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Report to the
Department of Trade and Industry

Fish & Fisheries in the SEA4 Area

Prepared by

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Executive Summary

SEA4 is the most northerly of the Strategic Environmental Assessment area extending from the north coast of mainland Scotland to the boundary with the Faroese EEZ. The southern boundary is a mostly rocky coastline, subject to strong currents and with few estuaries or sea lochs. The eastern boundary, after passing through the Orkney islands and to the east of the Shetland islands, traverses the continental slope and ends at the most northerly point of the EEZ at a depth of about 2400 metres. From this point the boundary extends along Faroe Shetland to the Wyville-Thompson Ridge where it has a depth of about 1000 metres. The western boundary crosses the west of Shetland continental shelf to Cape Wrath. Within these boundaries SEA4 encompasses a wide range of ecosystems from the coastal fringes of mainland Scotland, the island groups of Orkney and Shetland, the west of Shetland shelf, the continental slope of the Faroe Shetland Channel, some of the deepest parts of the Faroe Shetland Channel and a segment of the Norwegian Sea basin.

SEA4 is effectively the link between the North Sea and the west of Scotland. For fisheries management the International Council for the Exploration of the Sea (ICES) has divided the northeast Atlantic into Sub-areas. SEA4 lies within two major Sub-areas: Sub-area IV (North Sea) and Sub-area VI (West of Scotland). The boundary between these two Sub-areas is 4° W. This boundary has no biological meaning and there is free movement of fish between the areas. These Sub-areas cover very large areas and are further divided into Divisions and for some fish species into Sub-divisions. The smallest area for which statistical information on fisheries is available has been used in this report. However, these areas are still large compared to the ICES statistical rectangles representing one degree of longitude and 0.5 degree latitude (approximately 30 X 30 nautical miles). International data at this level is not widely available and in this report only landings data for Scottish vessels supplied by Fisheries Research Services is used. The separate assessment and management of most North Sea and west of Scotland fish stocks complicates the description of the fisheries of the SEA4 area.

Relevant aspects of the biology of 28 species or species groups have been described. Brief descriptions are given of the fishery for each species, including the method of fishing and the long term trends in the landings from each of the management areas are described. The primary management tool in the ICES area is a Total Allowable Catch (TAC). When a TAC becomes restrictive it can lead to under-reporting of catches or the reporting of landings to another area where the TAC is not restrictive. This is a particular problem in the SEA4 area for several of the important commercial species such as herring, mackerel and anglerfish and the adjustments made to compensate for this in assessing the status of the stocks have been described.

The SEA4 area also has some unique features in terms of fishery management. The Shetland Box limits the fishing activities of larger vessels around Orkney and Shetland and industrial fisheries are prohibited in the Norway pout box lying to the east of the SEA4 area. The shellfish fisheries around Shetland (excluding Norway lobster) are managed locally under a Regulatory Order. There is a separate management scheme for the Shetland sandeel fishery and in 2001 there was an emergency seasonal closure of trawling grounds west of Shetland as a cod conservation measure.

Several fish communities are recognised in the area including, coastal, northern shelf and outer shelf/shelf edge. However, it is the deep-water communities of SEA4 that are unique to the UK EEZ. The widely used upper, mid and lower slope categories are irrelevant because of the very rapid change in temperature below the sill depth of the Wyville-Thompson Ridge at about 500 m. Shallower than 500 m the fish community has many affinities with that of the Atlantic continental slope to the west of the Hebrides. In the transition zone between the Atlantic and colder Norwegian Basin water the fish community mostly comprises species that are seldom if ever encountered in the warmer Atlantic. Below the transition zone the fish fauna is sparse and unique to this area. Most of our knowledge of the biology and ecology of these deep-water communities is inferred from studies of the similar fauna of the Norwegian continental margin.

Fisheries are very important in the SEA4 area. There are several demersal fisheries of which the mixed fishery for cod, haddock and whiting is the most important. However, there are serious concerns about the status of these stocks and a stringent recovery plan is being introduced. The saithe and Norway pout fisheries appear to be sustainable at present levels of exploitation. Anglerfish are an important bycatch of most of these fisheries and there are concerns about their sustainability. The relatively new fishery for Greenland halibut in the transition zone is not currently assessed. The main pelagic fisheries are for herring and mackerel. The herring fishery has had many problems in the past but at present appears to be sustainable at present levels of exploitation. The mackerel is a highly migratory species and SEA4 is a feeding area for two stocks. Changes in migration routes have resulted in changes to the pattern of fishing and consequently to misreporting of catches. There are concerns about the status of the stock. The most important industrial fishery is for sandeel and the interaction between sandeels and the seabird colonies of Shetland is a significant factor. The sandeel fishery was closed for some years and is now strictly regulated. Blue whiting is exploited along the upper slope and there are concerns about the sustainability of this highly migratory species. The most important offshore static gear fishery is the longline fishery for ling and tusk. Close to Orkney and Shetland creel fisheries for various shellfish are important. The Shetland fishery for all shellfish, except Norway pout, is managed locally under a regulatory order.

The SEA4 area is important for fisheries and in an effort to avoid conflict between the oil and gas industry and the fishing industry in what is generally considered to be an extreme environment, UKOOA and the Seafish Industry combined to produce a handbook for fishermen which describes the various facets of hydrocarbon exploration and production. The various closed or controlled areas for fishing in the area recognise the economic importance of the industry and also the links between fish and the internationally important seabird colonies. Herring and sandeels differ from the other fish species found in the area by having eggs that are laid on the seabed. Both species spawn in the area and the spawning grounds should be protected from disturbance. Care should be taken in using landings data to identify areas sensitive to seismic activity. The frequent misreporting of landings of some key species has enhanced the apparent importance of the area around 4° W. Some of these landings may have come from outside the SEA4 area. The deep-water fish communities are unique to the UK EEZ.

1. Introduction

This report concerns fish and fisheries of the area designated by the DTI as Strategic Environment Assessment area 4 (SEA4). It covers the area to the west of the Shetland and Orkney island groups and most of the UK sector of the Faroe Shetland Channel.

The extent of SEA4 and its bathymetry is shown in Figure 1.1. The southern boundary of SEA4 comprises the north coast of mainland Scotland. This is mostly an exposed and rocky coast with few estuaries or sea lochs. To the southwest the boundary extends from Cape Wrath to about 60°N 07°W on the Wyville-Thompson Ridge. This ridge, which lies at a depth of about 500 m, separates the deep waters of the Atlantic from those of the Faroe Shetland Channel. This boundary is shared with area SEA7 which covers the west coast of Scotland and the UK EEZ including the Rockall Plateau and beyond. The SEA7 assessment has not yet been carried out. From the Wyville-Thompson Ridge the boundary extends north eastwards along the axis of the Faroe Shetland Channel to about 63° 50' N 0° 30' W. Close to the edge of the ridge the depth is about 1000 m and it gradually increases reaching about 2400 m at the most northerly point. Along this boundary lies SEA1 (referred to as the White Zone) for which an assessment has already been carried out (http://www.offshore-sea.org.uk).

The easterly boundary from 63° 50' N 0° 30' W to about 62°N 01° 30' E follows the UK EEZ. This boundary is approximately perpendicular to the continental slope and in a distance of about 130 nautical miles the depth changes from 2400 m to about 300 m. At this point the boundary runs in an approximately southwesterly direction to the east of Shetland and then through Orkney to Duncansby Head on the Scottish mainland. The first part of this boundary adjoins the most northerly part of SEA2 for which a report on the fish and fisheries has been completed (Rogers and Stocks, 2001). The remainder of this boundary adjoins SEA5, the assessment of which has not yet been carried out.

Within these boundaries SEA4 encompasses a wide range of ecosystems from the coastal fringes of mainland Scotland, the island groups of Orkney and Shetland, the west of Shetland shelf, the continental slope of the Faroe Shetland Channel, some of the deepest parts of the Faroe Shetland Channel and a segment of the Norwegian Sea basin.

SEA4 is effectively the link between the North Sea and the west of Scotland. For fisheries management the International Council for the Exploration of the Sea (ICES) has divided the northeast Atlantic into Sub-areas (Figure 1.2). SEA4 lies within two major Sub-areas: Sub-area IV (North Sea) and Sub-area VI (West of Scotland). To comply with accepted usage Sub-area VI is termed West of Scotland throughout this report. However, it is important to remember that it also includes part of the north coast of Scotland. The boundary between these two Sub-areas is 4° W. These Sub-areas are further divided into Divisions (Figure 1.2) so that the area to the east of 4° W lies within Division IVa and the area to the west is within Division VIa. These divisions are very large. Division IVa extends eastwards to the Norwegian Coast and from 62° N to 57° 30'N. Division VIa extends westwards to 12° W and from 60°N to 54° 30 'N. Some ICES Working Groups have further subdivided these Divisions for stock assessment purposes. For example the ICES Working Group on the assessment

of herring divides Division IVa into an east and west component and Division VIa into a north and south component. These must be used with caution since Working Groups for other species often use different sub-divisions more appropriate to the fish stock being assessed. Any description of the status of the fish stocks of the SEA4 area is made more difficult by the treatment of the North Sea and the west of Scotland as separate management units for most fish species.

In the context of fish and fisheries the North Sea is usually defined as ICES Sub-area IV, although for some fish stocks it may include the Skagerrak (Division IIIa) and parts of the English Channel (Division VIId) (Figure 1.2). However, as pointed out by Daan et al., (1990), for fish "the North Sea is an open system and ought not to be considered in isolation from the west of Scotland shelf, the English Channel and the Skagerrak". Fish move to and from the North Sea into adjacent areas to feed and spawn.

The SEA4 area also has some unique features in terms of fishery management. These will be described in more detail Section 5. The Shetland Box limits the fishing activities of larger vessels around Orkney and Shetland and industrial fisheries are prohibited in the Norway pout box lying to the east of the SEA4 area. The shellfish fisheries around Shetland (excluding Norway lobster) are managed locally under a Regulatory Order. There is a separate management scheme for the Shetland sandeel fishery and in 2001 there was an emergency seasonal closure of trawling grounds west of Shetland as a cod conservation measure.

2. Sources of information

For the easterly area of SEA4 (ICES Division IVa) the Atlas of North Sea Fishes (Knijn et al., 1993) is a useful source of information. The atlas is based on bottom trawl surveys carried out between 1985 and 1987 and presents distribution maps and basic biological data for 98 North Sea fish species or species groups. Most of data are from annual surveys of which the International Young Fish Survey and the Scottish Groundfish Survey are most relevant to SEA4. These and other surveys predate the material used for the Atlas and are ongoing. They provide fishery independent data to many of the ICES Working Groups. In the Atlas the data are presented on a grid of ICES Statistical Rectangles representing one degree of longitude and 0.5 degree latitude (approximately 30 X 30 nautical miles). Because different trawl types are used in the different surveys correction factors have been applied to the abundances of some species. The nature of the sampling method introduces some limitations to the data. Avoidance of grounds where gear damage can occur or modification of the gear to enable trawling on such grounds can bias the results. Inshore coastal areas were not effectively sampled. The surveys were primarily aimed at young fish and the adults of many species are poorly sampled. Some species such as sandeels and some of the flatfish are also poorly sampled by the trawls.

The SEA2 report on North Sea Fish and Fisheries (Rogers and Stocks, 2001) is a valuable up to date source of information. It covers a wide offshore area of the North Sea and extends from about 53 ° N to almost 62 ° N. Although it only has a contiguous boundary with SEA4 at its most northerly point, the accounts of the fish and fisheries in the northern part of the North Sea are very relevant to SEA4.

Much of the historical information on the fish species and the fish populations of the west coast of Scotland was reviewed by Gordon and de Silva (1980) and Gordon (1981). This information is also relevant to the westerly part of SEA4.

Fisheries Research Services (FRS) have been carrying out routine groundfish surveys in Quarter 1 (usually in March) since 1981. The area covered includes the whole of Sub-area VI. Since 2000 the depth range covered has been from 20 to 500 m. The target species are cod, haddock, whiting, saithe and herring. Length age frequency distributions are constructed for all these species. All other species are recorded and, at least, length data are collected. Indices of abundance at age are calculated for the target species and these data are used by the ICES Northern Shelf Assessment Working Group and the Herring Assessment Working Group.

The mackerel recruit survey in Quarter 4 covers the same area as the Quarter 1 groundfish survey. These surveys began in 1985 and are generally carried out in November. The target species now include cod, haddock, whiting, saithe and herring. Every summer FRS carries out an annual herring acoustic survey in the northern part of Division VIa. Routine surveys of scallops and *Nephrops* are undertaken and more recently inshore/sea loch surveys have been undertaken (Fisheries Research Services, 2002). Biannual surveys of deep-water fishes have been undertaken since 1998 but these were mostly carried out to the west of the Outer Hebrides.

The UK Offshore Operators Association Ltd (UKOOA) have published a report entitled “Fisheries Sensitivity Maps in British Waters” (Coull et al., 1998). These

provide a compilation of the known spawning and nursery grounds for the main commercial species around the whole of the UK. The report also provides monthly seismic sensitivity charts and fishing effort and value charts.

The final report of the recently completed EU project *Developing Elasmobranch Assessments* (DELASS) is a useful source of information on sharks, skates and rays (Heessen, 2003).

The Norwegian Deep is relatively close to the SEA4 area. The fish populations of this area have been extensively studied by Bergstad (1989, 1990a, 1991a, b). In 1993 the Nordic Council funded a three year study of the ling, blue ling and tusk of the northeast Atlantic (Bergstad and Hareide, 1996; Magnússon et al., 1997). The study area included the shelf edge of the SEA4 area. The continental slope of the Faroe Shetland Channel probably has much in common with the slope off Norway at comparable latitudes. Two studies on the fish populations by (Bakken et al., 1975 and Bergstad et al., 1999) are relevant. The latter was a component of the Norwegian *Mare Cognitum* project.

The stocks of most commercial fish and shellfish are assessed on an annual basis by ICES. Individual stocks are assessed by Working or Study Groups. The reports of these independent groups of scientific experts are reviewed by the ICES Advisory Committee on Fishery Management (ACFM) who provide the management advice to bodies such as the EU, non EU countries and the Northeast Atlantic Fisheries Commission (NEAFC).

The Working Groups of most relevance to the SEA4 area are as follows.

Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (Cod, haddock,whiting, saithe, plaice, Norway pout and sandeel).

Herring Assessment Working Group for the Area South of 62°N (herring and sprat)

Working Group on the Assessment of Northern Shelf Demersal Stocks (cod, haddock, whiting, anglerfish and megrim)

Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine, and Anchovy

Working Group on the Biology and Assessment of Deep Sea Fisheries Resources (ling, blue ling, tusk and roughhead grenadier).

Northern Pelagic and Blue Whiting Fisheries Working Group (Blue whiting)

Arctic Fisheries Working Group (Greenland halibut)

The fish stock assessments carried out by the ICES Working Groups use the best catch data that are available. These do not necessarily conform with the official national statistics of landings reported to ICES. The data used very often include estimates of unreported landings as well as corrections for misallocation of landings by species or area. ICES also tries to estimate, where possible, total catch by taking

into account discards, bycatches in industrial fisheries and other unreported landings. It is not always possible to reveal the sources of these additional data and in the landings tables they are not allocated to a particular country

The spatial scale at which the data are reported varies considerably between Working Groups and also between species. For some species data on landings are given by very large areas while for others it is by ICES Division or a species-specific sub-division. International data by ICES Statistical rectangles are not generally available although for some species some information is given in the form of charts in Working Group reports. These are often incomplete, being representative only for the countries supplying the information. For this report Fisheries Research Services provided data on the mean landings by Scottish vessels of the main commercial species for the years 1997 to 2001 for each of the statistical rectangles of the SEA4 area. These data are sourced from official logbooks that fishing vessels over 10 metres in length are obliged to keep.

To provide an overview of the fisheries and the long-term trends, data on landings have been extracted from ICES reports on the smallest possible scale relevant to the SEA4 area. For most species there are separate data sets for the North Sea and the west of Scotland. Where appropriate the estimated catch as used by the ICES Working Groups, after allowing for unallocated landings, misreporting and discarding, have been used. Because the reporting areas are so large the data may not be entirely relevant to SEA4 but they show overall trends. Scottish landings data obtained from the annual Scottish Fishery Statistics may in some cases improve the relevance of the data but it is important to remember that these are landings as reported to ICES and have not been adjusted for misreporting to other areas. Although information is given on landings into Shetland and Orkney it is important to recognise that these are not, except in the case of small coastal vessels, an indication of fishing effort in the SEA4 area. Many vessels may land there catch elsewhere and in the case of Shetland catches from other areas are landed for processing.

The primary management tool in the ICES area is the annual total allowable catch (TAC). TACs can either be analytical, based on an assessment, or precautionary. Most fishes in the North Sea are covered by a TAC either for an individual species or, as in the case of some less important species, by a grouped TAC. This is usually set by area and where a stock spans two or more areas it can result in misreporting of landings if the TAC in an adjacent area becomes restrictive. This problem is particularly relevant to the SEA4 area which has important stocks that span the boundary at 4° W between the North Sea (Sub-area IV) and the west of Scotland (Sub-area VI). For example, there was a long established TAC for anglerfish on the west of Scotland (Sub-area VI) but there was no TAC in the North Sea (Sub-area IV) until 1998. When the fishery on the west of Scotland expanded, particularly into deeper water, the TAC became restrictive and the over-quota catches were reported to the North Sea. When the TAC was introduced for Sub-area IV, according to accepted practice, it had to be based on officially reported landings, which includes the misreported landings. Misreporting continues to occur and in the words of one Working Group report has become institutionalised. While it is relatively easy to correct for misreporting in target species such as anglerfish, herring and mackerel it is more difficult, in many cases, to reallocate misreported bycatch of other species.

Changes in the amount of a particular species of fish landed can be caused by a number of factors. An increase or a decrease in landings may not always be the result of an improvement or a deterioration of the stock. Factors such as changing market demand, changes in fishing method or migration of the stock to other management areas could provide an alternative explanation. The catch per unit of effort is a much more useful measure. The measurement of effort for the commercial fleet is problematical and, as the following statement confirms, is no longer reliable for the Scottish fleet. ”Whilst vessels over 10 metres are obliged under EU regulations to report precise landings for each statistical square the reporting of the associated effort is no longer mandatory. The situation has now arisen where some vessels report fishing effort whilst others do not; given this dichotomy of reporting Fisheries Research Services are unable to give any credence to the effort data”

3. Fish Species; biology and fishery

This section summarises the relevant aspects of the biology of individual species. The fishery for each species is described. Data on the national and international landings that are most appropriate to the SEA4 area are presented. For the most important commercial species, many of which comprise part of mixed fisheries, the status of the stock and the management are described in Section 5.

The species order follows the standard practice of most fish textbooks and the scientific nomenclature is as used in *The Fishes of the North-eastern Atlantic and the Mediterranean* (Whitehead et al., 1984, 1986)

3.1 Basking Shark (*Cetorhinus maximus*)

Biology

Kunzlik (1988) has reviewed the available knowledge on the basking shark. They are widely distributed in the North Atlantic. They feed on plankton which they filter from the water through a wide mouth and large gills. It is probable that most feeding takes place close to the surface with the dorsal fin frequently breaking the surface. They are thought to produce live young. Basking sharks move inshore during the warmer summer months and it is this migration that is exploited by the fishery. One explanation for their absence in the winter months is that they may disperse into deeper water.

Fishery

This was one of the earliest directed fisheries for pelagic sharks in the Northeast Atlantic (Heesen, 2003). Norway has always been the main country to exploit basking shark in a wide ranging fishery from the Barents Sea to the Kattegat, in the wider North Sea and to the west of Scotland and Ireland. There were also smaller Irish and Scottish fisheries. Figure 3.1.1 shows the Scottish landings together with the total estimated catch for the whole Northeast Atlantic. Most of the Scottish catch was from the west coast.

The conservation status of basking shark is summarised in Heessen (2003) as follows.

"In recent years the basking shark has become almost a protected species in some areas. Under UK legislation (Schedule 5 of the Wildlife and Countryside Act of 1981), no basking sharks are allowed to be caught within 12 miles of the coast and none landed even if caught outside territorial limits. Furthermore, for 2002 there is a complete ban on landings of this species from within EU waters of ICES sub-areas IV, VI and VII (Annex ID of Council Regulation 2555/2001)."

3.2 Porbeagle (*Lamna nasus*)

Biology

The porbeagle is distributed widely over the northern North Sea and the west of Scotland with the highest reported catches around the Shetland Islands (Gauld, 1989).

They are thought to be present all year round in deep-water off the Faroe Islands and to migrate into the North Sea during the second half of the year. The diet consist mostly of cephalopods and fish. The porbeagle is viviparous and produces about four young with a length at birth of between 60 and 75 cm.

