursery areas in the shallow waters of the Southern Bight (Coull *et al*. 1998). Other pelagic species

abundant in the region include sprat, which spawns over a wide area of the region within the summer months and the argentines, typically found over deep waters at the continental shelf.

Demersal species

Many of the larger, more commercially valuable gadoid species are more abundant in the deeper waters of the central and northern North Sea. Whiting is one of the most numerous and widespread species. Recaptures of tagged whiting and the use of parasitic markers, show that the populations to the north and south of the Dogger Bank form separate populations (Hislop & MacKenzie 1976). Whiting is one of the major predators of commercially important fish stocks in the North Sea. In the region, major spawning areas are found north of the Dogger Bank and east of Scotland and the spawning season extends from February to June (Coull *et al*. 1998). Much of the North Sea acts as a nursery ground for <1 year old whiting within the pelagic phase, particularly around the east coasts of Scotland and England (Coull *et al*. 1998). Haddock is found throughout the northern North Sea, where spawning takes place during spring between Shetland and the Norwegian Deep, before adults disperse west and into the central North Sea to feed (Albert 1994). During the summer months, the density of juveniles is greatest off the northeast coast of Scotland.

Cod are more abundant in the northern North Sea than in the southern North Sea and there are a number of spawning sites in the region. Nursery areas are most abundant in the eastern North Sea, but the Firth of Forth acts as an important site in the region (Coull *et al*. 1998). Tagging experiments have shown that there is a limited exchange of individuals between the northern North Sea and waters to the west of Scotland, although migrations are generally limited to 200 miles. Young saithe migrate into coastal waters of the north of Scotland, Orkney and Shetland, where they remain for 3-4 years, before recruiting to stocks in the northern North Sea (Newton 1984). There are extensive spawning and nursery grounds for the species in the region. Other large gadoids that are abundant in the region include pollack and ling (*Molva molva*).

Small gadoid species include Norway pout and silvery pout. Norway pout is a small, commercially valuable species of particular importance to the industrial fleet. It is found throughout the central and northern North Sea, typically at depths of between 80-200m. Fish mature at 1-2 years and spawning takes place between January and April on the continental shelf and slightly later in deeper waters. No specific spawning sites have been identified and it is believed that the activity is widely dispersed. Silvery pout is a shelf edge species, commonly found at between 200-500m. They are small, short-lived, benthopelagic fish which spawn from mid-winter to spring. A number of flatfish are present in the region, including plaice, lemon sole, dab and witch (*Glyptocephalus cynoglossus*).

Hagfish are a very primitive group of fish, eel-like and lacking true jaws. They are remarkable for their ability to produce large quantities of mucus. The species is widely distributed throughout the northeast Atlantic in depths of 20-600m, generally in deeper waters, where they favour muddy sediments in which they can bury themselves. They are scavengers of dead and dying fish that have sunk to the seabed, but will also feed on benthic invertebrates (Shelton 1978). Very little is known about their life history, although it is thought that there may be 3 annual spawning events (Grant 2006), during which females produce a small number of large eggs.

Elasmobranchs

The most abundant sharks found in the northern North Sea are the lesser and greater spotted dogfish, spurdog and the tope. Dogfish show a wide but patchy distribution in the

North Sea. Sightings of other species, such as the common skate, basking shark and porbeagle are rare in the northern North Sea (Rogers & Stocks 2001).

Diadromous species

The sea lamprey and river lamprey have both been recorded in the region. Although once an important fishery, lampreys are now rarely caught in large numbers. Rivers in the region, particularly in the northeast of Scotland, have a high concentration of salmon. In particular, the River Tweed supports a large salmon population. Sea trout are also present, but are more abundant on the west coast. The rivers and estuaries of the region provide an important habitat for the European eel (Robson 1996a).

Shellfish

The soft, sandy sediments of the Fladen Ground provide an important habitat for *Nephrops* and *P. borealis*. These species are also found over soft sediments around the Farne Deeps, while important populations of *Nephrops* also exist in the Firth of Forth and the Moray Firth (Lee & Ramster 1981). Scallop grounds may be found along the northern coast of the Moray Firth (Mason 1983). Cockles are particularly abundant in the Firth of Forth and at Findhorn Bay and the Culbin Bars in the Moray Firth (Chapman 2004), while mussels are harvested from the Dornoch Firth. Brown crabs, green and velvet crabs are widespread in coastal waters of the region, as are whelks and periwinkles.

A3a.4.5 Features of Regional Sea 2

Fish community

The southern North Sea is a dynamic ecosystem characterised by a sandy, flat, shallow seabed and considerable tidal mixing. Species diversity within the fish community is greater in the southern North Sea than in the central or northern North Sea (Callaway *et al*. 2002) and within the southern North Sea, fish diversity is greatest in the west (Rogers *et al*. 1998). Callaway *et al*. (2002) found that the southern North Sea is characterised by a high abundance of small demersal species, typically found closely associated with the seabed, including solenette (*Buglossidium luteum*), dab and common dragonet. Of species more loosely associated with the seabed, three distinct assemblages were identified in the region. The two most extensive of these could be characterised by whiting, grey gurnard, horse mackerel and dab. The third assemblage, located in the far south of the region, was characterised by high numbers of horse mackerel and mackerel.

Meanwhile, Corten & van de Kamp (1996) identified twelve, “southern,” species within the North Sea either as those with a greater abundance in the southern North Sea during summer than during winter, or as those with a distribution restricted to the southern North Sea. These species were: poor cod, bib, red mullet (*Mullus surmuletus*), sardine (*Sardina pilchardus*), lesser weever (*Echilichthys vipera*), anchovy (*Engraulis encrasicolus*), tub gurnard (*Chelidonichthys lucerna*), John Dory (*Zeus faber*), bass, black sea bream (*Spondyliosoma cantharus*), horse mackerel and mackerel. Other common species in the southern North Sea include pogge or hooknose (*Agonus cataphractus*), flounder (*Platichthys flesus*) and sand gobies (*Pomatoschistus minutus*) (CEFAS 2007).

Pelagic species

There are two main herring populations of importance in the southern North Sea: Dogger Bank, or Banks, herring, which spawns from August to September or October - traditionally on the Dogger Banks but probably now mostly closer to the English Coast; and Southern

Bight or Downs herring which spawns from November to January in the Southern Bight of the North Sea and the Eastern English Channel (Coull *et al*. 1998), after which pelagic larvae will drift towards important nursery grounds such as the Humber Estuary, Thames Estuary and the Wash. There is also a small spring-spawning stock of herring that spawns within the Thames estuary. North Sea mackerel overwinter in deep water to the east and north of Shetland, before migrating south to spawn between May and August (Coull *et al*. 1998). Spawning may take place in waters as far south as the Dogger Bank and juvenile fish remain in nursery areas in the shallow waters of the Southern Bight (Coull *et al*. 1998).