Fishery

Porbeagle are exploited along their migratory route mainly by Denmark, Norway and Faroes. For a while in the period 1930 to 1965 Norwegian liners extended their fishery to the waters around Orkney and Shetland. Total reported Scottish landings by all gears between 1958 and 1973 never exceeded 20 t. The decline in landings in recent years may reflect the demise of line and surface gillnetting as fishing methods in Scotland. A fishery developed from November 1987 to February 1988 off Shetland (Gauld, 1989). A recent attempt to revive this fishery was not successful.

3.3 Deep-water sharks

The many species of deep-water sharks (mainly of the family Squalidae) that are common on the continental slope to the west of Scotland (Gordon and Swan, 1997a) do not occur or are rarely caught on the continental slope area of SEA4. Only the shallowest living velvet-belly shark (*Etmopterus spinax*) whose depth range does not extend into the deeper slope waters occurs in appreciable quantities. This species is of small adult size and has no commercial value.

3.4 Spurdog (*Squalus acanthias*)

Biology

The spurdog was chosen as a case study species in a recently completed project entitled *Development of Elasmobranch Assessments* (DELASS) (Heessen, 2003). The spurdog has a worldwide distribution in temperate and boreal waters. It occurs on the continental shelf mostly at depths between 10 and 100 m although it is occasionally caught in the deeper waters of the continental slope. Spurdog tend to aggregate in large shoals of the same size or sex. Female spurdog begin to mature at about 70 cm and 50% are mature between 74 and 83 cm. They are viviparous (produce live young) with a gestation period of about 22 - 24 months. The young, numbering about 13, have a mean length at birth of about 26 cm. Tagging experiments in the 1960s indicated a winter migration from Scotland to Norway with a return migration in the summer. These experiments also suggested that there might be a northern and a southern stock of spurdog. However, recent investigations and a re-analysis of the data from earlier experiments lead to the consensus that there is a single Northeast Atlantic stock.

Fisheries

The following is a summary of information on spurdog fisheries from Heessen (2003). The fishery is long established in the ICES area but it was not until the 1930s that landings began to increase significantly reaching a peak in 1968 of over 50000 t. The annual landings of spurdog from 1970 onwards are shown in Figure 3.4.1 together

with the landings for the North Sea and the west of Scotland (including Rockall). The landings show a steady decline in recent years.

France, the UK, Norway and Ireland all take spurdog in both directed fisheries and as an important bycatch of trawl fisheries. The directed fishery is mainly a Norwegian longline fishery that developed after the war and moved into offshore waters including those around Shetland and Orkney. There was a change in the migration pattern of spurdog during the 1960s and the Norwegian longline fleet took advantage of this to increase there catches. Subsequently the catches began to decline and the consequent economic problems resulted in the collapse of the Norwegian fishery to the North of Scotland. Most landings of spurdog from the North Sea and off the west of Scotland are bycatch of bottom trawls and seine netters which are mainly targetting whitefish. There remain some local and seasonal directed fisheries. Currently more than half the landings of spurdog come from the North Sea and west of Scotland. In 1996 Scottish vessels landed 43% of the total Northeast Atlantic catch of spurdog of 16000 t.

The total landings by Scottish based vessels in 2001 were 3517 t of which 684 t were from the northern North Sea and 1494 t were from the west of Scotland (Anon 2002a). The mean reported landings of Scottish vessels by ICES statistical rectangle are shown in Figure 3.4.2 for the years 1997-2001. They show that most of the landings are from the west coast of Scotland. Figure 3.4.3 shows the landings over the same period for the ICES statistical rectangles within the SEA4 area. The highest landings are from the north coast immediately to the west of Orkney. The remainder of the landings are fairly evenly distributed over the continental shelf.

The stock assessment on spurdog carried out by the DELASS project concluded that the Northeast Atlantic stock was estimated to be severely depleted.

3.5 Skates and Rays (Family Rajiidae)

Most rays are caught as a bycatch of bottom trawling for roundfish. Because of their shape there is little size selectivity. The capture of immature fish and their low fecundity means that rays are very susceptible to overexploitation. In some areas this has resulted in changes in species composition. For example the common skate (*Dipterus batis*), once common in the North Sea is now only caught off Shetland (Walker 1995). The development of the deep-water fishery targeting Greenland halibut (*Reinhardtius hippoglossoides*) in the mid 1990s led to landings of the Arctic skate (*Raja hyperborea*) but, because of its soft flesh, it attracted a low price on the market.

Figures 3.5.1 and 3.5.2 show the reported landings of rays for ICES Sub-areas IV (North Sea) and VI (west of Scotland) respectively for the years 1973 to 2000 for Scotland and for all other countries combined (data from Heessen 2003). Figure 3.5.3 shows the distribution of landings by Scottish vessels of all skates and rays by ICES statistical rectangle averaged for the years 1997 to 2001. They show concentrations around Cape Wrath and to the west of the Orkney Islands and smaller concentrations northeast of Shetland. The landings specifically in the SEA4 area are shown in Figure 3.5.4. Landings tend to be highest from along the north coast and around the islands, especially Orkney. These probably represent captures by the inshore *Nephrops* fleet.

The skates and rays are not normally recorded at species level in the landings. During the DELASS project a pilot study was carried out to identify the species landed to the markets. Table 3.5.1 shows the estimated total landings for the west of Scotland and the North Sea by species.

TABLE 3.5.1 Estimated total landings (gutted weight in kg) of skates and rays into Scotland, 2000-2001, by species. (Modified from Heessen (2003)

Species		2000		2001	
Common name	Scientific name	West coast	North Sea	West coast	North Sea
Cuckoo ray	*Leucoraja naevis*	490876	493541	454506	452939
Spotted ray	*Raja montagui*	494181	29912	300352	29165
Thornback ray	*Raja clavata*	59209		175929	0
Common skate	*Dipterus batis*	121549	89734	183886	80045
White skate	*Raja alba*		14956	3073	16525
Shagreen ray	*Leucoraja fullonica*		119646		113868

3.6 Herring (*Clupea harengus*)

Biology

The herring is widely distributed throughout the northern Northeast Atlantic with a southern limit in the Bay of Biscay. It is a pelagic species dispersing over the surface at night and remaining close to the bottom during the day. It is a plankton feeder and copepods are dominant in its diet.

Herring are demersal spawners returning to the same spawning areas to lay their sticky eggs on stones and gravel. These eggs are shed in a single batch. Based on the spawning area and the timing of spawning the herring are divided into sub-populations or races. For example in the North Sea three main races have been identified. All three races are autumn spawners. The most northerly race is the Buchan/Shetland herring which spawns off the northeast coast of Scotland and around Orkney and Shetland in August and September. These spawning areas and others around the British Isles are shown in Figure 3.6.1 (Coull et al., 1998). A major northwest Scotland spawning area lies to the west of the Outer Hebrides and extends along the north coast of mainland Scotland and is relevant to the SEA4 area. This is designated as both a spring and an autumn spawning area.

After hatching herring larvae drift with the currents and for North Sea spawned herring the main nursery grounds are along the North Sea coast of mainland Europe and into the Skagerak and Kattegat (Daan et al., 1990). A component of these young herring originate from the northwest Scotland spawning grounds. The Moray Firth is also a nursery ground for west coast herring. Daan et al. (1990) drew attention to the importance of the Fair Isle Current as a major transporter of larvae of many species

into the North Sea and they highlight the artificial nature of the boundaries of the North Sea. On leaving the nursery grounds herring disperse to feeding grounds over a wide area where the different races become mixed (Figure 3.6.2).

Herring nursery areas also extend along the entire west coast of Scotland, including the Hebrides (Figure 3.6.3) (Coull et al.,1998). The biology of herring on these inshore nursery grounds has been described by de Silva (1973). Although nursery areas are not indicated as being important in the SEA4 area recent inshore surveys around Shetland have shown herring to be relatively abundant (Fisheries Research Services, 2002)

Herring from spring spawning in the Norwegian Sea (the Atlanto-Scandian herring) also occur in the northeastern sector of the North Sea. They can be identified by counting the number of vertebrae. The main feeding ground for these herring is in the central Norwegian Sea and in their migration to spawning areas on the Norwegian coast it is likely that a part of the population passes through the most northerly part of the SEA4 area (Napier and Goodlad, 1997).

Fishery

The herring fisheries collapsed in the mid 1970s and only recovered after a closure of the fisheries between 1977 and 1981. The North Sea fishery declined again in the mid-1990s but effective management measures combined with good recruitment in recent years has led to a recovery. Figure 3.6.4 shows the landings of herring averaged for the years 1997 to 2001 for each statistical rectangle of the SEA4 area. The high landings reported from between 4 and 5 °W, especially in E5 46, are most likely erroneous and represent reporting of over-quota fish caught in the North Sea to the west of Scotland (see below).

North Sea

There are two fishing fleets exploiting herring in the northern North Sea that are relevant to the SEA4 area. One is a directed fishery by purse seiners and trawlers and the other comprises all other vessels that take herring as a bycatch.

The autumn spawned herring of the North Sea (including the Skagerrak and part of the English Channel) are managed as a single unit. However, for the purposes of herring assessment the northernmost part of the North Sea (ICES Division IVa) has been further subdivided and Division IVa (west) is relevant to the SEA4 area. It is the area of ICES Division IVa lying between 4° W and 2° E (Figure 1.2). Figure 3.6.5 shows the reported Scottish catch together with the catch of other nations and also the ICES Working Group's estimate of the combined unreported and misreported catch for the years 1992 to 2001. The ICES Herring Assessment Working Group for the Area South of 62°N (Anon., 2002b) provides estimates of the North Sea herring catches by quarter and ICES Statistical rectangle for the year 2001. In the SEA4 area they are greatest in the 3rd quarter.

West of Scotland

For the purposes of the assessment of the herring stocks of the west of Scotland (ICES Division VIa) has been further subdivided into a northern and a southern sector. The southern sector is relatively small and encloses the waters to the west and north of Ireland. Division VIa (north) is relevant to the westerly part of SEA4. There are three herring fisheries in the area. A Scottish and Irish fleet of pair trawlers operate mostly in coastal waters, the Minch and around Barra. Scottish and Norwegian purse seiners operate mostly in the northern North Sea but also fish in the northern part of Division VIa. An international fleet of freezer trawlers, mainly registered in the Netherlands, German, France and UK (England), has operated in deeper water along the shelf edge (Anon., 2002b)

There is a problem with the data on the landings of herring from the west of Scotland because of misreporting of fish into the area of fish caught in other areas, notably from the North Sea. Figure 3.6.6 shows the reported Scottish landings and those from all other countries combined. The 'others' component includes landings, unspecified to country, not reported to ICES but identified by the ICES Working Group. The working group has also estimated the amount of misreporting and adjusted the landings for assessment purposes. The Working Group estimate of landings from the west of Scotland is shown in Figure 3.6.7. As a result of various regulatory measures, misreporting of catches has decreased in recent years.

3.7 Sprat (*Sprattus sprattus*)

Biology

Sprat is widely distributed around the fringes of the North Sea but were not found in the North Sea sector of SEA4 in the routine surveys used to produce the atlas of North Sea Fishes (Knijn et al, 1993). This is probably a result of the preference of sprat for coastal waters not sampled during the surveys.

Sprats are a short lived species and their abundance is very much dependent on the strength of the recruiting year classes. They spawn in most of the waters around the UK including the southern part of the SEA4 area (Coull et al., 1998) (Figure 3.7.1). Unlike herring the eggs are pelagic and the sprat is a batch spawner between May and August.

The nursery areas on the west coast of Scotland tend to be in inshore waters and sea lochs (de Silva, 1973). Mature fish also migrate inshore during the winter months and in some years are exploited by the fishery. Sprat were virtually absent from the inshore surveys carried out around the Shetland Islands in November/December 2001 (Fisheries Research Services, 2002).

Fishery

The Scottish landings of sprat from the North Sea are negligible, especially in ICES Division IVa west (Anon., 2002c).

3.8 Cod (*Gadus morhua*)

Biology

Juvenile cod are widely distributed throughout the North Sea whereas the adults form regional groupings with limited spawning and feeding migrations (Knijn et al.,1993). Cod are also widely distributed on the west coast of Scotland (Gordon and de Silva, 1980). Although outside the area of SEA4, the Norwegian Deep probably has much in common with the continental slope to the North of Shetland. In the Norwegian Deep cod were most frequent on the upper and middle slope and occurred predominantly in the southern areas where they appeared to seasonally migrate up and down the slope (Bergstad, 1990a, 1991 a, b).

For the purposes of assessment and management the North Sea (ICES Sub-area IV) and the west of Scotland (Sub-area VI) are treated as separate stocks (see below). However, genetic polymorphism studies (Wilkins, 1971) revealed differences between cod collected off Shetland and Scottish coastal cod.

Cod has a very high fecundity and spawning, which can occur between January and April, occurs all around the British Isles but in localised areas. No specific spawning areas have been identified in the SEA4 area (Coull et al., 1998) (Figure 3.8.1). Around the British Isles cod nursery areas tend to be located in inshore areas where the juveniles are associated with rocky shores (Figure 3.8.2). Because of this habitat preference cod were in low abundance in the inshore bottom trawl surveys carried out by Fisheries Research Services in 2002 (Fisheries Research Services, 2002). In Shetland area there was an occasional large catch which was considered to be associated with their shoaling behaviour.

Cod remain pelagic until the reach a length of about 7 cm after which they become demersal. There was no evidence for diel migration of cod in the pelagic phase (Bailey, 1975). The diet of pelagic cod in the northern North Sea (including easterly parts of the SEA4 area) was described by Robb and Hislop (1980). It was dominated by copepods. In a study of diel feeding behaviour to the east of Shetland, Robb (1981) showed that cod began feeding most actively in the evening reaching a peak by midnight. Adult cod feed on a wide range of fish and invertebrates (Wheeler, 1969).

Fishery

The landings by Scottish vessels of cod by ICES statistical rectangle averaged over the years 1997 to 2001 are shown in Figure 3.8.3 for the SEA4 area. Catches are fairly uniformly distributed over the continental shelf

North Sea

The management unit for North Sea cod also includes the Skagerrak and the eastern English Channel. Reported international landings, as shown in quarterly charts, in Anon. (2003a) indicate that depending on season most fisheries take place in an easterly arc from the English Channel extending along the eastern North Sea, into the Skaggerrak, to the west of Norway and around to Orkney and Shetland. In the SEA4 area the landings were greatest in the third quarter. Figure 3.8.4 shows the trends in

international cod landings for the whole North Sea management unit for the years 1963 to 2001. These are the data used by the ICES Working Groups for assessment purposes and include estimates of unallocated landings. The landings have declined steadily since the 1980s and more dramatically in recent years. Figure 3.8.5 shows the reported annual landings for Scotland, the rest of the UK and all other nations combined for the North Sea (Sub-area IV) only. In most years the Scottish catch amounts to between about 65 and 70% of the total UK catch. The landings for 2001 are provisional and are a combined amount for the UK. Nine other nations report landings of cod of which Denmark, Norway and the Netherlands are the most important.

West of Scotland

The cod fishery on the west of Scotland is predominantly by bottom trawlers. It is a mixed fishery that also targets haddock, anglerfish and whiting with bycatches that include saithe, megrim and lemon sole.

The total landings of cod for the years 1966 to 2001 from the west of Scotland, after relatively minor adjustments by the ICES Working Group for unallocated landings, are shown in Figure 3.8.6. They show a dramatic decline since the 1980s. In recent years Scottish landings as a percentage of the total reported landings have increased and now account for 60 to 70% of the total (Figure 3.8.7). This change is as a result of a decline in the French landings. Scottish landings account for between 85 and 95 % of total UK landings from this Division.

3.9 Haddock (*Melanogrammus aeglifinus*)

Biology

In the North Sea the haddock has a northerly distribution (Knijn et al., 1993). It is also widely distributed on the west coast of Scotland (Gordon and de Silva, 1980).

Spawning takes place in the northern North Sea and to the west of the Outer Hebrides from February to May (Coull et al., 1998) (Figure 3.9.1). It is possible that some of the spawning products from the west and north of Scotland are carried by the currents into the North Sea. There is some evidence from tagging of a winter migration of adults from the North Sea to northwest coast of Scotland (Jones, 1959). The nursery grounds are widely distributed mostly in offshore waters of the northern North Sea and the north and northwest of Scotland (Figure 3.9.2) (Coull et al., 1998). In the inshore surveys around Shetland there was a higher proportion of adult haddock and they were also absent from many of the sites (Fisheries Research Services, 2002). After the spawning shoals disperse some haddock gradually migrate westwards towards Orkney and Shetland to the feeding grounds (Knijn et al., 1993).

In their first year of life the youngest haddock are pelagic and carry out vertical migrations, being found in the scattering layer at night and close to the bottom during the day but exceptions were encountered (Bailey, 1975). Robb and Hislop (1980) found that the diet of these pelagic haddock was dominated by appendicularians with copepods as the next most important food item. They had two peaks of feeding activity, morning and evening but as fresh food was always present in the stomachs

feeding was continuous (Robb, 1981). Fish eggs dominated the morning diet while appendicularians and *Limacina* (a pelagic mollusc) were dominant in the evening. Juvenile haddock continue to feed on pelagic organisms but gradually benthic, slow-moving invertebrates become more important in the prey. Larger haddock also feed on a variety of fish (Knijn et al., 1993).

Fishery

The landings of haddock by ICES statistical rectangle averaged over the years 1997 to 2001 for the SEA4 area are shown in Figure 3.9.3. Landings are highest along the north coast, and are widely distributed over the shelf area.

North Sea

In the North Sea most of the haddock for human consumption are caught in the mixed demersal fishery. Scottish light trawlers, seiners and pair trawlers take a high proportion of the catch. Smaller amounts are landed by *Nephrops* trawlers using smaller mesh codends and discard rates can be high. Haddock are also taken as bycatch in the industrial fisheries prosecuted mainly by Denmark and Norway. Figure 3.9.4 shows the ICES Working Group's estimates of the landings for human consumption, the landings in the industrial fishery and the discards for the years 1963 to 2001 from Sub-area IV (North Sea) and Division IIIa (Skagerrak) combined. The peak in the 1960s represents the "gadoid outburst" a period of very high catches of gadoid or cod-like fishes.

Figure 3.9.5 shows the annual reported landings by Scotland and by all other nations combined for Sub-area IV for the years 1992 to 2001. The landings for 2001 are provisional and for that year the Scottish landings are combined with those of the rest of the UK. Scottish landings in previous years have always been about 95% of the total UK landings. Scottish landings amount to about 80 to 85 % of the total reported international landings for human consumption.

West of Scotland

Haddock on the west of Scotland are caught by several components of the Scottish fleet. Bottom trawlers with a codend mesh of 110 mm fish a variety of grounds along the west coast and to the north of the Hebrides. Two of these fishing grounds, the Rising Ground and the Solan Ground, are located within the SEA4 area. This fleet has tended to move further offshore to target anglerfish (*Lophius* spp.). *Nephrops* trawlers also land haddock as a bycatch. Both fleets discard substantial quantities of small haddock. Scottish seine netters also fish the same grounds as the trawlers and discard less small haddock. French trawlers targeting deep-water species along the shelf edge and continental slope also land small quantities of haddock**.** Figure 3.9.6 shows the estimated annual international catch of haddock from Division VIa for the years 1978 to 2001. These data comprise the reported landings, an adjustment for unallocated landings and an ICES Working group estimate of the weight of discarded haddock. Figure 3.9.7 shows the reported landings by Scotland and by all other countries combined for the years 1986 to 2000. The Scottish share of the landings has increased and now represents about 80% of the total. The extent of the estimated discarding is shown in Figure 3.9.8.

3.10 Whiting (*Merlangius merlangus*)

Biology

The whiting is widely distributed throughout the North Sea (Knijn et al.1993) and on the west of Scotland shelf (Gordon and de Silva, 1980). In an investigation of the fish communities of the Norwegian Deep the majority of the large catches of whiting were made shallower than 230 m depth (Bergstad, 1991a). There was a suggestion that the upper slopes of the Norwegian Deep may have some importance as an over-wintering ground.

For the purposes of assessment and management, whiting in the North Sea and the west of Scotland are regarded as separate stocks. The biological stock structure is poorly understood. However, a study of the parasites suggested that the stocks of whiting off the north coast of Scotland and around Orkney and Shetland were indistinguishable from those of the northern North Sea but were significantly different from those of the west coast of Scotland (Kabata, 1967). A separate north coast of Scotland population was suggested by a study of genetic polymorphisms (Wilkins, 1971). None of the whiting tagged in the North Sea and around Orkney and Shetland were recovered on the west coast of Scotland but there was quite a wide dispersal from the tagging site to the west of Shetland into the North Sea (Hislop and MacKenzie, 1976). These data from tagging and the use of a cestode parasite as a biological tag led Hislop and MacKenzie (1976) to conclude that older whiting migrate from the Moray Firth to the Shetland Islands and thereafter to the deeper waters to the east.