Sprat are most abundant in the shallow waters of the southern North Sea. Spawning takes place along the east coast of England from May to August with a peak during May and June (Coull *et al*. 1998). Nursery grounds are found around the Southern Bight and Dogger Bank and sprat mature to spawn for the first time at the age of two years. Other clupeids found in the southern North Sea include anchovies (spawn from April to August) and sardines (spawn from June to August). Horse mackerel around the UK are split into two stocks; a western stock and a North Sea stock. The North Sea stock spends most of the year in the central North Sea, Skagerrak and Kattegat, but migrates to the southern North Sea in the summer to spawn (Fishbase website).

Demersal species

Small gadoid species, including poor cod and bib, are typical of the southern North Sea community. Poor cod is found in coastal waters at depths of between 25-300m, where they feed on a range of small crustaceans and fish. The species spawns in winter at depths of between 50-100m. Bib tends to congregate in large schools around reefs and wrecks. They spawn in shallow waters, between March and April.

The Southern Bight is a major spawning area for whiting. The spawning season extends from February to June (Coull *et al*. 1998). Much of the southern North Sea acts as a nursery ground for <1 year old whiting within the pelagic phase, particularly around the mouth of the Thames and on the Dogger Bank (Coull *et al*. 1998). Cod are more abundant in the northern North Sea, but the southern North Sea remains an important area for spawning, with the main spawning season extending from January to April (Coull *et al*. 1998). The southeast North Sea acts as an important nursery ground for 1 and 2 year old cod. Righton *et al*. (2007) showed that there is a significant level of migration of cod from the southern North Sea northwards in spring and summer, although no migration was apparent between the southern North Sea and the English Channel. They also noticed behavioural differences between cod stocks in the region, suggesting different selection pressures may exist in the two areas.

Flatfish of particular importance in the region include solenette and dab, plaice, sole and lemon sole. Plaice is found in greatest abundance in the southern North Sea. Plaice spawn throughout the shallower parts of the southern North Sea, including the Dogger Bank and the Southern Bight, with spawning taking place between December and March. Sandy, shallow bays on the coasts of England and continental Europe act as important nursery grounds for plaice, with juveniles moving further offshore as they mature.

The sole is close to the northern limits of its distribution in the southern North Sea and is confined to areas where temperatures do not fall below 5°C for prolonged periods (Horwood 1993). Consequently, during cold winters, dense aggregations of sole are known to accumulate in deeper, warmer waters (Rogers & Stocks 2001). Sole spawn in shallow, inshore areas and sandbanks between March and May. Major spawning grounds include the Thames Estuary and the Norfolk Banks. Larvae are pelagic for approximately one month, after which they metamorphose into the demersal phase. As a result, local

abundances of <1 year old sole are likely to reflect the spawning success of local spawning aggregations (Beek *et al*. 1989). Nursery grounds are situated in coastal waters at depths of between 5 and 10m.

Elasmobranchs

The most abundant sharks found in the southern North Sea are the lesser and greater spotted dogfish, tope and thornback ray. The outer Thames Estuary is an important nursery area for a number of ray species, including thornback rays, adults of which migrate into Thames Estuary waters less than 10m deep from the wider Southern North Sea to breed in summer (Walker *et al*. 1997). Sightings of other species, such as the common skate, basking shark and porbeagle are rare in the southern North Sea (Rogers & Stocks 2001).

Diadromous species

The rivers and estuaries of southeast England provide an important habitat for the European eel. The up-river migration of elvers in the Thames occurs between April and October, with peak movement of eels in May and June (Naismith & Knights 1988). The sea lamprey and river lamprey are rare in the region, although they once comprised an important fishery in the rivers of southeast England. The allis and twait shad are present in the Thames Estuary. The Atlantic salmon and sea trout are most abundant around the northern and western coasts of the UK, but are also present in the southern North Sea, particularly in the Thames and Stour Rivers (Aprahamain & Robson 1998). Large numbers of sea trout are found off the north coast of Norfolk, feeding on sprat and sandeels, prior to returning to their home rivers in Northeast England.

Shellfish

The main site for *Nephrops* is on the shallow Dogger Bank, while pink and brown shrimp are abundant in the Wash and the Thames and Humber Estuaries. The east coast of England is a site of particularly intense spawning by brown crab (Rogers & Stocks 2001) but they are found throughout the region. Large populations of cockles are found in the Wash and the Thames Estuary. Mussels are abundant in the Wash, as are wild and cultivated oysters along the Essex and Kent coast (Rogers & Stocks 2001). Whelks and periwinkles are widespread in the region. Razor clams, including the introduced species *Ensis directus* as well as native species, are abundant in the Wash and locally elsewhere.

A3a.4.6 Features of Regional Sea 3

Fish community

The English Channel acts as a biogeographical boundary between the western waters and the North Sea for many species, but is also an important migration route for others (DEFRA 2005). The region supports a similar fish community to the southern North Sea and some species, such as plaice, migrate between the regions (Arnold & Metcalfe 1996). While much of the region is shallow with fine sediment on the seabed, some central areas such as the Dover Straights are deeper with coarser sediment and significant tidal streams (Kaiser *et al*. 1999). These habitats support a high diversity of invertebrates which in turn support small gadoids such as bib and poor cod, along with demersal species such as thickback sole (*Microchirus variegatus*) and red gurnard (DEFRA 2005a). Vaz *et al*. (2007) found the region to be strongly spatially structured. The lower temperatures and salinities in coastal areas favour bentho-demersal species (which particularly dominate when the autumn is cool and wet), while further offshore, or in warmer winters, pelagic species (horse mackerel) and demersal species (red mullet) tend to dominate the assemblage.

Species of seahorse (*Hippocampus hippocampus* and *Hippocampus. guttulatus*) occur in the English Channel although they are more common in French waters (DEFRA 2005a). Both species are on the IUCN red list (classified as data deficient).

Pelagic species

Mackerel is a seasonal visitor to the region, as the western spawning stock migrates eastward through the English Channel into nursery and feeding grounds in the southern and central North Sea over the summer months. Herring is abundant in the region, with summer and spring feeding grounds in coastal regions, although there is no major nursery or spawning ground in the region. Horse mackerel are abundant further offshore. Sprat are common in winter particularly in Lyme Bay and between Portland Bill and the Isle of Wight (Pawson & Robson 1998).

Demersal species

Of the gadoids, whiting and cod are common, with important spawning regions off east Sussex. Haddock and saithe are not common in the region, while other gadoids such as ling and pollack can be found around reefs and rocky outcrops (Pawson & Robson 1998).

Plaice and dab are the most abundant flatfish in the region, with important winter spawning taking place in the centre of the Channel. Some of the North Sea population spawns in the English Channel (Houghton & Harding 1976). Dab spawn between January and June and they, along with sole, migrate to coastal nursery waters before moving into deeper waters as they grow. Lemon sole, flounder, turbot (*Psetta maxima*) and brill (*Scophthalmus rhombus*) are also found in the English Channel. Flounder nursery sites may be found in riverine and estuarine areas. Solenette, common dragonet and lesser weever fish are also abundant in the region (Kaiser *et al*. 1999).