Whiting has a high fecundity and is a batch spawner with prolonged spawning period from about February to June. Spawning occurs widely throughout its range but some areas have been identified as of particular importance. These include the North Minch extending to part of the North Coast and also an area to the west of Shetland (Coull et al., 1998) (Figure 3.10.1). Hislop and MacKenzie (1976) noted that fish tagged to the west of Shetland in April were in spawning condition. The eggs and larvae are pelagic and on the west of Scotland the young remain pelagic until they attain a length of about 10 cm when they begin to be taken by fine-meshed bottom trawls from July onwards (Gordon, 1977a). The nursery grounds tend to be located inshore (including the sea lochs) and whiting remain in these areas for one or two years. Two year old fish are more frequently caught in the deeper sea lochs indicating that depth is an important factor in determining juvenile distribution. Cooper (1980) found evidence to suggest that the inshore distribution was an inshore migration rather than a passive dispersal from the spawning area as appeared to be the case for some other gadoid species. On a broader scale Coull et al., (1998) also show the importance of inshore areas as nursery grounds but found no evidence of significant grounds around Orkney and Shetland (Figure 3.10.2). This agrees with recent inshore surveys carried out by the Fisheries Research Services (FRS) in areas of the Scottish west coast and around the Shetland Isles (Fisheries Research Services, 2002). A total of 90 tows were carried out around Shetland and whiting were absent from the greater proportion of sites. There were a higher proportion of larger fish compared with other Scottish inshore areas although this might indicate a sampling bias.

The diel behaviour patterns of several juvenile gadoid species in the northern North Sea (including two areas east of Shetland) were investigated by Bailey (1975). Whiting were caught in equal numbers in midwater by day and night and only larger fish were caught in bottom trawls. The greatest abundance of pelagic whiting were caught in association with a high abundance of jellyfishes. The diet of pelagic whiting in an area east of Shetland was dominated by copepods, decapod larvae and amphipods (Robb and Hislop, 1980) and there appeared to have two peaks of feeding activity, one in the morning another in the evening (Robb,1981). Copepods were dominant in the diet during the evening and fish eggs during the day. The interactions between the diet of pelagic gadoids over a 24 hour period at a site to the east of the Shetland Islands was investigated in June 1991 (Bromley et al., 1995). Copepods and other invertebrates were the main diet of the smallest fish but fish became dominant in the largest fish. Cannibalism was common in whiting and probably reflects the prolonged spawning season of whiting and consequent wide size range within a year class. In the Norwegian Deep the diet was exclusively of crustaceans and fish with the latter becoming increasingly important with increasing fish size (Bergstad, 1991a).

Adult whiting is an active predator feeding on a wide variety of preys. Crustaceans and fish are the dominant prey items with fish becoming more important with increasing size (Gordon, 1977b; Hislop et al., 1991). Whiting is considered to be one of the major predators of fish such as Norway pout, sprat, sandeel and juvenile herring, cod and haddock (Knijn et al., 1993). In the Norwegian Deep crustaceans and fish were the only items in the diet and the number of prey types was lower than for other areas. Whiting tend to grow slowly after the first year, but growth rates are very variable. They reach maturity at about two years and can live for about seven or eight years.

Fishery

The Scottish landings of whiting from the SEA4 area averaged over the years 1997-2001 are shown by statistical rectangle in Figure 3.10.3. The highest reported landings tend to be from the east of Shetland and around Fair Isle.

North Sea

Most of the whiting for human consumption in the North Sea is caught by trawlers and seine netters in mixed demersal fisheries. Figure 3.10.4 shows the reported landings of whiting for human consumption by Scotland and by all other nations combined for the North Sea (including the eastern English Channel. Scottish landings account for about 90% of the total UK landings and between 65 and 70% of the total international landings for the years 1992 to 2001. There has been a steady decline in landings. In addition to the landings for human consumption there are landings as bycatch in the industrial fisheries. There is also a very significant amount of whiting discarded. Figure 3.10.5 shows the Working Group estimates the landings for human consumption and industrial bycatch together with an estimate of the weight of the discarded catch of whiting.

West of Scotland

The fleet targeting whiting in Division VIa is essentially the same as described for haddock, except that discarding is probably greater because of other additional factors such as low market value and restrictive TACs. Figure 3.10.6 shows the reported landings of whiting for human consumption by Scotland and by all other nations for ICES Division VIa. Scottish landings account for more than 90% of the total UK landings and between about 60 and 80 % of the international landings. The landings have decreased dramatically in recent years. Figure 3.10.7 shows the ICES Working Group's estimates of the weight of whiting discarded. It can amount to between 35 and 55% of the estimated total catch.

3.11 Blue whiting (*Micromesistius poutassou*)

Biology

In the North Sea surveys the blue whiting was only caught in large numbers in the summer in the most northerly parts of the North Sea and in the Norwegian Deep (Knijn et al., 1993). The main spawning grounds (Figure 3.11.1) are along the continental slope to the west of Scotland and after spawning the populations disperse on a feeding migration to the northern North Sea and the Norwegian Sea (Bailey, 1982). The distribution of these nursery grounds is shown in Figure 3.11.2. Blue whiting make incursions into the shallower North Sea in some years and Bailey (1975) noted that they were only caught in midwater trawls at night. Blue whiting have also been caught on the west of Scotland shelf in some years (Gordon 1977c)

The populations of blue whiting along the shelf edge of the SEA4 area are probably analogous to those of the Norwegian Deep, investigated by Bergstad (1990a). Blue whiting was the dominant species by number and weight during the winter in the 'main channel' of the Norwegian Deep. The concentrations of blue whiting in the Norwegian deep were always dominated by juveniles (Bergstad, 1991a). Fish in their first year of life appear in the area from September onwards. During the day they form a distinctive scattering layer over wide areas but are also common on the bottom. This blue whiting scattering layer is the deeper of two layers commonly observed in the summer. The upper layer consists mostly of pearlside (*Maurolicus muelleri*) and euphausiids (mainly *Meganyctiphanes norvegica*) (Bergstad, 1990a). Blue whiting is the dominant gadoid species in the Norwegian Deep.

Meganyctiphanes norvegica was the dominant prey item. Larger fish consumed pasiphaeids, *Pandalus* and fish, especially pearlsides. The diet of fish caught in midwater was similar except for the absence of near bottom species such as *Pandalus* (Bergstad, 1991a). Blue whiting of less than one year old caught in midwater to the east of Shetland had a diet dominated by euphausiids (Robb, 1981).

Blue whiting appear to be a relatively short lived species (5-7 years) and grow to about 20 cm at age 1. They become mature at about 20 cm (Knijn et al., 1993).

Fishery

Blue whiting is widely distributed in the North Atlantic from Gibraltar to the Barents Sea and although genetic and other evidence suggests that there may be several populations the boundaries are not clear. For this reason blue whiting is treated by ICES as a single stock. The fishery for blue whiting was established in 1977. Most of the catches are taken in a pelagic trawl fishery on spawning and post-spawning fish along the upper continental slope to the west of the British Isles (ICES Divisions Vb, VIa,b and VIIb,c). The mixed industrial trawl fishery in the North Sea (Sub-area IV) catches juvenile blue whiting. Figure 3.11.3 shows the estimated annual landings of blue whiting in the 'northern area' for each of these fisheries. This shows that the total fishery has expanded rapidly in recent years. Figure 3.11.4 shows the estimated landings for some countries from the spawning fishery. This fishery extends into international waters. It shows significant increases in catches by several countries. Included in others are countries such as Germany and Ireland that have also increased their catches. This expansion of the fishery was helped by a succession of strong year classes.

3.12 Norway pout (*Trisopterus esmarkii*)

Biology

The Norway pout is a small gadoid fish that only reaches a length of about 20 cm and lives for about three years. It is widely distributed both as juveniles and adults in the central and northern North Sea (Knijn et al., 1993). Norway pout was a numerically dominant species in several of the upper and mid-slope assemblages identified by Bergstad (1990a) in the Norwegian Deep. It is also widely distributed on the west coast of Scotland (Gordon and de Silva, 1980) where, after the pelagic phase, the juveniles spread into inshore waters and sea lochs (Gordon, 1977d; Cooper, 1980). In the recent inshore surveys of the Shetland Isles, Norway pout was the most abundant species (by number) accounting for 42% of the total catch (Fisheries Research Services, 2002).

Spawning occurs over a wide area in offshore waters of the west and north of Scotland and in the North Sea as far south as about 56 °N (Coull et al.,1998) (Figure 3.12.1). Areas of higher concentration exist to the northwest of Scotland (on the eastern boundary of SEA4) and between Shetland and Norway. There is some evidence to support a spawning migration to the latter area (Raitt, 1968). In shelf waters spawning occurs from January to April while in deeper waters it is from March to May. According to Coull et al.,(1998) the nursery grounds are located in the same areas as the spawning grounds.

While in the pelagic phase Norway pout carry out well defined diurnal vertical migration being found in the scattering layer at night and at the seabed during the day (Bailey, 1975). Copepods were the dominant prey by both number and weight (Robb and Hislop, 1980) The main peak of feeding activity of Norway pout was in the evening (Robb, 1981). Bromley et al., (1995) reported the almost exclusive dominance of copepods in the diet of Norway pout caught over a 24 hour period at a site to the east of Shetland in 1991.

Fishery

The fisheries for Norway pout in the North Sea and the west coast of Scotland are treated as separate management units by ICES. However, as there is no evidence of a stock separation in northern areas ICES is considering merging the two stocks in the future.

North Sea

The fishery in the North Sea is mainly by Danish and Norwegian vessels using small mesh trawls on the Fladen ground and along the edge of the Norwegian Deep. The same fishery also targets blue whiting. Data on the finer scale of the Danish catches by ICES statistical square provided to the ICES Working Group on the Assessment of Demersal Stocks in the North Sea and the Skagerrak (Anon., 2003a) reveals that an insignificant amount is caught within the SEA4 Area. Fishing for Norway pout is prohibited in part of the SEA4 area (see Section 5 and Figure 5.9).

Figure 3.12.2 shows the officially reported landings of Norway pout for ICES Division IV for the years 1995 to 2001. They show considerable variation as might be expected for a short lived species with fluctuating year class strengths. The variable landings can also reflect the diversion of effort to other industrial species such as sandeels. Figure 3.12.3 shows the historical trend in landings from 1961 to the present for the whole of the North Sea and the Skagerrak combined using data provided by ICES Working Group Members.

West of Scotland

The fishery in ICES Division VIa is mainly carried out by Denmark and there is considerable annual variation in landings. The reported landings of Norway pout from 1974 to 2001 area shown in Figure 3.12.4. The landings have steadily decreased since the mid 1990s.

3.12 Saithe (*Pollachius virens*)

Biology

In the North Sea saithe has a mainly northern distribution. The bottom trawl surveys only caught saithe of total length > 30 cm and because the species has a tendency to aggregate in shoals some very large catches were recorded (Knijn et al., 1993). The lack of juveniles in the northern North Sea is explained by their preference for inshore nursery grounds that are not suitable for trawling. They may remain in these coastal areas for one or two years. The movement of young saithe from the nursery grounds to the northern North Sea has been demonstrated by tagging experiments (Newton, 1984). The distribution of these nursery grounds as defined by Coull et al. (1998) is shown in Figure 3.13.1.

In the Norwegian Deep saithe is a dominant species at depths <250 m and was seasonally more abundant in summer and autumn (Bergstad, 1990a, 1991 a, b). They were more abundant below 300 m in winter. Saithe were also caught in the pelagic zone, at least up to 100 m off the bottom. The age composition ranged from 2 to 10

years but 3 and 4 year old fish were most abundant. Interannual differences in age composition were related to differences in the age of the migration of juveniles from the inshore nursery grounds.

Figure 3.13.2. shows a large area of spawning associated with the Norwegian Deep and the shelf edge north and northeast of Shetland (Coull et al., 1993). According to Daan et al. (1990) they spawn along the edge of the continental shelf at depths of 100-200 m.

The diet of young pelagic saithe in the northern North Sea was described by Robb and Hislop (1980). The diet changed from predominantly copepods in the smallest fish to fish in the largest individuals. Young saithe had one main feeding period during the evening and copepods were dominant at all times (Robb, 1981). Bergstad (1991a) has described the diet of saithe from the western upper slope of the Norwegian Deep. Crustaceans and fish were the dominant prey by weight. The dominant crustaceans were pelagic euphausiids and hyperid amphipods. Twenty four different species of fish were recorded in the stomachs with Norway pout and the mesopelagic pearlside (*Maurolicus muelleri*) being the dominant species. Blue whiting, mackerel and herring were more important in the diet of larger fish. Sandeels were not as important in the diet of smaller saithe as they were in the wider northern North Sea.

Fishery

The Scottish landings of saithe from the SEA4 area averaged over the years 1997-2001 are shown by statistical rectangle in Figure 3.13.3. This shows that the highest reported landings are along the shelf edge.

Prior to 1999 saithe from the combined North Sea and Skagerrak were assessed by ICES separately from those to the west of Scotland. Now the assessment for saithe applies to all three areas combined and Figure 3.13.4 shows the estimated of the total landings for the years 1967 to 2001. The landings of saithe have remained fairly constant throughout the 1990s at around 100000 t.

North Sea

The directed fishery for saithe in the North Sea takes place along the northern shelf edge and the Norwegian Deep. Most of the catches are taken by Norwegian, French and German bottom trawlers. The fishery is directed towards mature fish in the first quarter of the year and thereafter the catches are dominated by immature fish. Figure 3.13.5 shows the reported landings by country for the years 1992 to 2001. The UK landings, reported separately for England and Wales and for Scotland, have been combined. Scottish landings are about 2.5 times greater than those of England/Wales. In the mid 1990s it was estimated that about 10 to 15% of the catch was under-reported.

West of Scotland

The fishery in Sub-area VI comprises two components. There is a French and to a lesser extent Norwegian and German bottom trawl fishery operating along the shelf

edge and a Scottish fishery operating inshore. Figure 3.13.6 shows the landings by country for the years 1992-2001.

3.14 Tusk (*Brosme brosme*)

Biology

Tusk are caught mainly at the shelf edge and on the upper continental slope at depths between about 150 and 450 m (Knijn et al. 1993). They are not frequent in trawl catches because of their preference for rocky ground. Tusk have a northerly distribution in the Atlantic being found off East Greenland, around Iceland, the northern part of the British Isles and around Norway including the Skagerrak (Bergstad and Hareide, 1996; Magnússon et al., 1997). Although there is evidence of a genetic separation between the east and west Atlantic, there was no genetic evidence to support stock separation in the northeastern Atlantic. However the wide separation of fishing grounds might support the use of separate management units. It is not known whether the tusk migrates within its area of distribution. Spawning appears to take place in the northern North Sea and the Skagerrak from April to June (Magnússon et al., 1997). It is assumed that the nursery grounds are in deep water on rough bottom. The diet consists mainly of crustaceans and small fish such as Norway pout.

Fishery

North Sea

Figure 3.14.1 shows that this fishery is dominated by Norway. About 90% of the catch is by longline. Tusk is usually a bycatch of the fishery that targets ling. The fishery off Shetland is by the high-seas longline fleet that has been described in detail by Bergstad and Hareide (1996). These are highly mechanised vessels that freeze the catch on board. They also target cod and the effort expended on the different fisheries depends on the availability of quota.

West of Scotland

The same Norwegian longline fleet also operates in Sub-area VI and accounts for a high proportion of the landings (Figure 3.14.2). The French bottom trawl fishery targeting saithe and deep-water species also has a bycatch of tusk.

3.15 Blue ling (*Molva dypterygia*)

Biology

The blue ling is a deep-water species of the continental slope. On the slope to the west of the Hebrides it occurs at depths from 300 to about 1300 m with a peak abundance at about 800 m (Gordon and Hunter, 1994). It is one of the few commercially exploited deep-water species that crosses the faunal barrier of the Wyville-Thompson Ridge and occurs on the slopes of the Faroe Shetland Channel (Bullough et al., 1998) and the Norwegian Deep (Bergstad, 1991a). The depth distribution is truncated in the Faroe Shetland channel because of its preference for the relatively warmer water

temperatures. Blue ling has a northerly distribution around Iceland, in the Rockall Trough and around the north of Scotland to the Faroe Islands and Norway (Bergstad and Hareide, 1996; Magnússon et al., 1997). Blue ling aggregates for spawning and this forms the basis of some of the targeted fisheries, notably in the northern Rockall Trough and at locations around Iceland. Spawning occurs from about mid March to mid-April in Scottish waters. In the Norwegian Deep blue ling had a mainly piscivorous diet consuming Norway pout and blue whiting at shallower depths and argentine (*Argentina silus*) and roundnose grenadier (*Coryphaenoides rupestris*) at greater depths (Bergstad, 1991a). Some larger crustaceans were also present in the diet. Mauchline and Gordon (1984) reported a similar diet for fish from the Rockall Trough.

Fishery

North Sea

The fishery for blue ling in the North Sea is relatively minor, reaching a peak of about 600 t in 1991 (Figure 3.15.1). The French trawl landings declined in the mid 1990s most probably because of the greater emphasis on targeting deep-water species to the west of the Hebrides. The Scottish landings have increased and most of this increase is probably attributable to a bycatch of the fishery targeting Greenland halibut (*Reinhardtius hippoglossoides*) on the slope of the Faroe Shetland Channel.

West of Scotland

The reported landings of blue ling from 1988 to 2001 are shown in Figure 3.15.2. French trawlers used to take more than 95% of the catch but the catch of Scottish trawlers has been increasing since the mid 1990s.

3.16 Ling (*Molva molva*)

Biology

Ling are mainly caught in the northern deeper parts of the North Sea (Knijn et al., 1993). In the Norwegian Deep it was not abundant in trawl hauls and most were caught between 100 and 450 m depth (Bergstad, 1991a). Seasonal differences in abundance were minor but there was a trend for ling to be more abundant in the summer months. There is currently no evidence of genetically distinct populations of ling (Bergstad and Hareide, 1996; Magnússon et al., 1997). Spawning aggregations of ling have not been observed and the eggs are distributed over a wide area of the Northeast Atlantic. In Scottish waters spawning takes place between March and June. Ages of up to about 14 years have been reported but most fish in the Norwegian longline landings are between about 5 and 8 years. Ling have a mainly piscivorous diet feeding on species such as Norway pout, blue whiting, argentine, herring and cod. Squid, crustaceans and echinoderms are also consumed.

Fishery

The Scottish landings of ling from the SEA4 area averaged over the years 1997-2001 are shown by statistical rectangle in Figure 3.16.1. They show that the highest reported landings are along the shelf edge of the Faroe Shetland Channel.

North Sea

The reported landings of ling from ICES Division IVa for the years 1988 to 2001 are shown in Figure 3.16.2. The major directed ling fishery is the Norwegian longline fishery conducted around Shetland and in the Norwegian Deep (see tusk above). The Scottish landings are bycatch in the trawl fisheries. The Scottish share of the total landings increased in the mid 1990s to about 40%.

West of Scotland

The reported landings of ling from ICES Division VIa for the years 1988 to 2001 are shown in Figure 3.16.3. The main fisheries in Division VIa are the Norwegian targeted longline fishery and trawl fisheries by France and Scotland that take ling as a bycatch

3.17 Roughhead grenadier (*Macrourus berglax*)

Biology

The grenadiers are all deep-water species of the macrourid family. There are two species of grenadier that are exploited in the North Atlantic, roundnose grenadier (*Coryphaenoides rupestris*) and roughhead grenadier (*Macrourus berglax*). Both are found on the continental slope but only in some areas does their distribution overlap. Roundnose grenadier is commercially exploited in the deep-water trawl fishery to the west of the British Isles and is often the target species. It does not occur on the slopes of the Faroe Shetland Channel or on the Norwegian slope although it is found in some deep shelf basins and fjords and also in the deep basin of the Skagerrak. On the other hand, the roughhead grenadier can be quite abundant in the Faroe Shetland Channel and on the Norwegian slope, usually associated with the transition between warmer Atlantic water and colder Norwegian Basin water.

The diet of the roughhead grenadier is dominated by benthic organisms and pelagic prey constitute less than 30 % of the food. Five major groups of organisms were important in the diet; gammarid amphipods, brittle stars, polychaete worms, shrimps and fishes. The larger the grenadier, the larger the proportion of shrimps and fishes consumed. Studies on the Iceland-Faroe Ridge suggest that there is probably a spawning period at the end of spring.

Fishery

The roughhead grenadier is caught as a bycatch in both trawl and longline fisheries targeting Greenland halibut. It has a very rough scaly skin and mainly for this reason it does not have a high market value and is often discarded. In the North Sea the landings are insignificant and since 1988 have never exceeded 36 t and in some years

there are no reported landings. The landings from the west of Scotland follow a similar pattern.