Elasmobranchs

The thornback ray and lesser and greater spotted dogfish are present in the eastern English Channel. Large, open water species including blue sharks (*Prionace glauca*), thresher sharks (*Alopias vulpinus*) and porbeagle sharks are occasionally reported. The basking shark is not common in this region, although is occasionally sighted in waters around the Isle of Wight (Swaby & Potts 1998).

Diadromous species

There are no major salmon rivers in the region, although the Rivers Ouse and Rother are important for sea trout. Eels are relatively abundant in the rivers of the south east of England, although sea lampreys are not abundant in the region (Swaby & Potts 1998).

Shellfish

Substantial scallop grounds are found along the coast of this region (Mason 1983). Cockles, mussels, periwinkles and whelks are all present at shorelines. Crabs and lobsters are abundant on rocky ground in the region, with brown crabs typically found further offshore than lobsters. The Solent supports a healthy population of native oysters (*Ostrea edulis*).

A3a.4.7 Features of Regional Seas 4 and 5

Fish community

The Western Approaches may be split into three main regions: the western English Channel, the Celtic Sea and the Bristol Channel. The fish communities of these regions are influenced by the Atlantic Ocean and warm water pelagic species are occasionally reported in the area (Stebbing *et al*. 2002).

The western English Channel is deeper than the eastern Channel, with a steep shelving seabed. Consequently, the fish community is significantly different from that found further east. Monkfish and cuckoo rays, which are virtually absent from the eastern Channel, are relatively abundant in the western Channel (Pawson 1995). The high number of wrecks and reefs in the region provide habitats for pollack and conger eels (*Conger conger*). In the Celtic Sea, offshore species become increasingly abundant with depth, and species such as hake (*Merluccius merluccius*), megrim (*Lepidorhombus whiffiagonis*), long rough dab, blue whiting and boarfish (*Capros aper*) are common (Warnes & Jones 1995). The Bristol Channel contains a number of important spawning and nursery grounds, such as Carmarthen Bay where a number of juvenile rays and flatfish mature. Large numbers of the smalleyed ray (*Raja microocellata*) are present in the Bristol Channel.

Pelagic species

Mackerel is abundant at the shelf edge. Over winter they migrate into coastal waters off Cornwall, with the area acting as an important feeding and spawning ground. Herring are locally abundant, with a limited amount of spring spawning taking place to the south of Cornwall. The western English Channel is notable for the populations of sardine and horse mackerel, which are abundant in the region. Sardines spawn to the south of the Scilly Isles and Land's End (Pawson 1995), while horse mackerel spawn along the western shelf edge. Summer spawning sprat migrate inshore over the winter months. Argentines are also present in the region.

Demersal species

Cod are numerous in the region, thought to move inshore over winter after spending summer feeding around deep water reefs and wrecks (Pawson 1995). Aggregations of spawning cod form in spring off Trevose Head and to the south of Cornwall. Whiting are also abundant in inshore areas and spawns in similar locations to cod, while pollack and saithe are locally abundant, particularly around reefs and rocky outcrops. Haddock are rare in the region, while hake may be found in the deeper waters of the region. The area around the Cornish peninsula acts as an important nursery ground for ling (Pawson 1995). Poor cod and bib are also present.

Plaice and dab are the most commercially important flatfish in the region, although sole and lemon sole are also common. All these species spawn in the area, although the spawning periods are staggered throughout the year, perhaps avoiding competition (plaice from December to March, sole from March to May, lemon sole from April to September). These flatfish tend to move into deeper waters as they mature, with relatively little movement along the coast taking place. Sole is most abundant in the Bristol Channel and tends to be confined to areas with high sea bottom temperatures (Symonds & Rogers 1995).

Bass are abundant in inshore areas from spring as they migrate from warmer waters offshore. Bass spawn in the region from March to May and it is thought that the strongest recruitment takes place when the sea temperature is warmest at this time of year (Pawson *et*

al. 2007). Sandeels are present throughout the region, and other species commonly found include sea bream, John Dory, red mullet, gurnards, conger eel and various wrasse. Rocklings, boarfish, greater pipefish (*Syngnathus acus*), pogge, butterfish (*Pholis gunnellus*), blennies and dragonets have been recorded in CEFAS trawl surveys in this region.

Elasmobranchs

A number of ray species are present in the region, including the thornback ray and the cuckoo ray as well as the smalleyed ray. The thornback ray spawns in shallow bays around the region. Spurdogs and lesser and greater spotted dogfish may also be found, while large, open water species including blue sharks, thresher sharks and porbeagle sharks are occasionally reported. The Cornish coast is an area where basking sharks are particularly common, with numerous sightings reported annually in the summer months.

Diadromous species

Salmon and sea trout are present in many rivers in the region, particularly along the south coast of Wales, as are sea and river lampreys. The Bristol Channel is a particularly important region for shads and lampreys. The Rivers Severn, Usk, Wye and Tywi are known to contain spawning populations of twaite shad, and the allis shad is regularly recorded in the Severn Estuary (Maitland & Hatton-Ellis 2003). Eels are present in rivers throughout the region.

Shellfish

Offshore *Nephrops* grounds exist in the Celtic Sea, to the south of Ireland. Scallops (and to a lesser extent, queen scallops) are abundant on sandy sediments along the coasts of Dorset, Devon and Cornwall and also South Wales (Mason 1983). Brown crabs, green crabs, velvet crabs and lobsters are all abundant in the region, while the spider crab, a species with a south-westerly distribution in UK waters (Clark 1986), is particularly abundant in the region. The Severn estuary, and particularly the Burry Inlet and Carmarthen Bay, provide important grounds for cockles, whelks and razor clams. Crawfish are more abundant off the extreme south west of England and Wales than many other parts of the UK.

A3a.4.8 Features of Regional Sea 6

Fish community

Beam trawl surveys of the fish community of the Irish Sea identified 3 distinct categories of demersal fish (DEFRA 2005a). Sandy, inshore areas are dominated by flatfish species, including plaice, solenette, sole and dab and other bentho-demersal fish such as the tub gurnard, lesser weever fish, dragonets and gobies. The offshore assemblage is characterised by species such as thickback sole, lemon sole and red gurnard as well as by elasmobranchs such as the greater spotted dogfish and the cuckoo and spotted rays (*Raja montagui*). The third grouping is found over muddy sediments found to the west of the Isle of Man and is characterised by the presence of witch and long rough dab. Otter trawl surveys reveal a distinction between western and eastern inshore fish assemblages in the region, with haddock, Norway pout and various clupeid species all more abundant in the west.

Pelagic species

Mackerel is present in the region, particularly over winter off the Welsh coast, but there are no spawning or nursery sites in the region. Herring is the most important pelagic stock in the

Irish Sea, with particularly large abundance around the Isle of Man and Pembrokeshire. Spawning grounds are present to the east, and in recent years to the north, of the Isle of Man (late summer/autumn spawning) and off the Pembrokeshire coast near Milford Haven (spring spawning), with juvenile fish entering nursery grounds along the English and Irish coasts. The Clyde Estuary also supports a spring spawning population. Sprat are widely distributed throughout the region, spawning over a wide area between May and August (Pawson & Robson 1995).

Demersal species

Cod are widely distributed throughout the region in the summer, particularly in the deep water off the coast of Cumbria. Spawning grounds are situated in this area and to the west of the Isle of Man, with an important nursery ground located between the Isle of Man and the coast of Ireland. Whiting is abundant and widely distributed, particularly around coastal areas, while haddock, ling, pollack and saithe are found around wrecks and rocky reefs. Haddock are found in greatest numbers in the deeper waters to the west of the region. Important spawning grounds for whiting exist off the west of England and in Cardigan Bay, between February and June (Parker-Humphreys 2004).

Important flatfish in the Irish Sea include plaice, sole and dab, which are found over sandy areas of the seabed. Spawning areas for these species exist in coastal areas in the east of the region, such as within Cardigan Bay. Lemon sole can be found in deeper offshore areas. Bass and grey mullet are seasonally abundant inshore, with abundance decreasing further north. Sandeels are widely distributed throughout the region and juvenile and some adult monkfish may also be found in coastal waters.

Other demersal species common in the Irish Sea include the poor cod, abundant in the deeper central waters, dragonets and lesser weevers which are particularly abundant in the shallow waters of Liverpool Bay, as well as coastal species such as grey and red gurnards, the thickback sole and the solenette (Parker-Humphreys 2004).

Elasmobranchs

There are a number of sharks and rays present in the region. Lesser and greater spotted dogfish, tope, cuckoo rays, thornback rays and spotted rays are all present, particularly around the north Wales coast and in deeper offshore regions. The Lleyn peninsula is an area of particular abundance for the greater spotted dogfish (DEFRA 2005a). As well as this, the basking shark is often observed in the region, particularly to the south and west of the Isle of Man, but also off the Pembrokeshire coastline.

Diadromous species

Sea trout is abundant in Welsh and other rivers, while sea lamprey, allis and twaite shads and smelt (*Osmerus eperlanus*) have all been recorded in the Dee estuary. Atlantic salmon is also present in various parts of the region (Potts & Swaby 1995).

Shellfish

Nephrops is found in the soft sediments to the east and west of the Isle of Man as well as in the Firth of Clyde. The Irish Sea is an important region for scallops and queen scallops, with large grounds in Cardigan Bay, around the Isle of Man, the Solway Firth, Morecambe Bay and around islands in the Firth of Clyde. Cockles and oysters are also abundant throughout the region, particularly in the Solway Firth. Lobsters and brown crabs are abundant, particularly on the rocky shores of North Wales and the Lleyn Peninsula, while spider crabs

are also present in the region (Clarke 1986). Whelks are also abundant in places, including around the Isle of Man and off the North Wales coast.

A3a.4.9 Features of Regional Sea 7

Fish community

The Minch and the firths along the west coast provide important sheltered, inshore nursery grounds for many species. The fish assemblage in this region is comprised mainly of the gadoids haddock, hake and whiting and Norway pout as well as small pelagic species such as sprat (Gordon 1981). There is a high diversity of small bentho-demersal species including flatfish, gobies and blennies in the shallow, warm waters and sheltered sea lochs (Potts & Swaby 1997).

Pelagic species

A small number of mackerel migrate into the Minch after spawning in the autumn, although recent changes in the normal migration route has led to a decrease in numbers (Bryan 1994, cited by Robson 1997). Herring migrate into the Minch in winter, following spawning. A number of spawning cohorts exist to the west of Scotland, with spawning taking place to the south east of the Outer Hebrides, to the west of the Hebrides and to the north of Skye from August to September and again in the latter two sites in March and April. Larvae from the west coast spawning populations may be carried into the North Sea, mixing the stocks (Heath & MacLachlan 1986, cited by Robson 1997). Sprat is very common in winter in the Minch. Sprat spawn over the summer and juveniles use the sea lochs and firths of the coastline as nursery areas.

Demersal species

Cod spawn to the north of the region in the early months of the year with peak activity in February. The Minch is an important nursery ground for juveniles. Whiting and Norway pout also spawn in the area. Whiting, saithe, haddock and Norway pout are among the other gadoids that use the region as a nursery ground. Haddock are widespread in the area throughout the year.

Plaice, lemon sole and sandeels use the region as spawning and nursery grounds and are present throughout the year. Other demersal species abundant in the region include bib, cuckoo wrasse (*Labrus mixtus*), common dragonet, butterfish, bullrout, pogge, topknot (*Zeugopterus punctatus*) and red and grey gurnards. A number of gobies and blennies, at the northern edges of their distributions, inhabit the lochs of the region, including the tompot blenny (*Parablennius gattorugine*), black goby (*Gobius niger*) and butterfly blenny (*Blennius ocellaris*) which are more typically found in waters to the south west of the UK (Howson 1990, cited by Potts & Swaby 1997). The leopard spotted goby (*Thorogobius ephippiatus*) and Fries' goby (*Leseurigobius friesii*), reportedly rare in most UK waters, are frequently recorded in the sheltered sea lochs of the region. The former is a shy species that is rarely caught by remote methods, and is almost certainly not as rare as once thought. It is regularly observed by divers by its preferred habitat of small crevices or fissures (e.g. MacDougall 2002).

Elasmobranchs

The lesser spotted dogfish, common skate, cuckoo ray, nursehound (*Scyliorhinus stellaris*) and thornback ray have all been recorded in the Minch. The coastal waters of the west of

Scotland are notable for the high abundance of basking sharks, particularly in the summer (Robson 1997).

Diadromous species

Sea trout and salmon are abundant in the rivers and lochs of this region. Important lochs for these species include Loch Ewe, Loch Morar, Loch Shiel and Loch Lochy. Eels are likely to be present in the region. The twaite shad and allis shad have also been recorded in the region (Robson 1997).

Shellfish

The waters the Minch provide important habitats for *Nephrops*. The seabed in the region is soft and muddy and the species can be found in greatest abundance from the west of Skye to the Stanton Bank, between Islay and Jura and along the Kintyre Peninsula (Chapman 2006). *Nephrops* may also be found in the sea lochs around the coast of the mainland. Two species of shrimp are abundant in the region, *P. montagui* and the similar *Dichelopandalus bonnieri* (which typically has a more western distribution (Lee & Ramster 1981)). Scallops and queen scallops are abundant in sandy areas around the islands. Lobsters are present in greatest numbers around rocky areas of the coasts of the Hebridean Islands, while brown crabs are common throughout the region (Chapman 2006). Cockles are present, although individual cockle beds in the region are not large (Chapman 2006). Razor clams, whelks, periwinkles and velvet crabs are also abundant in the region and crawfish are present.