3.18 Horse Mackerel (*Trachurus trachurus*)

The horse mackerel or scad is a shoaling pelagic fish. It is also a highly migratory species that invades the North Sea during the summer months (Daan et al.,1990). They enter the North Sea from the north via the shelf edge and the south via the English Channel. For management purposes ICES divides the stock in the northern area into a western and a North Sea stock. The western stock comprises the commercial fishery in ICES Divisions IIa, IIIa (western part), Vb, IVa, VIa and some Divisions of Sub-areas VII and VIII. The main commercial landings are to the west of Ireland and Scotland, off the Norwegian coast and in the western Skagerrak. Landings in the SEA4 area are relatively minor and mostly in the first quarter of the year (Anon., 2003b)

The landings of horse mackerel by Scottish vessels by statistical rectangle for the SEA4 area averaged over the years 1997 to 2001 are shown in Figure 3.18.1. The Scottish share of the total catch in Division IVa is variable and does not exceed 10%.

ICES is concerned about the continuing decline in the spawning stock biomass and the high exploitation of juvenile fish at a time when recruitment is low.

3.19 Sandeel (Family Ammodytidae)

Biology

There are five species of sandeel that occur in the North Sea but about 90% of the commercial catch of sandeels consists of one species, *Ammodytes marinus*. It is predominatly an offshore species Sandeels are a shoaling species that lie buried in the sand during the night and emerge during the day to feed in midwater (Knijn et al., 1993). During the winter they remain in the sediment only emerging to spawn. Spawning takes place from November to February and is widespread over the shelf area of the SEA4 area (Figure 3.19.1) (Coull et al., 1998) The eggs are demersal being laid in sticky clumps on sandy substrates. The larvae are pelagic and after about 2 – 5 months they adopt the demersal habit.

It has been suggested that there are probably several sub-populations in the North Sea and a separate sub-population around Shetland and the Faroes and another on the west of Scotland.

Fishery

Sandeels support the largest fishery in the North Sea with estimated landings of over a million tonnes in the late 1990s. The spatial distribution of landings of sandeels is largely explained by the distribution of areas of suitable habitat (Wright et al., 1998). For biological sampling and assessments the North Sea has been divided into three main areas. The two largest are the northern and the southern North Sea separated at about 56° 30'N. The third is a box around Shetland and incorporating the northeast of Orkney. The sandeels of Shetland are not a separate biological stock but form part of

a larger complex of sub-populations. The sandeel box around Shetland recognises the importance of the seabird populations of the islands and their dependence on sandeels. The sandeel fishing grounds are inshore and close to the bird colonies. Figure 3.19.2 shows the estimated landings from the box around Shetland together with those for the northern area of the North Sea. Denmark and Norway are the largest exploiters of sandeels.

The Shetland fishery began in the 1970s and reached a peak of 52000 t in 1982. Thereafter the landings declined and seasonal closures were introduced in 1989 following poor sandeel recruitment and poor breeding success of sandeel dependent bird populations. The Shetland fishery was closed between 1991 and 1994. A restricted fishery began again in 1995 and the fishery re-opened in 1998 with a TAC of 7000 t, limited licensing and a June and July closed period. However, the landings have never reached the TAC and in 2001 they were only 1300 t. The existing management plan is effective until 2003. Most of the Shetland landings are taken in April, May and August.

The landings from the sandeel fishery from the west of Scotland have declined considerably in recent years and amounted to only a preliminary 295 t in 2001 (Figure 3.19.3). The landings are almost entirely by the Scottish fleet. The fishing grounds are close inshore and often adjacent to bird colonies. Current management consists of a TAC of 12000 t, a closure from 31 July and access restricted to vessels with a track record of fishing for sandeels.

The distribution of the landings of sandeel in the SEA4 area averaged over the years 1997 to 2001 are shown in Figure 3.19.4. The fishery is concentrated around Shetland and to the north of the Hebrides and mainland Scotland

3.20 Mackerel (*Scomber scombrus*)

Biology

The mackerel is a widely distributed and commercially important pelagic species. It is a fast growing species and most fish are sexually mature by three years of age. They have a prolonged spawning season with the eggs being shed in batches. The eggs, which contain a large oil globule, are mostly found in the upper 26 m of the water column (Coombs et al.1981). Young mackerel feed on copepods, other small crustaceans and fish larvae. Older fish feed on pelagic crustaceans, mainly copepods and euphausiids, and juvenile pelagic fish such as herring, Norway pout and sandeels.

There are two main stocks of mackerel based on the timing and area of spawning (Coull et al., 1998) (Figure 3.20.1). The existence of a third southern stock in the southern Bay of Biscay is now in doubt after tagging experiments revealed that at least some migrate along the western coasts of Europe to the feeding grounds off Norway (Uriarte and Lucio, 2001). The western stock spawns between March and July mainly to the south and west of the British Isles. The nursery area for the western stock extends to the shelf west of Orkney and Shetland (Coull et al., 1998) (Figure 3.20.2). Over the last 20 years there has been a westerly shift of the spawning areas and at the same time there has been a northerly shift in the distribution of juveniles (Walsh et al., 1996) with relatively high concentrations of juveniles over the shelf to

the west of Orkney and Shetland. After spawning the adult fish migrate northwards to feeding grounds in the Norwegian Sea and in the Northern North Sea. This northwards migration route and its timing has remained relatively stable (Walsh et al., 1995). There have, however, been significant changes in the route of the southerly migration since the 1970s. In earlier years the migration took place in late summer and autumn and the fish passed through the relatively shallow waters of the Minch. This was the basis of a substantial fishery in the Minch. Now the migration has become later so that the fish are passing through Shetland waters in January and are west of Scotland and Ireland in February. The majority of fish pass to the west of the Outer Hebrides instead of the Minch. The implication of this change for the fishery is described below.

The North Sea stock spawns mainly in the central North Sea and they then migrate to overwinter in the deep water to the east and north of Shetland and on the edge of the Norwegian Deep. Therefore there is a mixing of the two stocks in the northern North Sea and the Norwegian Sea.

Fishery

For management purposes ICES considers that all the mackerel from Spain to Norway (including the Skagerrak) are a single stock because it is impossible to separate the western and North Sea components on the feeding grounds in the northern North Sea. Nevertheless, ICES continues to recognise the different spawning components. The estimated catches of the western component increased from a low level in the 1960s to 800000 t in 1993. These were directed fisheries by purse seiners and pair trawlers and large catches were taken in the northern North Sea and the Norwegian Sea. A reduction in the quota reduced the catch to 200000 t in 1995 and since 1998 the catches have remained stable. The North Sea component was heavily fished in the 1960s by purse seiners with catches reaching 1 million tonnes in 1967. The stock subsequently collapsed and catches declined to less than 100000 t in the late 1970s and have probably become even lower. This component is considered to be severely depleted and outside safe biological limits. The changes in migration patterns of mackerel have caused problems for both fishermen and managers. For example, the change in the proportion of the stock in EU, Faroese and Norwegian waters requires agreement on how to share the available catch. The timing of the migration of the western component back to the spawning grounds has meant that quotas in the North Sea have become restrictive and catches in excess of the quota have been reported to the west of Scotland. Figure 3.20.3 shows the ICES Working Group's estimate of the weight of fish caught in North Sea but reported to the west of Scotland. In some years catches in the North Sea were reported to the Norwegian Sea (ICES Division IIa). The corollary is that the reported landings for west of Scotland are higher than the true catch.

Figure 3.20.4 shows the ICES Working Group estimates of the total mackerel catch, after adjusting for unallocated landings, misreported landings and discards, for the North Sea, west of Scotland and all other areas combined for the years 1969 to 2000.The effect of the decline in the North Sea spawning component in the late 1960s and in the 1970s is evident. Figures 3.20.5 and 3.20.6 show the reported catches for the North Sea (including the Skagerrak) and the Western area (west of Scotland, west of Ireland and parts of the Bay of Biscay) to show the proportion of the UK catch.

However, these data are only indicative given the levels of misreporting. Similarly, the landings by statistical rectangle by Scottish vessels in the SEA4 area averaged over the period 1997 to 2001 (Figure 3.20.7) should be treated with caution. The mean landings of 7898 and 4745 tonnes in E5 49 and E5 48, which lie immediately west of 4 °W, are most likely to comprise significant misreporting.

3.21 Redfish (*Sebastes* spp.)

Sebastes is a complex genus but two species comprise most of the commercial landings; *Sebastes marinus* (shelf) and *S. mentella* (oceanic and deep-sea). They are a species of northern latitudes and the main fisheries are at Greenland, Iceland, the Faroes and off Norway. Redfish, except for the commercially unimportant Norway haddock (*Sebastes viviparous*), have not been reported from the North Sea surveys (Knijn et al., 1993). ICES reports on relatively insignificant landings from the west of Scotland that are a bycatch of the demersal fisheries. No landings from the North Sea are considered by the ICES Working Group. However, they are being caught in the deep-water demersal fishery that targets Greenland halibut to the north of Shetland (Bullough et al., 1998). Figure 3.21.1 shows Scottish landings of redfish from the SEA4 area by statistical rectangle averaged over the years 1997-2001. The largest catches are along the shelf edge.

3.22 Megrim (*Lepidorhombus whiffiagonis*)

There are two species of megrim in UK waters, *Lepidorhombus wiffiagonis* (megrim) and *L. boscii* (four-spot megrim). The latter has a generally deeper and more southerly distribution. It is seldom caught on the Scottish continental shelf.

The megrim is present in low abundance in the North Sea with the only substantial catches being taken along the shelf edge to the north of Shetland at depths greater than about 100 m (Knijn et al., 1993). A similar distribution occurs to the west of Scotland (Gordon, 1981). Knowledge of the distribution and biology of megrim in the waters to the west of Scotland has significantly increased as a result of European Commission DG Fisheries Study Contract (98/096) entitled *Distribution and biology of anglerfish and megrim in waters to the west of Scotland* (Gordon, 2001a). Monthly landings of megrim by the Irish fleet between 1995 and 2000 from the west of Scotland were analysed. Peak landings per unit of effort were in January and May in most years. Biological sampling using research and commercial vessels extended along the edge of the continental shelf and into the SEA4 area. Ages of up to 16 years for females and 12 years for males were recorded. Megrim are asynchronous batch spawners and spawning occurred between January and April. The location of spawning fish caught throughout the study indicates that spawning occurs along the whole shelf edge/upper slope and that they may migrate into deeper water to spawn. Females attain a larger size than males and the disproportionate discarding of smaller males leads to a high proportion of females in the landings.

Fishery

A high proportion of the megrim caught by some fleets is in association with targeted fisheries for anglerfish. Misreporting of anglerfish landings between areas, especially between the North Sea and the west of Scotland, (see 3.26), also results in

misreporting of associated megrim landings. For the purposes of assessment the ICES Working Group reallocates a proportion of the reported landings of megrim from the ICES statistical rectangles immediately east of 4°W from the North Sea to the west of Scotland. Figure 3.22.1 shows the reported landings by Scottish vessels by statistical rectangle in the SEA4 area averaged for the years 1997 to 2001. It shows high reported landings in rectangles E6 46 and E6 47 which are probably associated with the misreporting of anglerfish.

West of Scotland

Until the 1990s the megrim was mainly a bycatch of the mixed bottom trawl fishery on the continental shelf. However, the targeted fishery on anglerfish in deeper waters that developed throughout the 1990s has led to increased fishing pressure on megrim. The recent landings from the west of Scotland are shown in Figure 3.22.2. These include an adjustment by the ICES Working Group for unreported landings which are referred to as "unallocated". There has been a steady decrease in landings since 1996. A high proportion of the UK landings, especially in recent years, are by Scottish vessels. The Scottish heavy trawl fleet has increasingly been changing to using twin rigs and larger (>100 mm) mesh sizes to target anglerfish in deeper waters. Megrim are also landed by the Scottish light trawl fleet that uses 80 mm mesh to target *Nephrops* on the shelf. Most of the Scottish landings of megrim are from the Butt of Lewis and the slope north of the Hebrides. It is probable that most of the French landings are also from the continental slope.

3.23 Lemon Sole (*Microstomus kitt*)

Biology

Although the lemon sole occurs throughout the North Sea its centre of distribution is in Scottish, Orkney and Shetland waters (Knijn et al. 1993). Spawning takes place over a wide area (Coull et al., 1998) (Figure 3.23.1) and off eastern Scotland it takes place from May to September (Wheeler, 1969). The diet of the lemon sole is dominated by polychaete worms. The nursery areas have similar distribution to the spawning areas (Coull et al., 1998) (Figure 3.23.2)

Fishery

The lemon sole is taken as a bycatch in mixed demersal fisheries and the status of the species is not assessed by ICES. In 2001 Scottish vessels landed a total of 2001 t of which 837 were from the North Sea (Division IVa) and 119 from the west of Scotland (Division VIa) (Anon, 2002a). Figure 3.23.3 shows the Scottish landings of lemon sole from the SEA4 area averaged over the years 1997-2001 by statistical rectangle. They were mostly from the continental shelf and were highest to the east of Shetland.

3.24 Plaice (*Pleuronectes platessa*)

Biology

The plaice is widely distributed throughout the North Sea although it is much more abundant as both juveniles and adults in the south and along the western fringes as far

north as Shetland (Knijn et al.,1993). It is also widely distributed on the west coast of Scotland (Gordon, 1981). It spawns throughout its adult range and a spawning area to the south of Shetland has been identified (Coull et al., 1998) (Figure 3.24.1). Plaice eggs are pelagic and the metamorphosing larvae enter coastal sandy areas which are the nursery grounds for plaice. After a year they gradually disperse offshore. Plaice can make quite extensive migrations between spawning and feeding grounds. They are benthic feeders consuming polychaete worms, amphipods, mysids, molluscs and brittle stars.

Fishery

The fisheries for plaice are most important in the southern and central North Sea and are mostly carried out by beam trawlers. Figure 3.24.2 shows the landings of plaice by Scottish vessels averaged over the years 1997 to 2001 for the statistical rectangles of the SEA4 area. The highest landings are between Orkney and Shetland. Figure 3.24.3 shows that Scottish catch of plaice is only a small part of the international catch from the North Sea, where the Netherlands take the largest share followed by Denmark, UK (England) and Belgium.

ICES consider that plaice are being harvested outside safe biological limits and have recommended a reduction in TAC. Changes in the mesh size regulations for towed gears, including beam trawls, in the northern part of the North Sea as part of the cod recovery programme should also benefit the recovery of plaice stocks.

3.25 Greenland halibut (*Reinhardtius hippoglossoides*)

Biology

The Greenland halibut is a deep-water flatfish that occurs in colder waters. It is widely distributed in the northern waters and is exploited around Greenland, Iceland, the Faroes and Norway. The fishery in the Faroe-Shetland Channel has only developed in recent years.

The Greenland halibut spawns in deep-water and is unusual for a flatfish because it is an active predator off the bottom and feeds mostly on other fishes and some crustaceans.

Fishery

The stock of Greenland halibut in the Faroe-Shetland Channel is probably an extension of the stock that is exploited off the coast of Norway (ICES Sub-areas I and II). The Norwegian fishery which began as a coastal longline and later included a gillnet fishery increased rapidly in the 1970s as a result of the development of a trawl fishery. Thereafter, catches declined and in 1992 the fishery was regulated to severely control the exploitation by trawl. The ICES Arctic Working Group that assesses the stock off Norway (ICES Sub-areas I and II) compiles landings data for the North Sea but the assessment of this part of the stock is not within its remit. Figure 3.25.1 shows the reported landings of Greenland halibut from the North Sea for the years 1973 to 2001. The landings data for Norway for 2000 and 2001 are preliminary. It shows the growth of the fishery during the 1990s. The Scottish and earlier French landings are

probably all from targeted trawl fisheries within the SEA4 area. Scottish landings of Greenland halibut for west of Scotland, probably all from the SEA4 area, were around 1000 t between 1995 and 1997 (Gordon, 2001b). Figure 3.25.2 shows the reported landings (tonnes) by Scottish vessels averaged over the years 1997 to 2001 by ICES statistical rectangle for the SEA4 area.

3.26 Anglerfish (*Lophius* spp)

There are two species of anglerfish in UK waters; the white anglerfish (*Lophius piscatorius*) and the black anglerfish (*Lophius budegassa*). They are most easily distinguished by the colouration of the lining of the body cavity (peritoneum), hence the names white and black anglerfishes. The black anglerfish has a more southerly distribution and although recorded in Scottish waters it is quite rare. The anglerfish is also frequently referred to by the industry as monkfish or simply as monks.

The anglerfish is widely distributed around Scotland both on the shelf and on the continental slope to depths of about 1000 m. A recent European Commission DG Fisheries Study Contract (98/096) entitled *Distribution and biology of anglerfish and megrim in waters to the west of Scotland* has made a significant contribution to our knowledge (Gordon, 2001a). Biological samples were obtained by chartering commercial vessels, sending observers on commercial vessels and from research vessel surveys. The most obvious result was an almost complete absence of mature females in all surveys. There was a consistent indication that males were more abundant in deeper waters. In the SEA4 area these hauls were concentrated along the shelf edge. A separate analysis of the most northerly sector, 59° 30' to 62° 00' N, corresponded quite closely to the SEA4 area. Anglerfish were caught only in the shallower depth strata (0-199, 200-399 and 400- 599 m). The catch rates were highest in the shallowest depth stratum. Immature females dominated at all depths and there were a higher proportion of mature males in the deeper strata.

Laurenson (1999) and Laurenson et al., (2001) studied the biology of anglerfish which were caught mostly within the 200 m contour around Shetland with the additions of some material from west of the Outer Hebrides. Most of the data were collected on board commercial whitefish trawlers although some additional data were obtained from inshore surveys for sandeels. In Shetland waters there was a significant increase in mean length and mean age with increasing depth. The percentage of mature female fish between 150 and 200 m around Shetland was 3.3 with a corresponding value for males of 16.9. No ripe females were caught.

Since the completion of the EC contract further work has been carried out by Fisheries Research Services as part of their Industry/Science partnership (Fisheries Research Services, 2002). A shelf edge survey using a commercial vessel included hauls to the east of the Wyville-Thompson Ridge in the SEA4 area. At depths greater than 400 m, where the temperature was below 4 °C, no anglerfish were caught. It was noted that there was a significant number of small angler fish on the shelf in the SEA4 area. Another survey had as its main objective the assessment of the abundance of juvenile anglerfish on inshore grounds with a view to identifying possible areas for seasonal closure. Three of the areas were within SEA4. In all areas about 90% of anglerfish were immature. The area known as the Noup had one of the highest

percentages of small fish and would warrant further consideration as an area for possible closure.

The anglerfish has a somewhat unusual reproductive biology. Spawning takes place between November and May (Afonso-Dias and Hislop, 1996).The eggs are pelagic but are retained within a buoyant gelatinous ribbon which can measure up to 10 m in length (Hislop et al., 2001). This aggregation of eggs and newly emerged larvae explains why egg and larval surveys have revealed little about the location and timing of spawning. The anglerfish has a prolonged juvenile pelagic phase in near surface waters (Hislop et al., 2000). In an attempt to elucidate the early life history of the anglerfish, Hislop et al. (2001) combined data on distribution and growth rates of the pelagic phase into a particle tracking model. One of the predictions of the model is that a large proportion of young anglerfish from a spawning area west of the Outer Hebrides (probably in deep water) will enter the North Sea.

The estimation of the age of anglerfish is difficult but investigations carried out under the EC contract have improved the validity of the estimates of both the early pelagic and the demersal anglerfish (Wright et al., 2002, Woodroffe et al., 2003). Adult ages of up to 13 years have been reported from Scottish waters.

The angler fish is primarily a sit and wait predator, using its lure (illicium) to attract prey, mainly fish, to its large gaping mouth.

Fishery

ICES consider that it is likely that the catches in the North Sea (including the Skagerrak) and the west of Scotland belong to the same biological stock and they are currently assessed as a single unit. However, there are some major problems with the assessment and management of the stock. Historically the west of Scotland was managed by a TAC but until 1998 there was no TAC for the adjacent North Sea. As the west of Scotland fishery expanded (see below) the TAC became restrictive and this encouraged misreporting of landings into the North Sea. When TACs were introduced for Sub-area IV they were based on previous reported landings and "are unlikely to have prevented further misreporting or to have improved conservation in either area." Figure 3.26.1 shows the reported landings of anglerfish for west of Scotland and the ICES Working Group's estimate of the true landings after adjusting for misreporting. The reported landings by Scottish vessels by statistical rectangle averaged over the years 1997 to 2001 are shown in Figure 3.26.2. The high landings reported for the rectangles to the west of 4°W, especially in 46 E6, are evidence of misreporting.

The fishery in the North Sea is mainly in the north reflecting the distribution of this species (Knijn et al, 1993). The UK accounted for about 75% of the officially reported landings.

The west of Scotland fishery is mostly by the UK and France with Ireland being the next most important nation. The Scottish fishery is by the two main fleets that target mixed roundfish. The Scottish light trawl fleet accounts for about 65 % of the landings while the Scottish trawl fleet accounts for 20%. The *Nephrops* trawl fishery accounts for about 10% of the landings. The development of a targeted fishery for

anglerfish in recent years has resulted in fleet changes such as a move to deeper offshore grounds and the development of specialised trawls. There is no minimum landing size for anglerfish and discard levels are low. The French vessels landing anglerfish are probably targeting shelf edge or deep-water species and most of their catches will be from west of the Hebrides. There is also a small gill net fishery around Shetland (Laurenson, 2001).

Because of the problem of misreporting, especially between Division VIa and IVa it is most appropriate to consider a "northern shelf" stock as the assessment unit. Figure 3.26.3 shows the combined estimated landings for this stock as used by the ICES Working Group for assessment. They show a steady increase beginning in about 1983 from around 9000 t to a peak of 34900 t in 1996. Since then there has been a rapid decrease in landings.

ICES considers that the combined stock is being harvested outside safe biological limits and advices a reduction in the TACs. Because of their body shape small fish are caught before they reach maturity. It was thought that there might be a reservoir of mature fish in deep-water but recent investigations have failed to verify the existence of such a population.

3.27 Norway Lobster (*Nephrops norvegicus*)

Biology

The Norway lobster is widely distributed in Scottish waters and is the third most valuable fishery in the North Sea and the most valuable on the west of Scotland. The Norway lobster lives in burrows and therefore its distribution is dependent on the availability of suitable muddy substrates. They are found at depths between 15 and 800 m but most of the fisheries are between 40 and 200m (Howard, 1982). Fertilisation and spawning takes place from August to November and the fertilized eggs are carried by the female for about nine months while they develop. Hatching begins in late April and continues until August. After a relatively short pelagic phase juvenile Norway lobster settle on the bottom and construct a burrow. The diet is very varied consisting of molluscs, worms, crustaceans and fish. They can also utilize small organisms in the mud. Growth is by moulting and they grow rapidly in their first year.

Light intensity appears to be the most important factor that determines when Norway lobsters emerge from their burrows to feed and therefore become most vulnerable to capture.

Fishery

The landings of Norway lobster in the SEA4 area by ICES statistical rectangle averaged over the years 1997 to 2001 are shown in Figure 5.27.1.

North Sea

In the North Sea the main fishing grounds are in the northern area, notably the Fladen Ground, the Moray Firth and the Noup. The Noup lies to the northwest of Orkney and

is within area SEA4 and its location is clearly visible by increased landings in Figure 5.27.1. Most *Nephrops* are caught by trawlers targeting the species. Although there are limited data for the stock on the Noup ground the catch rates suggest that current fishing level are acceptable.

West of Scotland

The main fishing areas are the South and North Minches and the Clyde. Most are caught by trawl but in the Minches about 15% can be caught by creel. The stock in the North Minch appears to stabilised in recent years.

3.28 Other shellfish

With the exception of Norway lobster most of the other shellfish is caught by small dredgers, creel boats or, in the case of winkles, on the shore. It is probable that most landings are made locally and therefore reflect the degree of fishing effort. Table 3.28.1 shows the reported landings for Shetland and Orkney for 2001 (Anon, 2002a). In Shetland the lobster fishery virtually collapsed after peaking in the 1960s and has never recovered (Watt and Arthur, 1996). This led to a diversification into the exploitation of other species such as velvet crab.

Table 3.28.1 The reported landings of some inshore shellfish species into Shetland and Orkney in 2001 (data from Scottish Fisheries Statistics 2001)

Common name	Scientific name	Shetland landings (tonnes)	Orkney landings (tonnes)
Brown crab	*Cancer pagurus*	316	1105
Queen scallops	*Aequipecten opercularis*	18	
Scallops	*Pecten maximus*	485	180
Velvet crabs	*Necora puber*	75	679
Whelks	*Buccinum undatum*	181	393
Cockles	*Cardium edule*		82
Periwinkle	*Littorina littorea*	82	
Green crab	*Carcinus maenas*		265
Lobster	*Hommarus vulgaris*	83	
Other shellfish		3	33

4. The Fish Communities of the SEA4 area

4.1 Coastal/inshore

The coastal fish communities of the north coast of Scotland and around Orkney and Shetland have not been the subject of comprehensive studies. The relevant chapters in the Joint Nature Conservation Committee (JNCC) "Coasts and seas of the United Kingdom" series (Barne et al., 1997a,b) have collated some of the available information. The need for improved information on coastal locations has been recognized by Fisheries Research Services who under the auspices of the Industry/Science partnership carried out trawling surveys in selected areas of the Scottish coast (Fisheries Research Services, 2002). This summary report notes that 90 trawl hauls were made around Shetland and that 46 fish species were recorded. Distribution and fish length data are provided for some important species.

4.2 Shelf/shelf edge

Daan et al., (1990) applied cluster analysis to the catch per unit of effort (kg/h) of the 50 most abundant species in the English groundfish surveys from 1982-1985 from the North Sea. These surveys had a maximum depth of 200 m. This revealed three clearly separated groupings of which two, a shelf edge and a central/northern, are relevant to the North Sea sector of the SEA4 area (Figure 4.1). The 10 dominant species by weight in each of these assemblages is given in Table 4.1.

Table 4.1 The 10 dominant species by weight in the shelf edge and the central/northern fish communities identified by Daan et al., (1990)

Shelf Edge	Percentage weight	Central/northern	Percentage weight
Saithe	43.6	Haddock	42.4
Haddock	11.6	Whiting	13.9
Norway pout	10.7	Cod	9.2
Whiting	9.1	Norway pout	4.7
Horse mackerel	7.6	Saithe	4.5
Blue whiting	4.1	Dab	3.7
Cod	3.8	Grey Gurnard	2.0
Mackerel	1.6	Herring	2.5
Hake	1.3	Lemon sole	1.8
Ling	1.2	Starry Ray	2.0
Total	94.6	Total	86.7

4.3 Continental slope

The continental slope to the west of the British Isles has been extensively studied, especially since the development of the deep-water fisheries targeting species such as roundnose grenadier (*Coryphaenoides rupestris*), black scabbardfish (*Aphanopus carbo*), blue ling (*Molva dypterygia*), orange roughy (*Hoplostethus atlanticus*) and anglerfish (*Lophius* spp.). Gordon (in press) has reviewed current knowledge of the fish and fisheries of Rockall Trough; the deep-water fisheries to the west and north of the British Isles have been described by Gordon (2001b), and for the ICES area by Gordon et al. (in press). A notable feature of the west of Scotland slope is that there is

no evidence of zonation of the fish assemblages. Each species has its own depth range which is highly variable between species. The overlapping of fish species each with a differing depth range results in a gradual change in the fish fauna with depth. Despite the lack of zonation most community studies recognize an upper, middle and lower continental slope. In their summary atlas of the demersal fishes of the North Atlantic Haedrich and Merrett (1988) proposed the following approximate limits: upper slope (200 - 750 m), middle slope (750 - 1500 m) and lower slope (1500 - 2250 m).The slope to the west of Scotland is also characterised by a gradual decrease in temperature with depth.

The west of Scotland slope is separated from the slope of the Faroe Shetland Channel (SEA4) by the Wyville-Thompson Ridge. This has a sill depth of about 500 m and constitutes a major faunal barrier (Gordon, 2001b). The changes in water temperature with depth are complex, not least because of the presence of five water masses of different origins (Bullough et al., 1998) (see also Figure 2 of the report on Seafloor sediments and sedimentary processes on the outer continental shelf, continental slope and basin floor. The sub-divisions of the slope used in other Atlantic areas are not applicable to this complex area. The upper slope (approximately 200 m down to sill depth of 500 m) is characterised by Atlantic water and temperatures are similar to the west of Scotland upper slope. Below about 500 m, in simple terms, the water temperature decreases rapidly reaching 0°C by about 1000 m. In reality the situation is much more complex and unstable. Nevertheless, Bullough et al., 1998 recognised a transition zone between the warmer Atlantic waters and the deeper Norwegian Sea water. It is therefore appropriate to describe three main deep-water communities in the Faroe Shetland Channel. These are the upper slope, a transition zone and a deep Norwegian Sea zone.

The investigations by Bergstad (1990a) on fish assemblages of the nearby Norwegian Deep are relevant to the upper slope of the SEA4 area. Two studies on the fish assemblages of the Norwegian slope at about 62°N are also relevant (Bakken et al., 1975 and Bergstad et al., 1999). The study by Bergstad et al.(1999) used multivariate analysis and clearly identified three station assemblages: upper slope (217-638 m), mid-slope (585-1020 m) and cold-water (1498-2051 m). A similar classification of species revealed four species groups. A Norwegian Sea deep-water assemblage had only three species and none in common with an Atlantic water shelf edge assemblage. Two assemblages were identifiable in the transition zone representing the warm and cold water ends of the temperature gradient. On the Norwegian slope relative fish abundance and biomass decrease with depth. Fish abundance decreases to about 10% at 800 m and 1% at 1000 m of that at the shelf edge.

Upper slope

There is little published information on the fish present on the upper slope of the Faroe Shetland Channel within the SEA4 area. In the 1970s the UK Ministry of Agriculture, Fisheries and Food (MAFF) carried out deep-water, bottom trawling surveys to the west of the British Isles (Bridger, 1978). The majority of the hauls were in the Atlantic water to the west of Scotland and Ireland but 20 hauls were carried out east of the Wyville-Thompson Ridge. The data from these surveys have subsequently been re-analysed by Gordon and Swan (1997b) with the support of the European Commission. The slope was divided into 250 m bathymetric zones. Table 4.2 gives

the number of fish in the 3 hauls in the 500 m bathymetric zone (375-625 m). The dominant species were rabbit fish, Norway haddock, bluemouth and blue whiting. Overall the fauna is similar to that found on the Atlantic upper slope to the west of the Hebrides except that all three species of redfish (*Sebastes* spp) would be less abundant in the Rockall Trough. The occurrence of Greenland halibut and roughhead grenadier are rare on the Atlantic slope to the west of the Hebrides Their patchy distribution is probably associated with cold water overflow.

The dominant species (by weight) of the Norwegian Deep (excluding the Skagerrak) at depths greater than 200 m are shown in Table 4.3. The species composition is similar to the MAFF 500m assemblage, except that bluemouth was not recorded. It was only present in one of the three MAFF hauls. Bluemouth have been observed to invade the North Sea as juveniles and their growth has been followed over several years (Heessen et al., 1996). A population of roundnose grenadier exists in the Skagerrak (Bergstad, 1990b; Bergstad and Gordon, 1994) and this is probably the source of this species in the Norwegian Deep. There is no evidence that roundnose grenadier is present on the upper slope of the Faroe Shetland Channel.

The species composition observed by Bakken et al., (1975) at 400 and at 500 m on the Norwegian slope at about 62 °N is shown in Table 4.4. On the basis of the temperature data these depth strata are probably most similar to the upper slope of the Faroe Shetland Channel. The species composition is broadly similar to the other studies.

The fish present in the upper slope assemblage (217-638 m) identified by Bergstad et al (1999) are shown in Table 4.5 together with their frequency of occurrence. The most abundant species were the redfishes (*Sebastes mentella* and *Sebastes viviparous*) Greenland halibut and blue whiting.

In conclusion the upper slope fauna of the Faroe Shetland Channel has many similarities with the fauna of the upper slopes of the Rockall Trough and the Norwegian continental margin. Some of the investigations, where the depth range exceeds about 500 m, (e.g. Bergstad et al. 1999) have some of the deeper colder water species such as Greenland halibut and roughhead grenadier that are typical of the transition zone.

Transition zone

The transition zone refers the area of the slope where the bottom water temperature is changing rapidly (Bullough et al., 1998). On the southern slope of the Faroe Shetland Channel it tends to be quite a narrow zone whose depth varies according to the tidal cycle by up to 100 m. Seasonal variations were also observed. In this zone Bullough et al., (1998) identified Greenland halibut as the target species of the fishery with a bycatch of blue ling, roughhead grenadier, tusk, the two species of redfish (*Sebastes marinus* and *S. mentella* and the Arctic skate).

The hauls in the 750 m bathymetric zone (625 – 875 m) used to analyse the hauls carried out in the MAFF survey (Gordon and Swan, 1997b) most closely correspond to the transition zone. Table 4.6 shows the species composition, the number of fish caught and the frequency of occurrence in hauls. This was a diverse fauna but only a

few species were dominant. Many of the dominant species, such as Greenland halibut and Arctic skate, were the same as those observed by Bullough et al., (1998). There are a number of fish that were not identified to species because this is a poorly understood deep-water fauna.

The 600 and 700 m bathymetric zones of Bakken et al. (1975) also correspond to transition zone of the Norwegian slope where the dominant species are Greenland halibut, Arctic skate, roughhead grenadier and blue whiting (Table 4.4). The eelpouts (*Lycodes* spp) were not identified to species.

The species identified in the transition zone assemblage of the Norwegian slope identified by Bergstad et al. (1999) are shown in Table 4.5, together with their frequency of occurrence. Although they were not present in every haul, the dominant species were Greenland halibut and roughhead grenadier.

Therefore the demersal fish fauna in the transition zone in the Faroe Shetland Channel appears to be quite diverse and to have strong affinities with the equivalent zone on the Norwegian continental margin. Relatively few species are dominant and of these Greenland halibut is commercially the most important. Roughhead grenadier and Arctic skate are also abundant and are landed as bycatch.

Norwegian Sea deep water

In the MAFF surveys 9 hauls were carried out in the 1000 m bathymetric zone (875-1125 m). The catch given in Table 4.7 has a mixture of the fauna of the transition zone and the lower slope cold-water fauna. In 1996 the Scottish Association for Marine Science carried out two trawls in the Faroe Shetland Channel at 1060 and 1520 m and the preliminary identification of the catch is shown in Table 4.8. With the exception of Arctic skate at 1000 m the fauna was typical of the cold deep Norwegian Sea Basin. The identification of the eelpouts, with the exception of *Lycodes esmarki*, is tentative pending the on-going revision of this group. The sampling was done by a small shrimp trawl fished on a single warp. This was the same trawl that was used for some of the sampling by Bergstad et al. (1999) on the Norwegian slope. The species present in the deep Norwegian Sea water assemblage (1498 - 2051 m) identified by Bergstad et al. (1999) are shown in Table 4.5. Only 6 species were caught of these only the eelpout *Lycodes frigidus* and *Paraliparis bathybius* were relatively abundant. The biomass is low and many of the species are of small adult size.

Table 4.2 Numerical abundance of species in the three MAFF hauls in the 500 m bathymetric zone. The + after the number is because *Micromesistius poutassou* (blue whiting) and *Argentina silus* (argentine or greater silver smelt) were recorded in all three hauls but only counted in one. *Gadiculus argenteus thori* (silvery pout) was recorded in two hauls but only counted in one. The identity of 'Mock hake'is not known.

Species name	Common name	Total	Frequency
Chimaera monstrosa	Rabbit fish	732	2
Sebastes viviparous	Norway haddock	201	2
Helicolenus dactylopterus	Bluemouth	148	1
Micromesistius poutassou	Blue whiting	123 +	3
Sebastes marinus	Golden redfish	48	2
Argentina silus	Argentine	47 +	3
Gadiculus argenteus thori	Silvery pout	40 +	2
Brosme brosme	Tusk	32	2
	'Mock hake'	31	2
Molva dypterygia	Blue ling	31	2
Galeus melastomus	Blackmouth dogfish	31	2
Reinhardtius hippoglossoides	Greenland halibut	24	1
Lepidorhombus sp.	Megrim	9	1
Macrourus berglax	Roughhead grenadier	7	1
Etmopterus spinax	Velvet belly dogfish	6	1
Pollachius virens	Saithe	4	2
Molva molva	Ling	4	1
Sebastes mentella	Deep-water redfish	3	1
Etmopterus sp.	Unidentified lantern shark	1	1
Hippoglossus hippoglossus	Halibut	1	1
Lepidion eques	Lepidion	1	1
Molva macrophthalma	Mediterranean ling	1	1

Table 4.3 The dominant species (by weight) of the Norwegian Deep (excluding the Skagerrak) at depths greater than 200 m. (from Gordon, 1992 using data from Bergstad, 1989).

Species name	Common name	Percent by weight
Micromesistius poutassou	Blue whiting	41.7
Sebastes viviparous	Norway haddock	13.8
Chimaera monstrosa	Rabbit fish	11.2
Argentina silus	Argentine	6.2
Pollachius virens	Saithe	4.2
Etmopterus spinax	Velvet belly dogfish	3.6
Trisopterus esmarkii	Norway Pout	2.8
Coryphaenoides rupestris	Roundnose grenadier	2.6
Meluccius merluccius	Hake	2.3
Brosme brosme	Tusk	1.5
Gadus morhua	Cod	1.3
Gadiculus argentius thori	Silvery pout	1.2
Squalus acanthias	Spurdog	1.1
Lophius piscatorius	Anglerfish	1.1
Glyptocephalus cynoglossus	Witch	0.6
Hippoglossoides platessoides	Long Rough Dab	0.4
Gaidropsarus vulgaris	Three bearded rockling	0.1

Table 4.4 The fish catch (no. per hour trawling) on the slope between 400 and 700 m at about 62-63°N 01-03°W. * denotes midwater species. (from Gordon 1992 using data from Bakken et al., 1975)

	Species	Common name	Number
400 m 2 trawls			
	Micromesistius poutassou	Blue whiting	553
	Argentina silus	Argentine	133
	Sebastes viviparous	Norway haddock	97
	Chimaera monstrosa	Rabbit fish	24
	Trisopterus esmarki	Norway pout	18
	Pollachius virens	Saithe	13
	Etmopterus spinax	Velvet belly dogfish	7
	Molva d. dypterygia	Blue ling	6
	Gadiculus thori	Silvery pout	4
	Hippoglossoides platessoides	Long rough dab	4
	Phycis blennoides	Greater forkbeard	1
500 m 2 trawls			
	Micromesistius poutassou	Blue whiting	94
	Sebastes viviparous	Norway haddock	16
	Molva d. dypterygia	Blue ling	13
	Etmopterus spinax	Velvet belly dogfish	4
	Argentina silus	Argentine	4
	Sebastes marinus	Golden redfish	3
	Hippoglossoides platessoides	Long rough dab	3
	Chimaera monstrosa	Rabbit fish	2
	Raja hyperborea	Arctic skate	1
	*Benthosema glaciale**	Lantern fish	1
600 m 5 trawls			
	Micromesistius poutassou	Blue whiting	537
	Macrourus berglax	Roughhead grenadier	81
	Reinhardtius hippoglossoides	Greenland halibut	61
	*Benthosema glaciale**	Lantern fish	26
	Raja hyperborea	Arctic skate	13
	Lycodes spp.	Eelpouts	11
	Argentina silus	Argentine	6
	Raja radiata	Starry skate	4
	*Notolepis rissoi**	-	3
	Sebastes marinus	Golden redfish	3
	Pollachius virens	Saithe	1
	Cottunculus microps	Polar sculpin	1
700 m 4 trawls			
	Reinhardtius hippoglossoides	Greenland halibut	164
	Lycodes spp.	Eelpouts	9
	Macrourus berglax	Roughhead grenadier	8
	*Benthosema glaciale**	Lantern fish	7
	Raja hyperborea	Arctic skate	6
	Micromesistius poutassou	Blue whiting	4
	Myxine glutinosa	Hagfish	1
	Molva d. dypterygia	Blue ling	1
	Sebastes marinus	Golden redfish	1

Table 4.5 The species caught and the number of hauls in which they were present in the three assemblages on the Norwegian slope identified by Bergstad et al., (1999).