A3a.4.10 Features of Regional Sea 8

Fish community

The Scottish continental shelf is an ecosystem characterised by oceanic inflows from the Atlantic Ocean, such as the warm continental shelf current. To the west of the Hebrides and around the north coast of the Scotland, haddock, whiting, Norway pout, poor cod and grey gurnards dominate the assemblage. In deeper water along the shelf edge silvery pout, bluemouth (*Helicolenus dactylopterus*) and the hollowsnout rattail (*Caelorinchus caelorhincus*) are key members of the community (DEFRA 2005a).

Pelagic species

This region is an area of mixing between the western and North Sea mackerel stocks with mackerel originating from both. Limited spawning takes place around Shetland and Orkney during the summer feeding migration, but the majority of the stock goes past the islands to feed in the deep waters at the shelf edge to the northwest of Shetland (Gordon 2006). However, during the return trip in autumn, most of the stock passes around Shetland. The western mackerel stock spawns from March to July in waters to the west of the Hebrides (Coull *et al*. 1998). Herring is locally abundant in the region, particularly when feeding in summer and autumn, and also around Orkney and to the southwest of Shetland during the late summer spawning period (Gordon 2006). To the west of the Hebrides, spawning takes place from March to April and again in late summer (Coull *et al*. 1998). Sprat is abundant with spawning occurring around the west and north coasts of the mainland. In some years, sprat is present around the coast of Shetland during migration, but their presence is irregular and unpredictable (Lee & Ramster 1981). Blue whiting is very abundant in deep waters to the north of Orkney in February, and spawning takes place between February and April along the continental slope to the west of Scotland at depths of 300-600m (Gordon 2006). After spawning, fish disperse to the North and Norwegian Seas to feed (Gordon 2006).

Juvenile blue whiting remain on the nursery grounds for 2-4 years before returning to spawn (Gordon 2006).

Demersal species

Cod, haddock and whiting are all abundant in the region, with cod widely distributed off Orkney in the summer and whiting abundant in inshore waters. Spawning areas for these species exist to the west and north of the Hebrides and in the case of whiting, to the west of Shetland. Ling, pollack and saithe are also present, with saithe particularly abundant around Shetland. Norway pout is abundant in offshore regions and spawns around the shelf from January to April and further offshore a few months later (DEFRA 2005a).

Plaice, dab and long rough dab are abundant in areas of sandy seabed, while megrim and witches are more abundant in the deeper waters of this region than elsewhere. Megrim is particularly abundant to the northwest of Orkney. The main area for witches in the North Sea lies to the east of Orkney. Halibut, which are rare elsewhere, are frequently found off the coast of Shetland. Flounders spawn offshore in late winter. Monkfish and gurnards are also abundant in the area, with juvenile monkfish and non-spawning adults found in inshore regions of Orkney and Shetland. Sandeels are common in sandy areas across the region. A number of cold water (boreoarctic species) such as Vahl's eelpout (*Lycodes vahlii*), Esmark's eelpout (*Lycodes esmarkii*) and the wolf-fish (*Anarhichas lupus*) are present in the northern parts of the region (DEFRA 2005a).

Elasmobranchs

The spurdog, lesser spotted dogfish, thornback ray and cuckoo ray are all abundant in the region. Porbeagle sharks have been reported to gather south of Sumburgh Head in Shetland to give birth (Swaby & Potts 1997). The basking shark is frequently observed throughout this region, particularly west of the Hebrides. The common skate, listed as endangered by the IUCN, is relatively abundant in northern parts of the Scottish continental shelf, particularly around Shetland.

Diadromous species

There are few rivers in the region to support populations of salmon. Lochs such as the Loch of Spiggie in Shetland, contain sea trout, while eels can be found in the small rivers of Orkney and the Hebrides.

Shellfish

The most important shellfish species on the Scottish continental shelf and slope is *Nephrops*, which is found on suitable sediments across the region down to depths of 600m (Chapman 2006). The shrimps *P. montagui* and *D. bonnieri* are also abundant. Lobsters and brown and velvet crabs are present in coastal regions, including the east of the Hebrides, the north of Scotland, Orkney and Shetland. Cockles, mussels and whelks are abundant around the coasts of Orkney and Shetland (Chapman 2006).

A3a.4.11 Features of Regional Seas 9, 10 and 11

These Regional Seas may be characterised as offshore, deep water regions and consequently the fish assemblages found here are quite different from those of other regions. Most of the key pelagic and demersal species from Regional Sea 8 will still be found in these regions, but there will be fewer small, coastal species and a number of deep water species. This section will therefore concentrate on the deep water communities.

The Faroe Shetland Channel is separated from the deep shelf edge waters to the west of Scotland by the Wyville Thomson Ridge, which rises to a depth of approximately 500m. This separation means that the fish communities on either side of it are quite distinct, particularly below 500m (Gordon 2001). At this depth, the water of the Faroe Shetland Channel is cold and comprised mainly of Norwegian water, while to the west, water is of warmer Atlantic origin. The continental slope margin of the Faroe Shetland Channel may be divided into three zones: an upper slope, the transition zone and the deep Norwegian Sea zone (Bullough *et al*. 1998).

The upper slope zone lies approximately between 200-500m depth and is characterised by Atlantic water with temperatures similar to those of the west coast. The dominant species found in this region are rabbitfish (*Chimaera monstrosa*), Norway redfish (*Sebastes viviparus*), bluemouth and blue whiting (Gordon & Swan 1997, cited by Gordon 2006). A similar community can be found at similar depths in Regional Seas 10 and 11, although redfish (*Sebastes* spp.) are less abundant to the west of the Hebrides (Gordon 2003).

The transition zone was identified by Bullough *et al*. (1998) and defined as the area of the slope where the bottom temperature changes rapidly with depth in the transition between the warm Atlantic water and the cold Norwegian Sea water. The main species identified by Bullough *et al*. (1998) were the Greenland halibut (*Reinhardtius hippoglossoides*) and roughhead grenadier (*Macrourus berglax*) (which are associated with cold water overflows (Gordon 2003)) along with blue ling (*Molva dypterygia*), tusk (*Brosme brosme*), two species of redfish (*S. marinus* and *S. mentella*) and the Arctic skate (*Amblyraja hyperborea*). This assemblage is quite diverse and similar to that of the Norwegian continental shelf margin. A number of these species, such as the Greenland halibut and the roughhead grenadier, are rare to the west of the Wyville Thomson Ridge (Gordon 2003). Analysis of the results of MAFF (Ministry of Agriculture, Fisheries and Food) surveys carried out in the mid 1970s (Gordon and Swan 1997, cited by Gordon 2006) suggests that the transition zone in the Faroe-Shetland Channel occurs approximately between 625-785m depth.

The deep Norwegian Sea water lies below the transition zone and is an area of low biomass and diversity. In surveys carried out by SAMS (Scottish Association for Marine Science) in 1996 at depths of 1060m and 1520m, a number of species of eelpout were identified as well as the Greenland halibut and Arctic skate.

Over 120 demersal fish species have been identified on the continental slopes to the west of Scotland below 400m depth (Gordon *et al*. 1994). There is no evidence of zonation in the fish assemblage in deep waters to the west of Scotland, such as is seen in the Faroe-Shetland Channel. The slope is characterised by a gradual decrease in temperature with depth and as each species occupies its own, highly variable, depth range, there is also a gradual change in the fish fauna with depth (Gordon 2003). Key members of the deepwater community in Regional Seas 10 and 11 include ling, blue ling, tusk, roundnose grenadier (*Coryphaenoides rupestris*), argentines, black scabbardfish (*Aphanopus carbo*), orange roughy (*Hoplostethus atlanticus*) and greater forkbeard (*Phycis blennoides*). There is a greater abundance of elasmobranchs to the west of Scotland than in the Faroe Shetland Channel with deepwater sharks such as the leafscale gulper shark (*Centrophorus squamosus*) and the blackmouth dogfish (*Galeus melastomus*) present (Gordon *et al* 1994). Within the Rockall Trough, the dominant species at 250m depth are silvery pout, bluemouth and blue whiting, while in deeper waters a variety of morid cod, grenadiers, arrowtooth eels and deep water sharks dominate (Gordon & Bergstad 1992).

A3a.4.12 Evolution of the baseline and environmental issues

Recent research has suggested that there have been substantial changes in the fish communities in the northeast Atlantic during the 20th Century. These communities consist of species that have complex interactions with one another and the natural environment. Fish species will undergo natural variation in population size, largely as a result of year to year variation in recruitment success. These population trends will be influenced by human exploitation and broad-scale climatic and hydrological variations.

A3a.4.12.1 Climate

As well as coming under severe pressure from anthropogenic factors, fish communities are likely to be affected by future climate change. Climate change may influence fish distribution and abundance through affecting growth rates, recruitment rates, behaviour, survival and responses to changes at other trophic levels, although exact responses are very difficult to predict. This could have a major effect on the community structure of the region. Sea surface temperatures (SST) in the North Sea are predicted to rise by between 0.5-1^{0}C by 2020 and by up to 4^{0}C by 2080 (Hulme *et al*. 2002).

Alheit & Hagen (1997) analysed data on herring and sardine landings at ports around the English Channel and southern North Sea dating back to the 10th Century. They found that large landings of herring were correlated with cold winter weather, while warm winters lead to large catches of sardine. Perry *et al*. (2005) showed marked changes in the distributions of North Sea fish over the past 25 years with the distributions of two-thirds of species having shifted in mean latitude. They found a northwards shift in the southern or northern population boundaries of a number of species had occurred. The northern boundary of bib, a southern North Sea species, was shown to have moved northwards by 342km between 1978 and 2001. Based on the projected SST increases of Hulme *et al*. (2002), Perry *et al*. (2005) predicted that the bib population may extend over the entire North Sea by 2080, while blue whiting may have retracted from the region by 2050. Drinkwater (2005) predicts that cod stocks in the Celtic and Irish Seas will have disappeared by 2100 as a result of temperature and hydrodynamic changes. Recent studies have shown that anchovy and sardines, which were absent from the North Sea until the mid 1990s, have extended their distribution as far north as the west coast of Norway (Brander *et al*. 2003). Changing temperature may also affect the habitat of species. Hedger *et al*. (2004) found that North Sea aggregations were present in deeper water in the 1990s than the 1980s.

Twelve fish species which were classified as typical southern North Sea species by Corten & van de Kamp (1996) were observed by Beare *et al*. (2004) to have increased in abundance dramatically in the northern North Sea since the mid 1990s. An invasion of bluemouth that was recorded in the winter of 1990-1991 has persisted, with oceanic inflow from the Atlantic suspected to have been a major contributing factor (Heessen *et al*. 1996). Snake pipefish (*Entelurus aequoreus*) has also shown a dramatic increase in northern European waters since 2003 (Harris *et al*. 2007) and the species is now found as far north as Svarlbard (Fleischer *et al*. 2007). This species is increasingly recorded as being part of the diet of seabirds around the UK coast, but the rigid, bony structure makes it a difficult prey for birds to swallow and there are numerous reports of chicks choking to death on their meal (Harris *et al*. 2007). Red mullet (*Mullus surmuletus*) abundance has also been reported to have dramatically increased in the northern North Sea since 1995, with almost none having been recorded in the previous 70 years (Beare *et al*. 2005). It has been speculated that red mullet caught in the northern North Sea have migrated north for the winter months from an expanding southern North Sea population (Beare *et al*. 2005). Bass also appear to be breeding further north.

Changes in species composition may mean a change in the community structure. Vaz *et al*. (2007) detected an increase in species diversity in the English Channel community between 1997-2002, and sightings of a number of warm water fish such as blue-fin tuna (*Thunnus thynnus*), grey triggerfish (*Balistes capriscus*), large pelagic sharks and seahorses have increased (Stebbing *et al*. 2002). In contrast, the spurdog (and a number of other sharks and rays) has largely disappeared from reported catches in the southern North Sea and English Channel since 1999 (Vaz *et al*. 2007).

Dippner (1997) found a high correlation between SST and variability in the recruitment of cod, whiting and mackerel in the North Sea. A decline in the survival of cod larvae (and consequently, recruitment) in the North Sea since the mid 1980s has been linked to a change in the copepod community and particularly to a decline in abundance of *Calanus finmarchicus*, an important prey item for larval cod (Beaugrand *et al*. 2003). The distribution of basking sharks in recent years has been positively correlated with sea temperature, a pattern that may be linked to the distribution of the warm water copepod *Calanus helgolandicus* (Cotton *et al*. 2005).

A changing climate may also affect migration routes of some species. There has been a northerly shift in the mackerel spawning grounds and a change in the timing of adult migration into these grounds with the result that fewer mackerel now pass through the Minch during their migration (Walsh *et al*. 1995). The timing of spawning may also be affected, with Greve *et al*. (2001) (cited by Pinnegar *et al*. (2008)) noting the earlier appearance of fish larvae in the southern North Sea in recent years. Flounder has been observed to undertake spawning migrations up to two months earlier in cooler conditions (Sims *et al*. 2004), while the navigation of salmon back to home rivers may be severely affected as it relies on a range of environmental cues, potentially affecting recruitment success (Pinnegar *et al*. 2008). Recent CEFAS tagging studies have shown that adult bass are more likely to remain close inshore over winter than during the 1970s and 1980s, with less evidence of pre-spawning migrations from the North Sea to the western English Channel (Cefas 2008).

Shellfish populations are often strongly tied to particular sediment types and so distributions of these species may be less likely to change with time than those of free-swimming fish. However, it has previously been noted that the settlement of many bivalve species (e.g. cockles, mussels) is dependent on a range of environmental factors (Chapman 2004). As a result, significant changes in the environment may cause low stock recruitment and potentially the disappearance of a species from a ground. Changing environmental conditions may also affect the distributions of migratory crustaceans, such as lobsters and crabs.