Species name	Common name	Frequency		
		217- 638 m (7 hauls)	585-1020 m (6 hauls)	1498-2051 m (4 hauls)
Argentina silus	Argentine	4		
Raja fyllae	Round ray	3		
Raja lintea	Sail ray	1		
Lycodes vahli	Eelpout	2		
Lycenchelys sarsi	Eelpout	1		
Phycis blennoides	Greater forkbeard	1		
Glyptocephalus cynoglossus	Witch	3		
Hippoglossoides platessoides	Long rough dab	3		
Brosme brosme	Tusk	5		
Sebastes mentella	Deep-sea redfish	7		
Chimaera monstrosa	Rabbit fish	3		
Trisopterus esmarki	Norway pout	3		
Anarhichas minor	Spotted wolfish	1		
Sebastes viviparous	Norway haddock	4		
Lophius piscatorius	Anglerfish	1		
Micromesistius poutassou	Blue whiting	7	1	
Raja radiata	Starry ray	2	2	
Bathyraja spinicauda	Spinetail ray	2	2	
Macrourus berglax	Roughhead grenadier	2	2	
Lycodes esmarki	Eelpout	3	3	
Reinhardtius hippoglossoides	Greenland halibut	3	4	
Lycodes eudipleurostictus	Eelpout		2	
Lycodes squamiventer	Eelpout		1	
Lycodes seminudus	Eelpout		1	
Lycenchelys muraena	Eelpout		3	
Cottunculus microps	Polar sculpin		3	
Careproctus longipinnis			1	
Raja hyperborea	Arctic skate	2	6	1
Lycodes pallidus	Eelpout		4	1
Onogadus argentius	Arctic rockling	2	5	1
Lycodonus flagellicauda	Eelpout		3	1
Lycodes frigidus	Eelpout			2
Paraliparis bathybius			1	4
Rhodictys regina				1

Table 4.6 Numerical abundance of species in the eight MAFF hauls in the 750 m bathymetric zone. The + after the number is because not all the fish were counted. * denotes midwater species.

SpeciesName	Common name	Total no fish	Frequency
Raja hyperborea	Arctic skate	148	6
Reinhardtius hippoglossoides	Greenland halibut	102 +	8
Lycodes esmarki	Eelpout	69	4
Micromesistius poutassou	Blue whiting	32	5
Molva dypterygia	Blue ling	26	4
Macrourus berglax	Roughhead grenadier	22	6
Careproctus sp.		18	4
Cottunculus sp.		13	2
Lycodes sp.	Eelpout	12	3
Cottunculus microps	Arctic sculpin	11	2
Sebastes viviparous	Norway haddock	10	2
Coryphaenoides rupestris	Roundnose grenadier	9	1
Raja sp.	Unidentified skate	9	5
Chimaera monstrosa	Rabbit fish	6	2
Myctophid*	Lanternfish	6	2
Sebastes marinus	Golden redfish	4	1
Argentina silus	Argentine	4	3
Rockling	Rockling	3	1
Onogadus argentatus	Arctic rockling	2	2
*Notolepis rissoi**		2	1
Etmopterus spinax	Velvet belly dogfish	1	1
Raja lintea	Sail ray	1	1
Raja radiata	Starry ray	1	1
Helicolenus dactylopterus	Bluemouth	1	1
Myxine glutinosa	Hagfish	1	1
Molva molva	Ling	1	1
Brosme brosme	Tusk	1	1
Epigonus telescopus	Deep-water cardinal fish	1	1
Galeus melastomus	Blackmouth dogfish	1	1
Myxine sp.	Hagfish	+	1

Table 4.7 Numerical abundance of species in the three MAFF hauls in the 1000 m bathymetric zone.

1000 m bathymetric zone (9 hauls)			
Species			Frequency
Lycodes spp.	Unidentified eelpout	85	4
Reinhardtius hippoglossoides	Greenland halibut	59	8
Lycodes esmarki		51	3
Raja hyperborea	Arctic skate	34	6
Onogadus argentatus		26	5
Myctophid	Lantern fish	17	5
Rockling	Rockling	14	2
Cottunculus sp.		10	3
Raja fullonica		9	1
Cottunculus microps		8	1
Raja sp.	Unidentified skate	7	2
Paralepis sp.		4	2
Careproctus sp.		4	3
Raja radiata		3	1
Liparid	Liparid	3	1
Paraliparis sp.		2	2
Argentina silus	Argentine	1	1
Micromesistius poutassou	Blue whiting	1	1
Paraliparis bathybius		1	1

Table 4.8 Preliminary lists of fish caught by a small bottom trawl fished on a single warp by RRS Challenger at depths of 1060 and 1520 m and in the Faroe Shetland Channel in March and June 1990

61°23'N 04°25'W 1060 m		
Lycodes pallidus	Eelpout	48
Raja hyperborea	Arctic Skate	22
Onogadus argenteus	Rockling	19
Cottunculus sadko	-	17
Paraliparis bathybius	-	7
Lycodes esmarki	Eelpout	6
Reinhardtius hippoglossoides	Greenland Halibut	6
Lycodonus flagellicauda	Eelpout	5
Careproctus spp.	-	3
Lycodes reticulatus	Eelpout	2
61°40'N 02°54'W 1520 ~		
Paraliparis bathybius	-	36
Rhodicthys regina	-	16
Raja hyperborea	Arctic Skate	15
Lycodes frigidus	Eelpout	13
Lycodes pallidus	Eelpout	2
Lycodes esmarki	Eelpout	1
Lycodes reticulatus	Eelpout	1
Lycodes flagellicauda	Eelpout	1
Reinhardtius hippoglossoides	Greenland Halibut	1

5. Fisheries overview

The Scottish Fisheries Protection Agency carries out routine surveillance using a spotter plane. These surveys are concentrated on the most heavily fished areas and do not follow a set pattern. The distribution of sightings of fishing vessels is not random. Despite these limitations they do give an indication of the spatial distribution of fishing effort. Figure 5.1 shows the sightings for a three month period in 2001 and serves to emphasise the importance of fisheries in the SEA4 area.

The artificial boundary at 4° W between the North Sea and the west of Scotland adds to the difficulty of describing the fisheries of the complex SEA4 area

5.1. Demersal Fisheries

The total landings of demersal fish species by Scottish vessels averaged over the years 1997 to 2001 by ICES statistical rectangle in the SEA4 area are shown in Figure 5.2. They show two areas of high landings one from around Shetland and the other in four statistical rectangles immediately to the east of 4°W. The latter is mainly an artefact of misreporting of catches between ICES Sub-areas IV and VI.

For reasons stated in Section 1 no new data on fishing effort by Scottish Vessels have been used for the SEA4 area in this report. However, Coull et al. (1998) have provided maps of fishing effort for different categories of fishing. These are based on the logbooks that UK vessels are obliged to keep. The effort is measured as the time spent fishing (nominal fishing effort). Vessels of less than 10 metres that do not report their catches are excluded. No adjustment has been made for the varying efficiency of the vessels. The data are collected by ICES Statistical rectangle and these data have been smoothed to produce contour maps. Of particular importance to the SEA4 area is the fact that rectangles that cover both shallow and deep-water areas have been adjusted to place more emphasis on the effort into shallower waters.

Figure 5.3 shows the demersal (excluding beam trawls) fishing effort by UK vessels. The effort is high over the whole continental shelf area of SEA4 and is particularly high in areas northwest of Orkney and north of Shetland.

The Shetland Box (Figure 5.4) was established in 1983 and its purpose is to protect commercially important local fisheries. It restricts the number of vessels of 26 m and over in length that fish for demersal species (excluding Norway pout and blue whiting). Four countries, Belgium, France, Germany and the United Kingdom, have an allocation of vessels that are licensed to fish within the box. The activities of vessels of less than 26 m are unimpaired by the existence of the box.

5.1.1. Mixed fishery targeting cod, haddock and whiting

This fishery is carried out on the continental shelf by bottom (otter) trawlers and seine netters and is one of the most important fisheries in the SEA4 area. Although the greatest fishing effort lies to the east of Shetland there is also a substantial fishery to the west of the islands throughout the year. The anglerfish is a major bycatch of this fishery and its special features and status have been described in 3.26.

Cod are heavily exploited in the North Sea and ICES has consistently advised that the exploitation rate should be reduced. In 1997, Cook et al., (1997) warned that without a substantial reduction in fishing the stock of North Sea cod could collapse. In November 2000 ICES advised that the North Sea and west of Scotland stocks were at serious risk of collapse and the European Commission (EC) introduced various technical measures, such as mesh size increases, to assist the recovery of the stock. In 2001 the EC adopted an emergency regulation to protect spawning cod by closing areas to fishing by gears likely to catch cod from mid-February to the end of April 2001. This included a large area of the shelf to the west of Shetland lying within the SEA4 area (Figure 5.5). ICES ACFM reported in 2002 that the North Sea stock was outside save biological limits and the spawning stock biomass was at an all time low.

ICES recommended a "closure of all fisheries for cod as a targeted species or a bycatch". It was noted that this would also reduce the catches of other species in the mixed fishery, notably haddock and whiting. Changes might also be required in other fisheries such as those for *Nephrops* in terms of times, areas or methods fished.

The action taken by the European Union was to reduce the TAC and effort (days at sea) reductions are being introduced. At the time of writing the latter measures have yet to be finalised and a longer term cod recovery programme is being negotiated.

ICES also advises that haddock and whiting in the North Sea area are outside safe biological limits. ICES recommends that fishing for haddock and whiting should be prohibited unless it can be demonstrated that there would be no bycatch or discards of cod. Technical measures, such as increased codend mesh sizes and square mesh panels introduced as part of a cod recovery plan could reduce the catches of whiting.

The west of Scotland cod stock is in a similar situation to that of the North Sea. As in the North Sea an area of the west of Shetland shelf was closed to fishing from February to April 2001. ICES has also recommended a closure of the fishery. Haddock and whiting are also outside safe biological limits and the advice for cod determines the advice for these species. The European Union has reduced the TAC for all species and technical measures are being implemented.

5.1.2 Saithe

The trawl fishery for saithe takes place in the deeper water along the shelf edge and upper slope/ The assessment of the stock by ICES is uncertain because there are few survey data to confirm stock trends. However the stock is considered to be within safe biological limits. The medium term projection for the fishery is that there is a low probability of it falling below the precautionary level if *status quo* of fishing mortality is maintained.

5.1.3 Deeper-water fisheries

In recent years a deep-water fishery targeting Greenland halibut has developed in the transition zone between the warmer Atlantic and colder Norwegian Sea waters. This status of this stock is unknown. Below the transition zone (c. 700 m) there are no commercial fisheries and it is unlikely that any will develop due to the low fish

biomass. There is no equivalent in the SEA4 area to the deep-water fisheries that have been developed to the west of the Hebrides.

5.1.4 Nephrops trawl fishery.

The bottom trawl fishery for *Nephrops* (Norway lobster) takes place throughout the year in areas where the seabed is muddy. The effort on fishing *Nephrops* and shrimps is modest compared to some other areas in the UK and is greatest around the Orkney Islands (Figure 5.6). To some extent this may be an underestimate due to the large number of vessels of <10 metres whose effort is not included in these charts. The most important location in the SEA4 region is the area called the Noup, that lies to the west of the Orkney Islands. The status of the stock in this area is uncertain but the current level of exploitation is thought to be acceptable.

5.1.5 Beam trawl fishery

Beam trawling is of relatively minor importance in the SEA4 area compared with the central and southern North Sea. This is in part due to the availability of suitable fishing grounds and probably because the Shetland Box (see below) excludes or limits vessels of some of the countries that dominate this type of fishing.

5.1.6 Scallop dredging

Dredging for scallops (*Pecten maximus*) is an important fishery where there is a suitable seabed of sand and gravel. There are good scallop grounds around both Orkney and Shetland and especially to the north and west of Shetland. The vessels engaged in this fishery range greatly in size and this determines the size and number of the toothed dredges that can be towed. Most fisheries are relatively close inshore and around Shetland are managed under a regulatory order (see 5.4.3). There are also small fisheries for queen scallops.

5.2 Pelagic fisheries

The pelagic fisheries are much more international than those for demersal species and they tend to be prosecuted by larger vessels using purse seine and both single and paired boat midwater trawling. The two largest fisheries, for herring and mackerel, are seasonal. The herring fishery takes place during the summer and autumn. The mackerel migrates northwards through the area in the early part of the year and southwards during the winter. The main mackerel fishery focuses on the winter migration.

The pelagic effort is shown in Figure 5.7. It is relatively high throughout the SEA4 area. The apparent division into two areas of high effort is most likely an artefact of misreporting of pelagic catches between ICES Sub-areas IV and VI when quotas become restrictive.

The total landings of pelagic fish species by Scottish vessels averaged over the years 1997 to 2001 by ICES Statistical rectangle in the SEA4 area are shown in Figure 5.8. With the exception of an area east of Shetland they are highest in four statistical

rectangles to the west of 4°W. As for the demersal species this is a clear indication of misreporting of landings of fish caught in Sub-area IV to Sub-area VI.

5.2.1 Herring

ICES considers that the North Sea autumn spawned herring stock is within safe biological limits. The assessment of the status of the west of Scotland stock is difficult because of serious misreporting of fish caught in other areas into Division VIa, notably from the North Sea (Sub-area IV). More reliable catch data and improvements in biological sampling mean that the most recent assessment is less uncertain and point to the stock being exploited at a sustainable rate. The prognosis for the next few years is good. The TAC for the west of Scotland fishery has not been restrictive in recent years.

5.2.2 Mackerel

The ICES advice is that the combined Northeast Atlantic mackerel stock is currently harvested outside safe biological limits. It has recommended the closure of the fishery in the central and southern North Sea and the Skagerrak and no fishing for mackerel in the northern North Sea (Division IVa) from February until July.

5.3 Industrial fisheries

The most important industrial fisheries in the SEA4 area are for sandeel, blue whiting and Norway pout.

5.3.1 Sandeel

The sandeels around Shetland are managed as a separate unit. The fishery was completely closed between 1991 and 1994 following a decline in recruitment and poor breeding success of sandeel dependent seabirds. Since 1995 a restricted fishery has been allowed. The number of vessels licensed to fish is limited and the fishery is closed during the months of June and July.

5.3.2 Blue whiting

Management of blue whiting is complex because part of the stock is in international waters. There has been a rapid expansion of the fishery and since 1998 the catches have exceeded 1 million tonnes and reached 1.7 million in 2001. ICES considers that a series of exceptionally good year classes in the 1990s have delayed a severe depletion of the stock. Nevertheless, ICES advise that the stock is being harvested outside safe biological limits. In 2001 ICES proposed that, since the landings were significantly above the recommended catch and in the absence of an agreed TAC, the fishery should be closed in all areas. However, in 2002 ICES ACFM revised their assessment and considered that the stock was in a better state than previously been estimated They recommended that the landings should be less than 600000 tonnes but at the November 2002 meeting of the North East Atlantic Fisheries Commission (NEAFC) no TAC was agreed.

5.3.3 Norway pout

The management advice for the North Sea stock is that the Norway pout can sustain current fishing mortality. However, in managing the fishery the bycatch of haddock, whiting and blue whiting should be taken into account and existing measures to protect these species should be maintained. This includes the Norway pout box which extends into the eastern fringes of the SEA4 area (Figure 5.9). Its purpose is to protect juvenile haddock and whiting from capture by the small mesh nets used in the Norway pout fishery. The importance of Norway pout as food for other fish species is also an important management consideration. The mixed industrial fishery in the North Sea can contain variable proportions of blue whiting as a bycatch.

There is insufficient information to evaluate the the west of Scotland stock and consequently there is no management advice for the stock in this area.

5.4 Static gear fisheries

The fishing effort by static gear is high around both Orkney and Shetland (Figure 5.10).

5.4.1 Longline fishery for ling and tusk

The Norwegian offshore longline fishery has a long history dating back to the 16th century (Bergstad and Hareide, 1996). The boom in this fleet was in the 1980s when prices for ling and tusk were high and expectations for cod were high. The fleet is highly mechanised and became more efficient with the introduction of the autoline system in the 1970s. This system automatically baits the hooks and shoots and hauls the lines. The fishery for ling and tusk extends from the continental shelf of Norway, off the Shetlands, the Hebrides, Ireland, the Faroes and the Rockall Bank.

In the Norwegian longline fishery in Division IVa there has been a reduction in the mean length of ling since the 1970s and also a decline in the number of large fish in the landings (Bergstad and Hareide, 1996). This is due to a combination of stock depletion and variable recruitment. A high recruitment in 1993 resulted in 45% of the landings being of fish <70 cm total length. A similar situation exists in the Norwegian longline fishery in Division VIa. ICES consider that the status of the stock is highly uncertain and recommends a 30% reduction in effort.

The status of the tusk is uncertain because of lack of adequate data for assessment in recent years. Based on previous assessments and the increasing fishing effort, ICES consider that the stock may be outside safe biological limits and recommended a 30% cut in overall fishing effort. Tusk has a slower growth rate and higher age at maturity than ling and will therefore be more vulnerable to over-exploitation in the mixed fishery for ling and tusk.

5.4.2 Gill net fishery

There is a small gill net fishery for anglerfish around Shetland.

5.4.3 Inshore creel fisheries

These fisheries target a variety of shellfish. Lobster at Shetland is severely depleted and effort has been displaced to other species such as brown, velvet and green crabs.

The inshore fisheries for shellfish around Shetland are managed by the Shetland Shellfish Management Organisation. It was established under Scottish Statutory Instrument 1999 No. 194; The Shetland Islands Regulated Fishery (Scotland) Order 1999. This gives the organisation the right to regulate the fisheries for oysters, mussels, clams, lobsters, scallops, queens, crabs, whelks and razorshells for a period of 10 years from 31 January 2000. The *Nephrops* fisheries are not included in the order. The management area is from low-water springs to six miles from the coast. Before the order came into place there was no effective management of these fisheries which are a valuable asset to the large number of small vessels that fish around the islands. At the present time management is essentially by effort control such as licensing of vessels, limitations on the size of vessel and on the types of fishing gear and their size. Discussions are in progress to enable similar regulation for Orkney and the Highland Region.

6. Fishery and oil and gas industry interactions

Rogers and Stocks (2001) dealt very comprehensively with the interactions between fishing activity and the oil and gas industry in their technical report for SEA2. The SEA2 area has a very wide latitudinal range and is contiguous with SEA4 at its northern extremity. Almost all of what has been written is equally relevant to the shelf part of SEA4 and therefore the following section simply highlights any special features of the SEA4 area.

6.1 Shelf area of SEA4

6.1.1 Seismic Activity

Seismic surveys can disrupt the behaviour of fish populations and are considered to be a special concern during spawning activity when fish tend to be aggregated. It follows that a precautionary approach should be taken to the licensing of seismic surveys to minimise possible detrimental effects on spawning fish. As a precautionary measure, seismic activity should be banned within the area that was closed, as an emergency measure, to cod fishing for part of 2001 (Figure 5.5). A special problem that exists in SEA4 is the unreliability of the location of officially reported landings for a number of species (see Section 3). The apparent intense fishing activity on either side of 4°W is largely an artefact. The precise location of capture of some of these misreported species is unknown and may, in some cases, be from outside the SEA4 area

6.1.2 Cuttings disposal

The potential impacts of cuttings piles has been comprehensively dealt with in the SEA2 report. Of particular concern are the possible smothering effects on areas of seabed utilised by fish that have demersal eggs. The most important are herring and sandeel both of which have spawning areas in the SEA4 area.

6.1.3 Hydrocarbon spill

The implications and the legislation relating to hydrocarbon spill have been described in the SEA2 report. The Braer oil spill off Shetland in 1993, although not related to the exploration and production of oil, provides a good example of the potential impacts. The important inshore, shallow-water fish and shellfish fisheries in and around the many inlets of the Orkney and Shetland Islands must be considered as a special area at risk. This is, of course, linked to the internationally renowned seabird populations many of which depend on juvenile sandeels for food.

6.1.4 Surface installations, subsea structures, well heads and pipelines.

The interaction between oil installations and the fishing industry has been comprehensively described in the SEA2 report. The recognition that both the fishing and the oil industry were operating in an extreme environment resulted in the Sea Fish Industry Authority and UKOOA combining to produce a Kingfisher Notebook on the West of Shetland area (Hopper (Ed.), 1997). This describes in simple terms the various facets of the oil industry in the hope of avoiding inter-industry conflicts.

6.1.5 Fisheries management

Many of the fisheries of the North Sea and the west coast of Scotland are considered to be outside safe biological limits and ICES has recommended various measures including reductions in TACs and fishing effort. The translation of these recommendations into management regulations is the responsibility of the European Union and this inevitably results in compromises to satisfy the differing requirements of the member states and other non-EU countries with an interest in the stock. In addition to the imposition of TACs, various technical measures, such as gear modification and mesh sizes, are applied. These are of little relevance to the oil and gas industry. Management measures that close areas or restrict access either seasonally or to different sectors of the fleet or the gears that they use can have implications for the oil and gas industry. The very fact that area closures have been implemented indicates that these are sensitive areas. The Shetland Box recognises the importance of fisheries to the economy of the islands and seeks to afford some protection to the local industry. The earlier complete closure and the now seasonal closure of the Shetland sandeel fishery recognise the important link between sand eel recruitment and seabird breeding success. The Norway pout box, which impinges on the eastern margin of the SEA4 area recognises that this is an important area for juvenile haddock and whiting and the closure of this area to industrial fishing by small mesh trawls seeks to protect these stocks. The most recent conservation measure was the emergency seasonal closure in 2001 of grounds to the west of Shetland to demersal trawling to protect spawning stocks of cod.