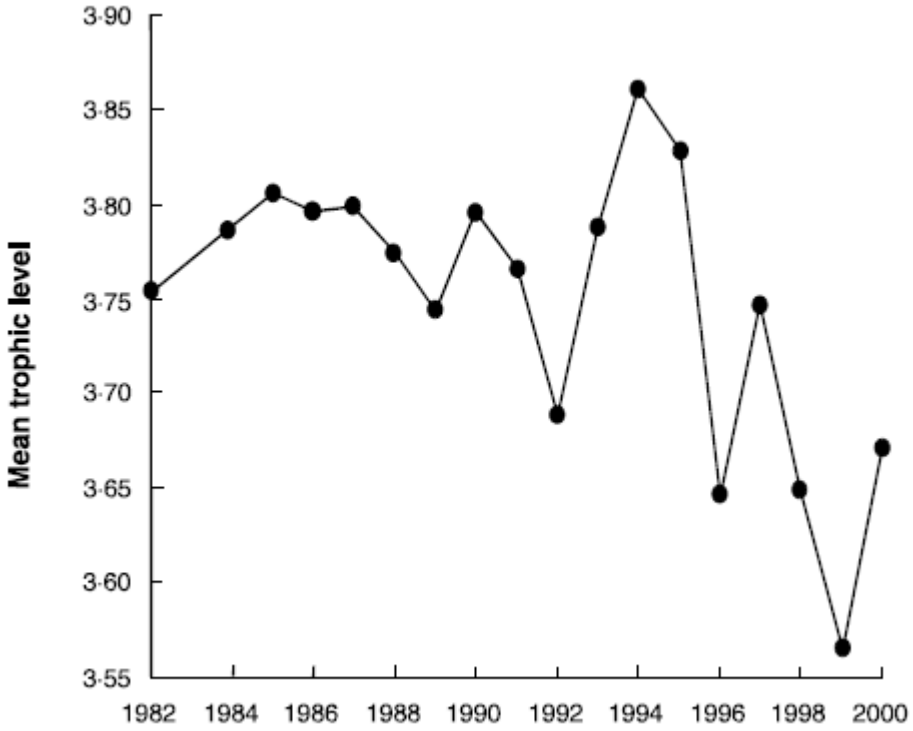
A3a.4.12.2 Overfishing

Many fish are subject to considerable fishing pressure, which will act to reduce biomass of commercially valuable species and, potentially, non-target species. The cod populations around the UK are currently threatened, with spawning stock biomass well under the recommended minimum level, due in part to unsustainable harvesting (ICES 2008). The benefits of sustainable management of fish stocks can be seen in the herring population. Following a collapse in the early 1970s, the spawning stock biomass of this species has risen to healthy levels, with a short moratorium (1977-1981) and subsequent technical measures ensuring careful management and sustainable harvesting (ICES 2008).

The impact of fisheries has had a role in changing the species dominance by the selective removal of large fish (generally the most fecund individuals within species) from the

community and from individual populations (Rogers *et al*. 1998). Overfishing will tend to result in a decrease in the mean trophic level of the fish community (Pinnegar *et al*. 2002) as large, predatory fish are targeted – see Figure A3a.4.6 which summarises data from the Celtic Sea - but an increase in diversity (Bianchi *et al*. 2000). An example may be seen in the southern North Sea, where plaice and dab have been replaced by the likes of dragonet and poor cod over the course of the 20th Century (Rogers & Ellis 2000).

Figure A3a.4.6 – Mean trophic level of fish in Celtic Sea, 1982-2000



Source: Pinnegar et al. (2002)

The ICES reports of the Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems (ICES 2007, ICES website), provide valuable insights to population status and trends over time for the majority commercial exploited fish species.

Very large declines in eel populations since the 1970's have been reported throughout Europe, including Britain. The number of new glass eels entering European rivers declined to 10% of former levels and recent figures show that this has now dropped to 1% (ICES website).

A3a.4.12.3 Trophic interactions

Fish are important components of marine ecosystems, operating at a number of trophic levels. Consequently, fish populations will be determined by both top-down factors, such as predation, including fishing, and bottom-up factors, such as ocean climate and plankton abundance. Fish are an important prey item for the top marine predators including seabirds, cetaceans and humans, and small planktivorous species such as sandeels and herring act as important links between zooplankton and top predators (Frederiksen *et al*. 2006). The influence that fish abundance can have on predators is best illustrated by sandeels, which

have declined in abundance dramatically in recent years, with sandeel landings in the North Sea decreasing by over 50% since 2003 (Frederiksen *et al*. 2006). This decline has coincided with a series of breeding failures amongst sandeel dependent seabirds such as puffins (*Fratercula arctica*) and kittiwakes (*Rissa tridactyla*). Declines in sandeel populations have also been linked with increased rates of starvation in harbour porpoise (*Phocoena phocoena*) (MacLeod *et al*. 2007), although the quality of the evidence that supports this suggestion has been questioned (Thompson *et al*. 2007).

A3a.4.12.4 Sensitivity to contamination

A significant source of contamination is that of riverine discharge, which may result in toxic algal blooms which can result in fish and shellfish kills and shellfishery closures. Hormonal disruption of flounder through oestrogenic contamination has been observed around UK estuaries (Allen *et al*. 1999). Hormonal disruption through contamination also occurs in gastropod and bivalve shellfish. Female whelks and dog whelks (*Nucella lapillus*) exposed to tributyltin (TBT), an antifoulant used on the hulls of boats until 1987, have been reported to develop male sex organs (Polockzanska & Ansell 1999). This condition, called imposex, can have significant impacts on the reproductive success of a population.

The effects of contamination from oil on demersal fish have been assessed in a number of species both in the field and in the laboratory. A number of indicators of hydrocarbon contamination, such as the activity of certain enzymes in the liver, may be used to investigate this. Within two weeks of the *Sea Empress* spill off the coast of Pembrokeshire, Kirby *et al*. (1999) collected dab and plaice samples from near to the site. They found elevated hepatic enzyme activity, providing evidence of significant levels of hydrocarbon contamination. Aas & Klungsøyr (1998) concluded that cod and haddock were not significantly affected by locally elevated poly-aromatic hydrocarbon (PAH) concentrations surrounding platforms in Norwegian waters.

A3a.4.12.5 Conservation frameworks

In addition to fisheries management measures, a number of conservation frameworks apply to fish species within UK waters (see Table A3a.4.2). The *Wildlife and Countryside Act 1981 (as amended)* applies to territorial waters and lists (Schedule 5) several species of marine and estuarine fish which receive protection under the Act. The Act makes it an offence (subject to exceptions) to kill, injure, or otherwise disturb any wild animal listed on the schedule and prohibits interference with places used for shelter or protection by these species. The Act does not apply in Northern Ireland, where the equivalent is the Wildlife (Northern Ireland) Order 1985 (although no marine fish are covered by this Act). European Protected Species (Annex IV species) receive protection via the various UK Habitats Regulations. The 2007 amendments to these Regulations resulted in consequential amendments to the Wildlife and Countryside Act with respect to whole or partial removal from Schedule of the Act 5 of European Protected Species to ensure consistency of regulation. There are six diadromous species that require the designation of SACs (Special Area of Conservation) in UK waters under Annex II of the EC Habitats Directive, although the salmon is only protected in freshwater habitats. Other diadromous species are protected under Annex IV or V, which offer protection against deliberate disturbance, capture or killing.