The closure or partial closure of these grounds to certain types of fishing activity can also have the effect of diverting fishing effort to other areas where there could be conflict with existing oil and gas developments. Some sections of the fleet might also change to using a different type of fishing gear, perhaps in a different area, and this could have implications for conflict with existing underwater structures such as pipelines.

6.2 Deep-water area of SEA4

Deep-water fisheries are often described as those that take place at depths greater than 400 metres. However, such a definition is purely arbitrary and there are many species that occur both on the shelf and the continental slope such as anglerfish and tusk. The southern slope of the Faroe Shetland Channel is very different from the slope to the west of the Hebrides. The deep-water fishery in SEA4 is confined to the warmer Atlantic water and to the relatively narrow transition zone between that Atlantic water and the cold Norwegian Sea water. The depth of this lower limit varies with location but it is generally around 700 metres.

The interactions between the slope fisheries and the oil industry are similar to those on the shelf described above. When towing a bottom trawl on the shelf a trawler will normally pay out an amount of wire equivalent to about three times the depth of the water. In deep-water this can often be reduced but nevertheless it means that the trawl can be on the bottom at some considerable distance behind the ship. As a safety precaution consideration should be given to increasing the dimensions of safety zones around installations situated in deep-water areas.

The ultimate source of the energy in the form of food entering the deep-sea is derived from surface production. The amount of this energy that reaches the seabed decreases with increasing depth. In the deep-water to the west of the Hebrides the demersal fish biomass on the upper and midslope could not be sustained by fish feeding on the benthos (Gordon et al., 1995). Instead it is the daily vertically migrating plankton (invertebrates and small fish) that are thought to be important in transporting energy rapidly from the surface to the deep-water (Mauchline and Gordon, 1991). This is in agreement on studies of the diet of the deep-water fishes which suggests that they make relatively little use of the benthos. Although there have been few studies of the diet of the deep-water fish species of the upper slope the Faroe Shetland Channel, investigations in the Norwegian Deep (Bergstad 1991a,b) and in the deep-water of the Skagerrak (Bergstad et al, 2001) suggest that pelagic prey will also be important. When considering human impacts on deep-water fishes, it is probable that contaminants in the surface waters will affect the fish, currently being exploited, more rapidly through the food chain than will any contamination of the benthos. Environmental impact assessments usually place great emphasis on investigating the benthos but the important role of the pelagic food web in maintaining the high abundance of deep-sea fishes should not be neglected.

Below the transition zone the water temperature rapidly decreases and there is an equally rapid decline in both fish biomass and diversity (see Section 4). Little is known about the biology and distribution of these species. The SEA4 area is the only part of the UK EEZ where these species occur. The truncation of the daily vertical migration of plankton caused by the change in water temperature may limit the food supply and be the main explanation for the low biomass.

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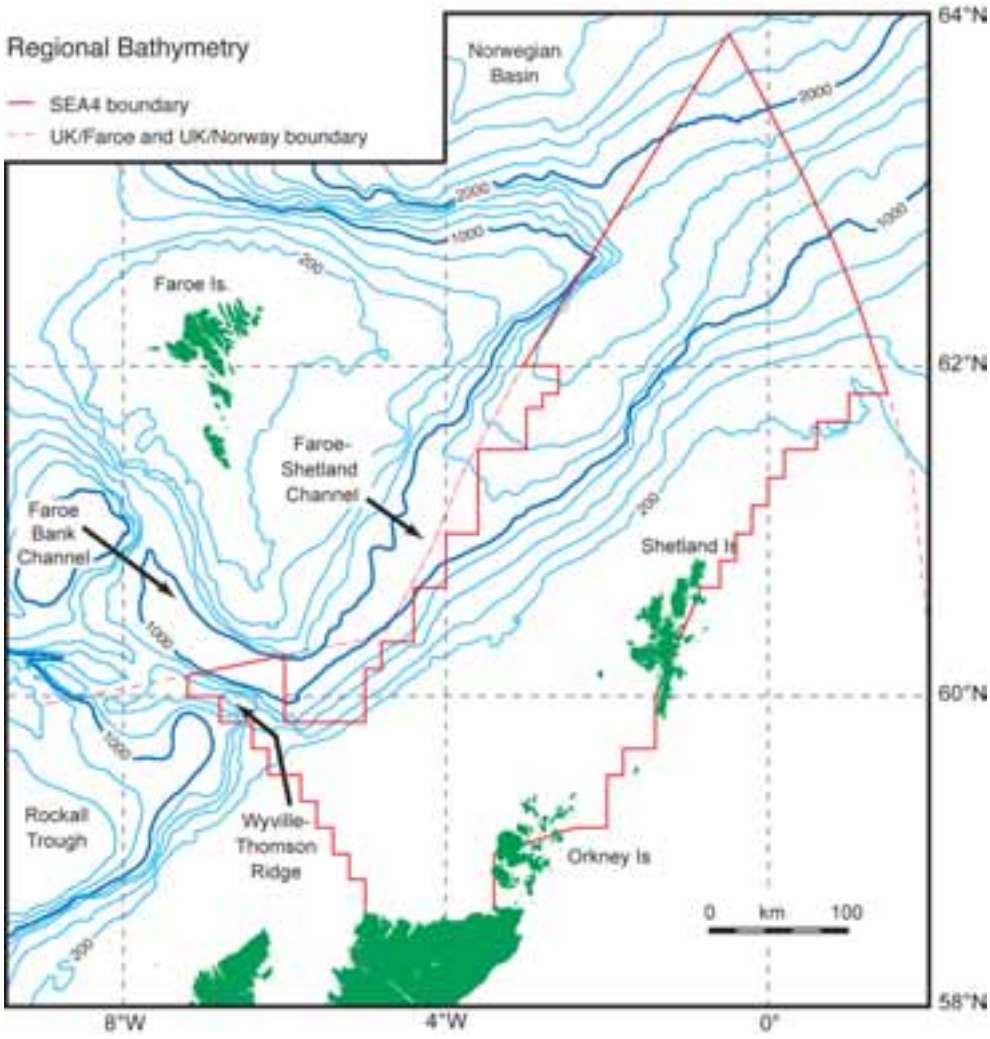

Figure 1.1 The bathymetry of the SEA4 area

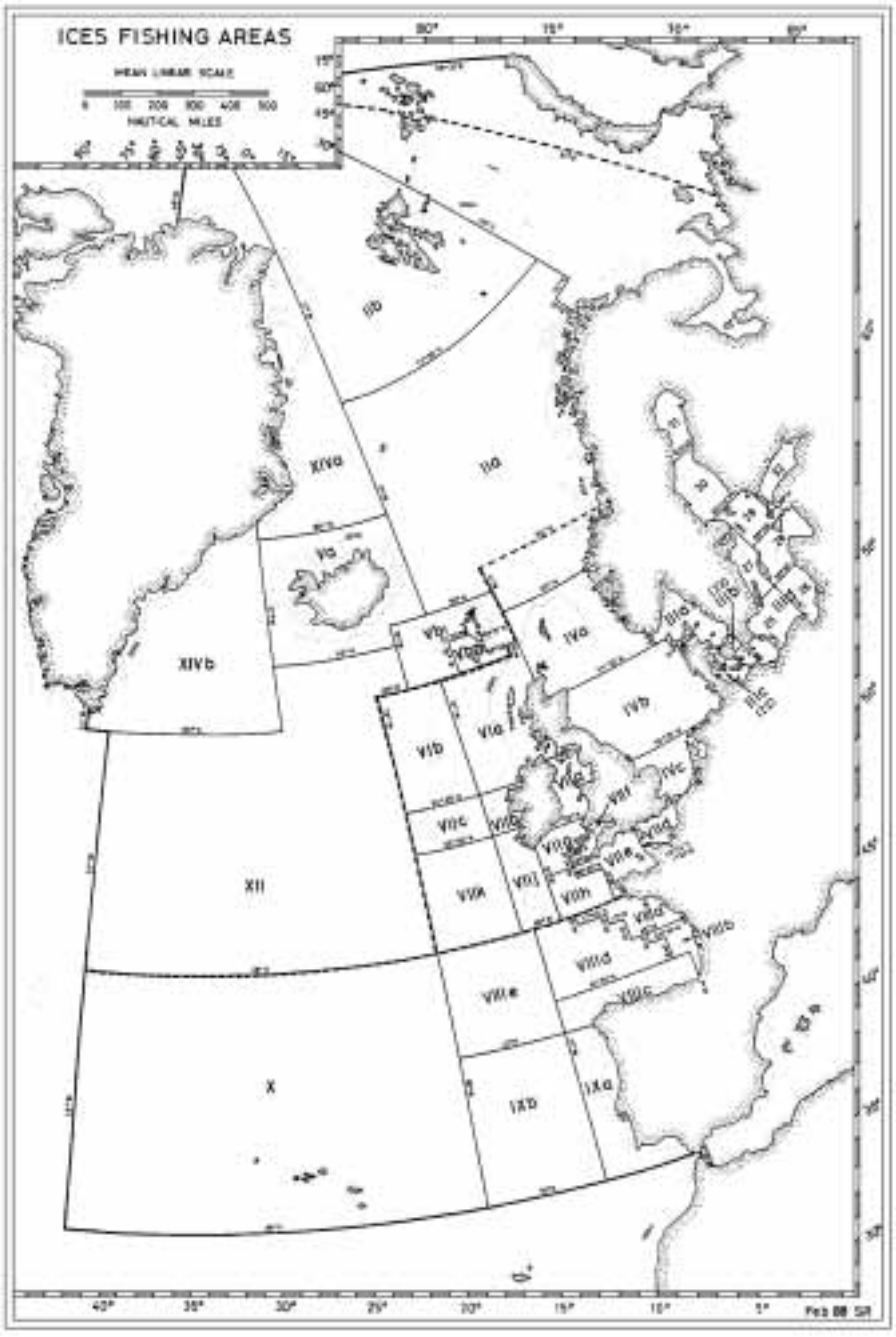

Figure 1.2 The ICES area showing Sub-areas and Divisions

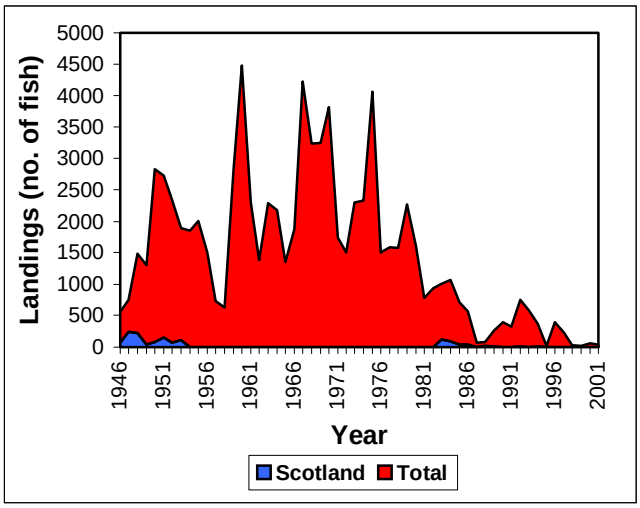

Figure 3.1.1 The total estimated catch and the reported Scottish landings (numbers of fish) of basking shark for the northeast Atlantic for the years 1946 to 2001. Data from final report of DELASS project (Heessen 2003)

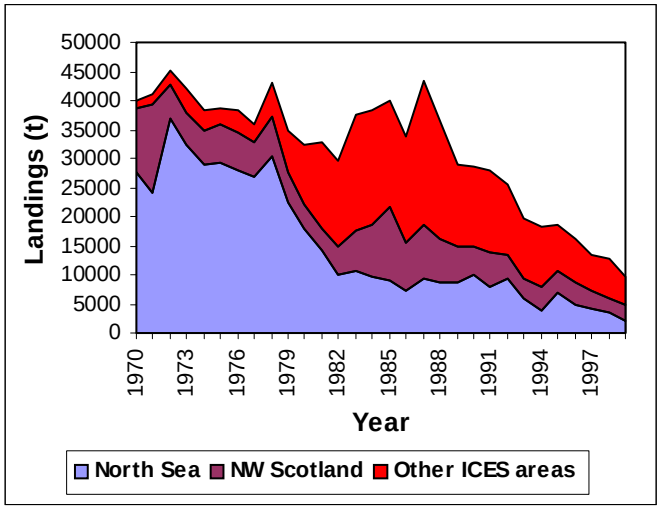

Figure 3.4.1 The annual reported landings (tonnes) of spur dog for the North Sea, West of Scotland and all other ICES Sub-areas combined for the years 1970 to 1999. Data from final report of DELASS project (Heessen 2003).

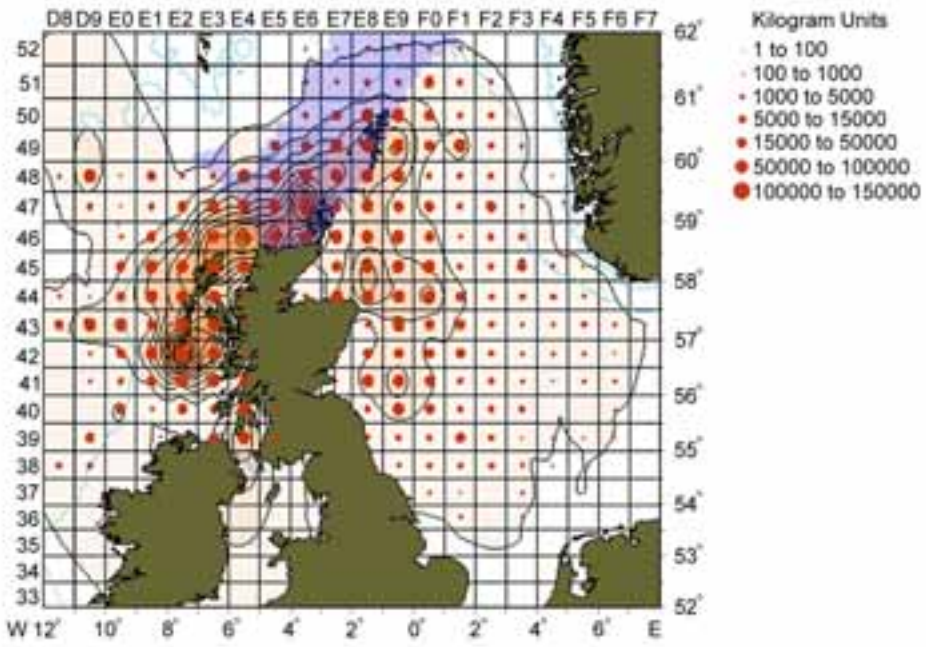

Figure 3.4.2 Mean annual landings (tonnes) of spurdog for 1997-2001 by Scottish vessels. (modified from a figure supplied by Fisheries Research Services for the final report of DELASS project (Heessen 2003)

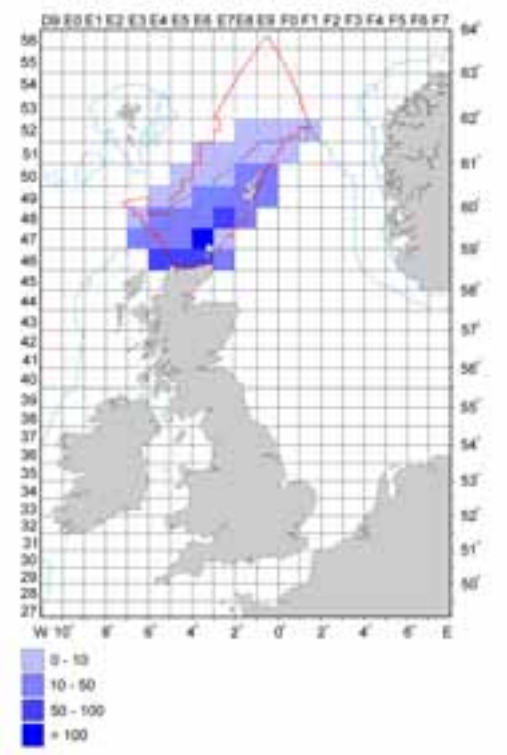

Figure 3.4.3 Mean annual landings (tonnes) of spurdog by Scottish vessels by statistical rectangle for the SEA4 area for the years 1997 – 2001 (data from Fisheries Research Services)

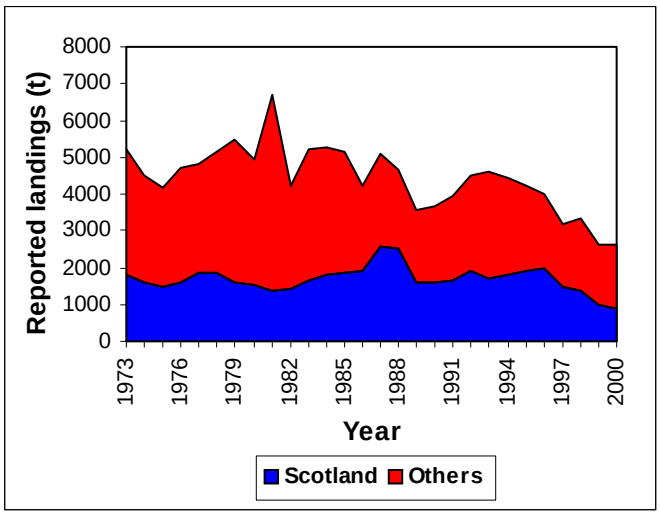

Figure 3.5.1 The reported landings of rays (tonnes) in ICES Sub-area IV for the years 1973 to 2000

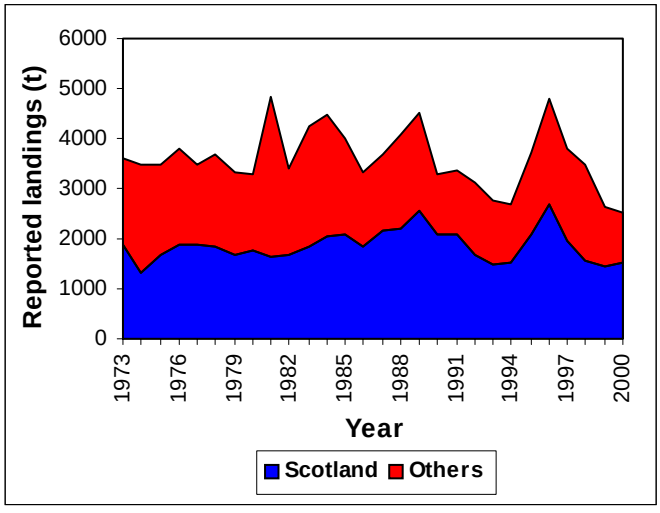

Figure 3.5.2 The reported landing of rays (tonnes) in ICES Sub-area VI for the years 1973 to 2000

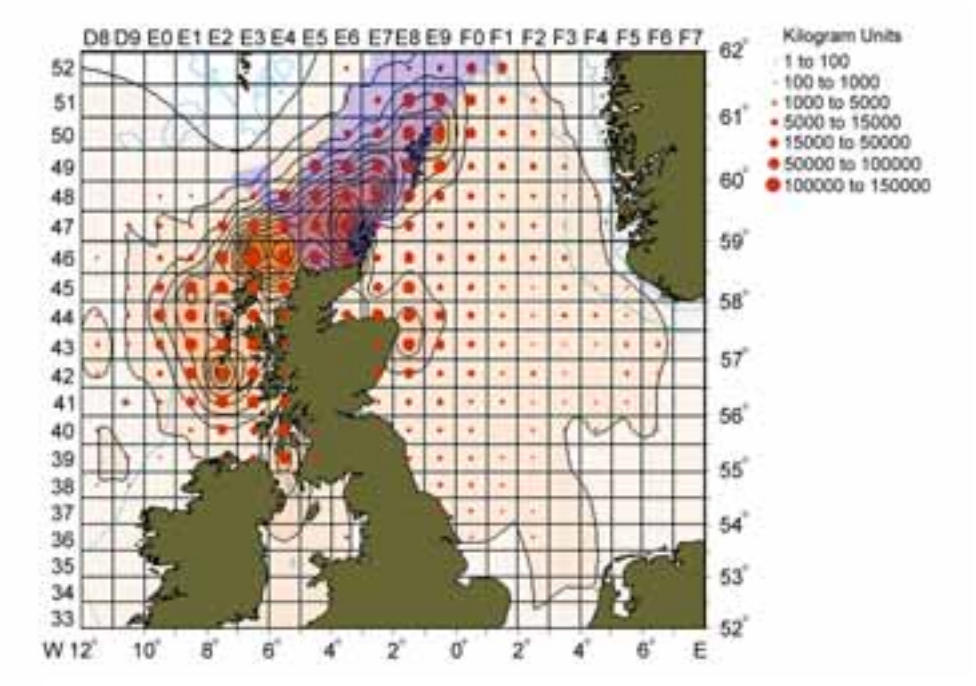

Figure 3.5.3 Mean annual landings (tonnes) of mixed ray species for 1997-2001 by Scottish vessels. (Modified from a figure supplied by Fisheries Research Services for the final report of DELASS project (Heessen 2003)