As well as this, a number of species of relevance in the northern North Sea have been listed under Annex V of the OSPAR list of threatened and/or declining species and habitats and by CITES (Convention on International Trade in Endangered Species), an international agreement between governments to regulate international trade in wild animals and plants. A number of species are also listed on the IUCN (International Union for the Conservation of

Nature) Red List of Threatened Species. A number of fish species are also the subject of UK Biodiversity Action Plans (BAPs), as priority species. As well as a UK wide list, individual lists exist for Scottish, Welsh and Northern Irish species and there is some variation between these lists.

Table A3a.4.2 – Marine fish afforded protection under national legislation and international conventions

Species	Wildlife and Countryside Act[1]	EC Habitats Directive	OSPAR	CITES	IUCN	Biodiversity priority species
Pelagic fish						
Mackerel (*Scomber scombrus*)						UK list + Wales
Herring (*Clupea harengus*)						UK list + Wales & Scotland
Horse mackerel (*Trachurus trachurus*)						UK list + Wales
Blue whiting (*Micromesistius poutassou*)						UK list
Northern bluefin tuna (*Thunnus thynnus*)			Y		Data deficient	UK list
Demersal species						
Atlantic cod (*Gadus morhua*)			Y		Vulnerable	UK list + Wales & Scotland
Whiting (*Merlangius merlangus*)						UK list + Wales & Scotland
Saithe (*Pollachius virens*)						Scotland only
Hake (*Merluccius merluccius*)						UK list + Wales & Scotland
Ling (*Molva molva*)						UK list + Wales & Scotland
Blue ling (*Molva dypterygia*)						UK list
Tusk (*Brosme brosme*)						Scotland only
Norway pout (*Trisopterus esmarkii*)						Scotland only
Monkfish (*Lophius piscatorius*)						UK list + Wales
Black scabbardfish (*Aphanopus carbo*)						UK list
Roundnose grenadier (*Coryphaenoides rupestris*)						UK list
Norway redfish (*Sebastes*						Scotland only

Species	Wildlife and Countryside Act[1]	EC Habitats Directive	OSPAR	CITES	IUCN	Biodiversity priority species
viviparus)						
Plaice (*Pleuronectes platessa*)					Least concern	UK list + Wales & Scotland
Sole (*Solea solea*)						UK list + Wales
Deepwater sole (*Bathysolea profundicola*)						Scotland only
Atlantic halibut (*Hippoglossus hippoglossus*)					Endangered	UK list
Greenland halibut (*Reinhardtius hippoglossoides*)						UK list
Giant goby (*Gobius cobitis*)	Schedule 5					
Couch's goby (*Gobius couchii*)	Schedule 5					
Sandeel (*Ammodytes marinus*)						UK list + Wales & Scotland
Sandeel (*Ammodytes tobianus*)						Scotland only
Short snouted seahorse (*Hippocampus hippocampus*)	Schedule 5 (England only)		Y	Appendix II	Data deficient	UK list
Long snouted seahorse (*Hippocampus guttulatus*)	Schedule 5 (England only)		Y	Appendix II	Data deficient	UK list + Wales
Orange roughy (*Hoplostethus atlanticus*)			Y			UK list
Commercial marine fish						NI only
Deepwater fish species						NI only
Elasmobranch species						
Basking shark (*Cetorhinus maximus*)	Schedule 5		Y	Appendix II	Vulnerable	UK list + Wales, Scotland & NI
Tope (*Galeorhinus galeus*)					Vulnerable	UK list + Wales
Spurdog (*Squalus acanthias*)			Y		Vulnerable	UK list + Wales
Porbeagle (*Lamna nasus*)			Y		Vulnerable	UK list + Wales
Blue shark (*Prionace glauca*)					Lower risk / Near threatened	UK list + Wales
Shortfin mako (*Isurus oxyrinchus*)					Lower risk / near threatened	UK list
Angel shark (*Squatina*	Schedule 5 (England only		Y		Critically endangered	UK list + Wales

Species	Wildlife and Countryside Act[1]	EC Habitats Directive	OSPAR	CITES	IUCN	Biodiversity priority species
squatina)	– not between 6-12nm of coast)					
Gulper shark (*Centrophorus granulosus*)			Y		Vulnerable	UK list
Leafscale gulper shark (*Centrophorus squamosus*)			Y		Vulnerable	UK list
Portuguese dogfish (*Centroscymnus coelolepis*)			Y		Near threatened	UK list
Kitefin shark (*Dalatius licha*)					Data deficient	UK list
Common skate (*Leucoraja batis*)			Y		Critically endangered	UK list + Wales, Scotland & NI
Spotted ray (*Raja montagui*)			Y		Least concern	
Sandy ray (*Leucoraja circularis*)						UK list
Undulate ray (*Raja undulata*)						UK list + Wales
White skate (*Rostroraja alba*)			Y		Endangered	UK list + Wales
Thornback ray (*Raja clavata*)			Y		Lower risk / Near threatened	Scotland only
Diadromous species						
European sturgeon (*Acipenser sturio*)	Schedule 5 (not Scotland)	Annex II & IV	Y	Appendix I	Critically endangered	UK list + Wales & Scotland
Allis shad (*Alosa alosa*)	Schedule 5	Annex II & V	Y		Least concern	UK list + Wales, Scotland & NI
Twaite shad (*Alosa fallax*)	Schedule 5	Annex II & V			Least concern	UK list + Wales, Scotland & NI
River lamprey (*Lampetra fluviatilis*)		Annex II & V			Least concern	UK list + Wales & Scotland
Sea lamprey (*Petromyzon marinus*)		Annex II	Y		Least concern	UK list + Wales & Scotland
Smelt (*Osmerus eperlanus*)					Least concern	UK list + Wales, Scotland & NI
Whitefish (*Coregonus lavaretus*)	Schedule 5	Annex V	Y		Vulnerable	UK list + Wales & Scotland
European eel (*Anguilla anguilla*)			Y	Appendix II (from March 2009)	Critically endangered	UK list + Wales & Scotland
Atlantic salmon (*Salmo salar*)		Annex II (freshwater only)	Y		Least concern	UK list + Wales & Scotland

Species	Wildlife and Countryside Act[1]	EC Habitats Directive	OSPAR	CITES	IUCN	Biodiversity priority species
Sea trout (*Salmo trutta*)					Least concern	UK list + Wales
Commercial Shellfish species						
Crawfish (*Palinurus elephas*)						UK list + NI
Native oyster (*Ostrea edulis*)			Y			Scotland & NI
Horse mussel (*Modiolus modiolus*)						NI only
Dog whelk (*Nucella lapillus*)			Y			

Note: [1]Does not apply to Northern Ireland and may vary between England, Wales and Scotland. Information sourced January 2009