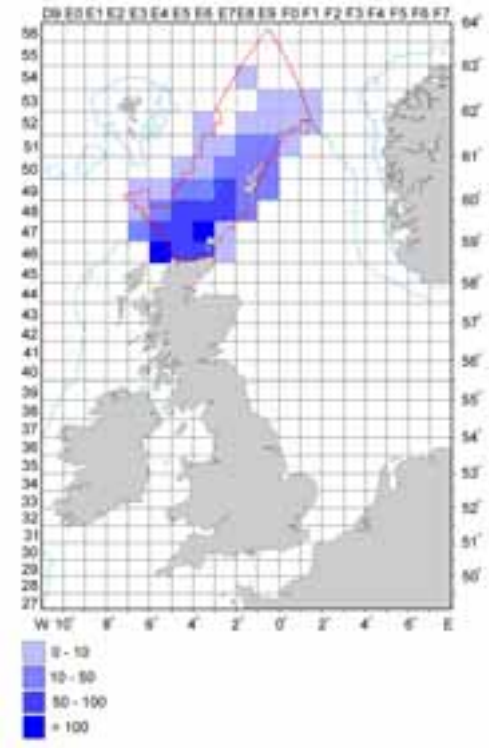

Figure 3.5.4 Mean annual landings (tonnes) of rays by Scottish vessels by statistical rectangle for the SEA4 area for the years 1997 – 2001 (data from Fisheries Research Services)

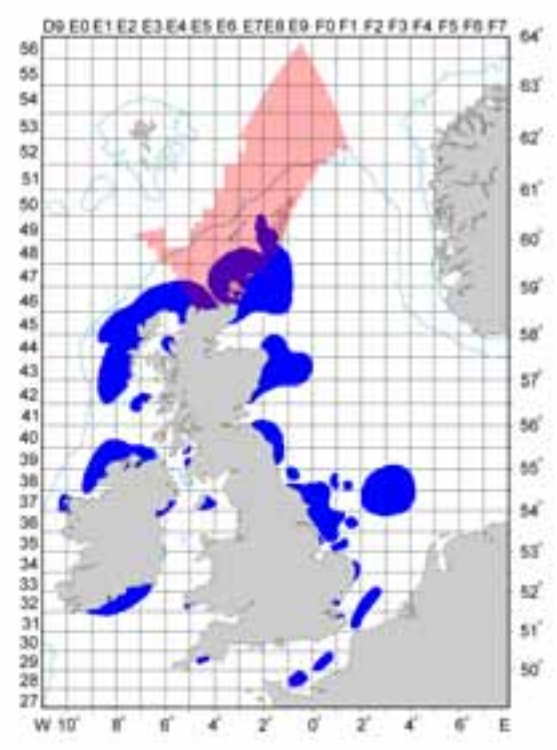

Figure 3.6.1 Herring spawning grounds around the British Isles (modified from Coull et al, 1998)

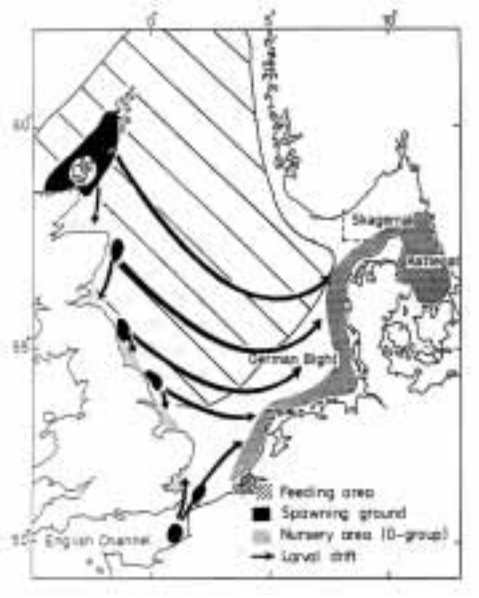

Figure 3.6.2 The spawning, nursery and feeding grounds of herring in the North Sea (from Daan et al., 1990).

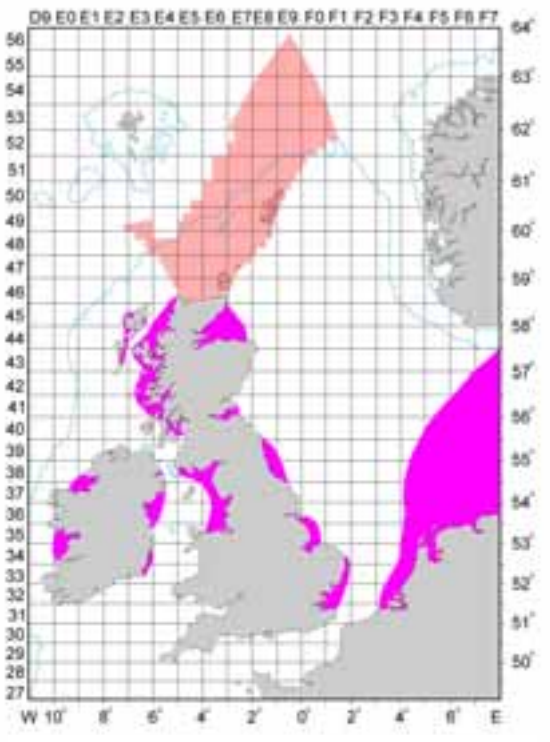

Figure 3.6.3 Herring nursery areas around the British Isles (modified from Coull et al, 1998)

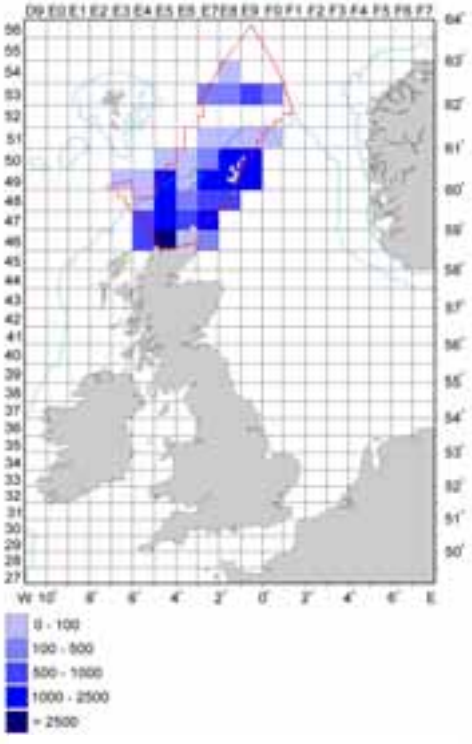

Figure 3.6.4 Mean annual landings of herring (tonnes) by Scottish Vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

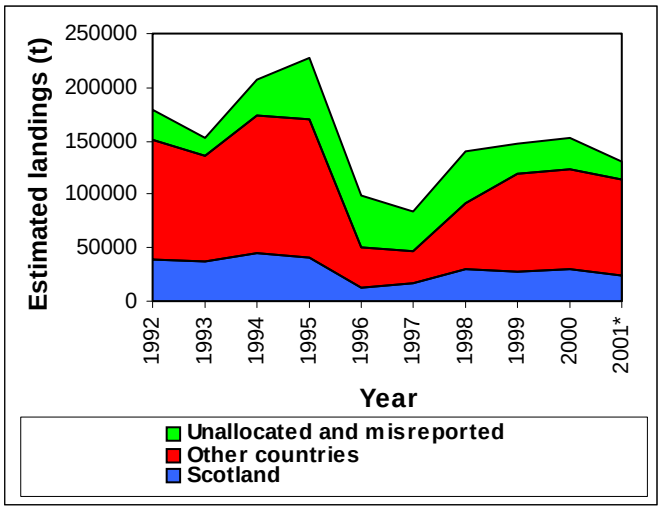

Figure 3.6.5 The catch of herring (tonnes) in ICES Division IVa (West) as used by the ICES WG. The data for 2001 are provisional. The reported landings by Scotland and by all other countries combined together with the estimates unallocated and misreported landings are shown.

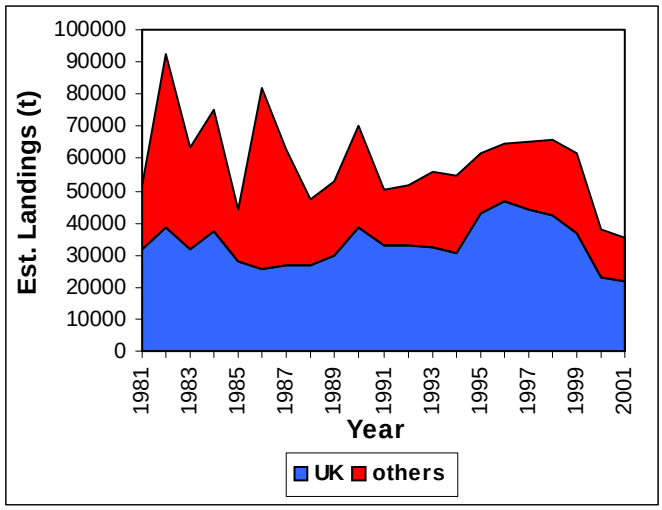

Figure 3.6.6 Reported landings (tonnes) of herring by UK and by all other countries combined for ICES Division VIa (north). 'Others' includes estimates of unreported landings and discards.

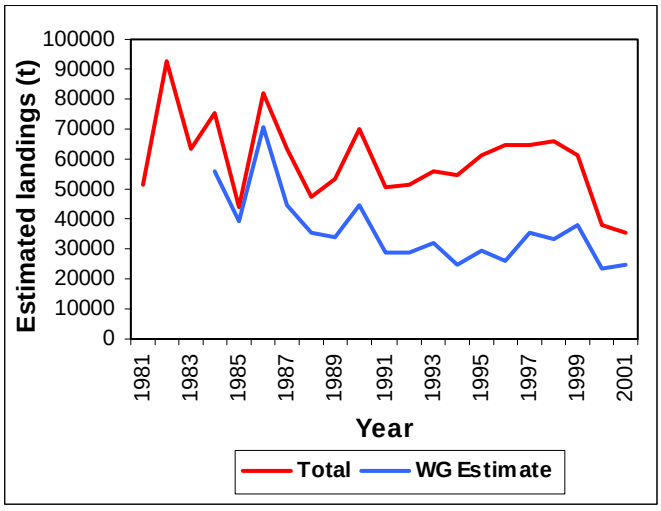

Figure 3.6.7 Total herring catch as given in Figure 3.6.6 and the adjusted catch after excluding misreported catches into Division VIa from other areas.

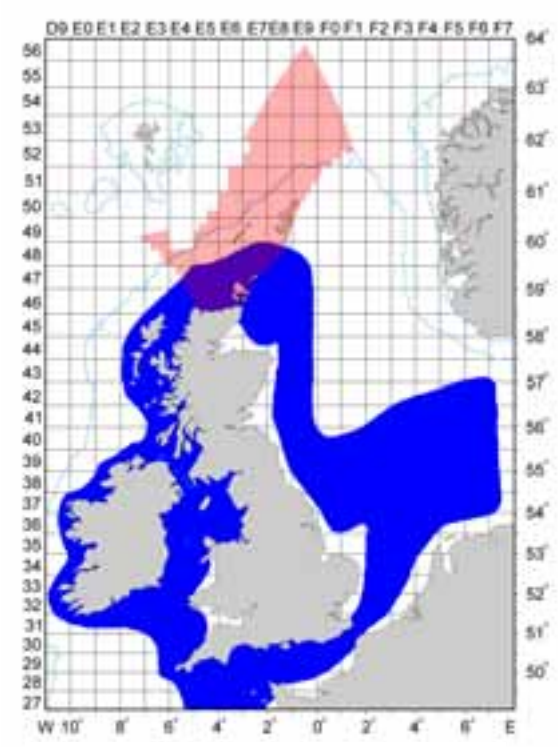

Figure 3.7.1 Sprat spawning grounds around the British Isles (modified from Coull et al, 1998)

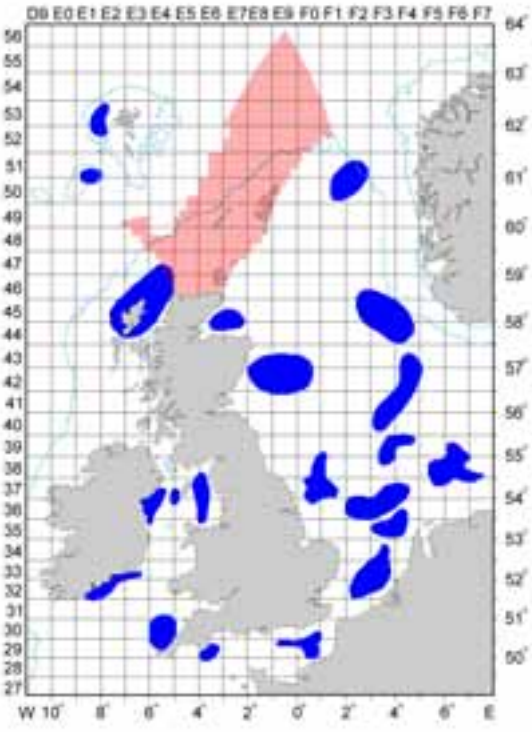

Figure 3.8.1 Cod spawning grounds around the British Isles (modified from Coull et al., 1998).

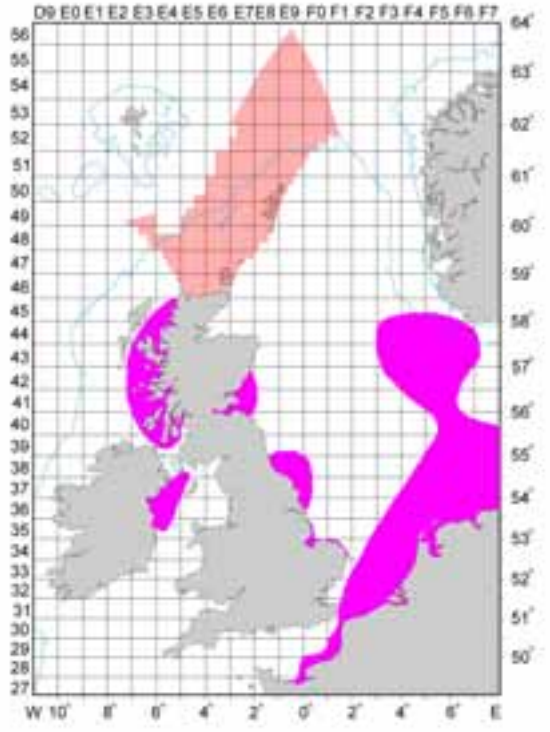

Figure 3.8.2 Cod nursery areas around the British Isles (modified from Coull et al., 1998).

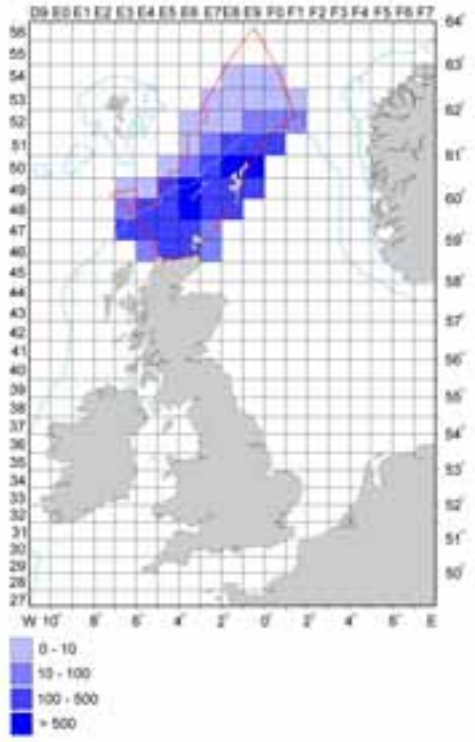

Figure 3.8.3 Mean annual landings of cod (tonnes) by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

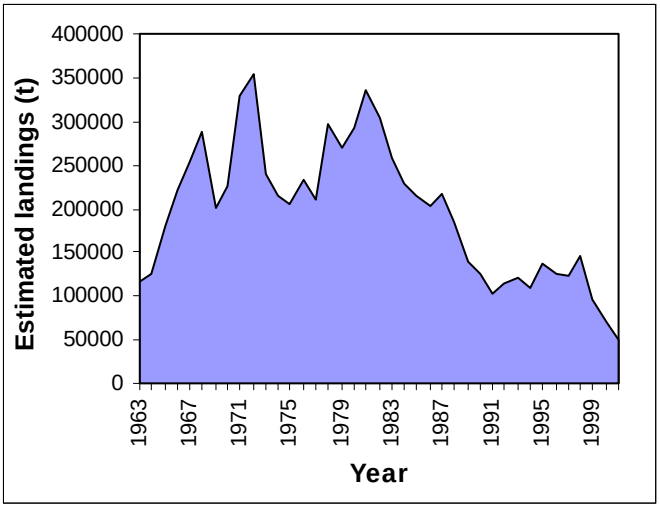

Figure 3.8.4 The international landings of cod (tonnes) from the North Sea management unit from 1966 to 2001. These are ICES Working Group estimates and include unallocated landings

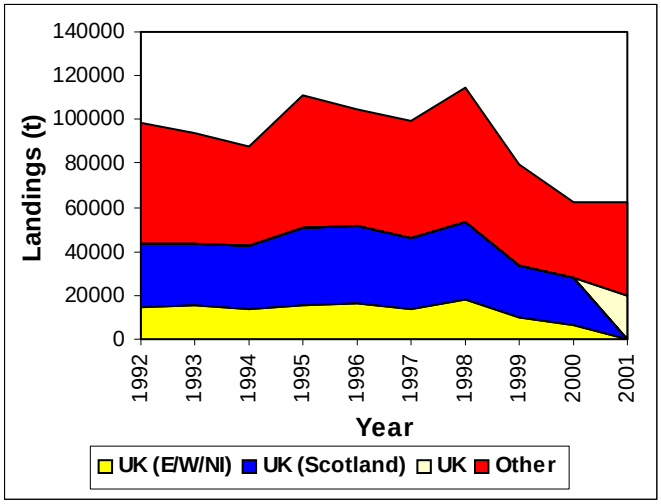

Figure 3.8.5. The reported landings of cod (tonnes) for Scotland, the rest of the UK and all other nations combined for Sub-area IV for the years 1992 to 2001. 2001 data are provisional.

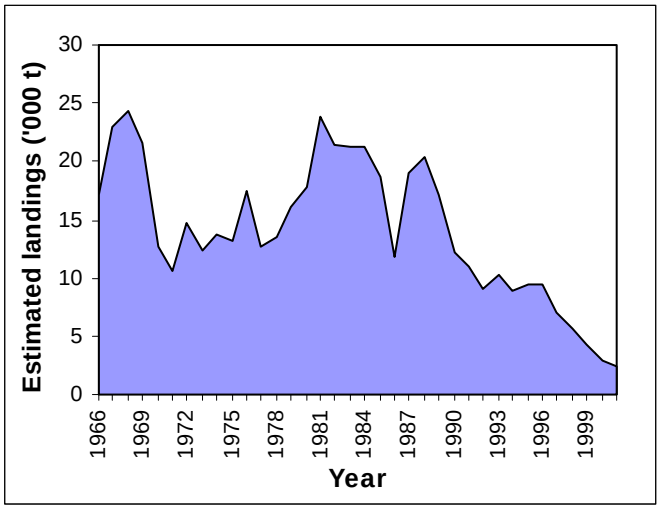

Figure 3.8.6 The international landings of cod (tonnes) from ICES Division VIa from 1966 to 2001. These are ICES Working Group estimates and include unallocated landings.

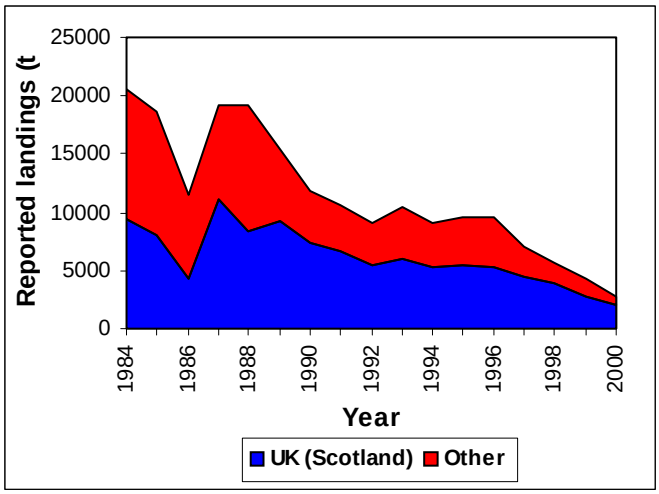

Figure 3.8.7 The reported landings of cod (tonnes) for Scotland and for all other nations combined for ICES Division VIa for the years 1984 to 2000.

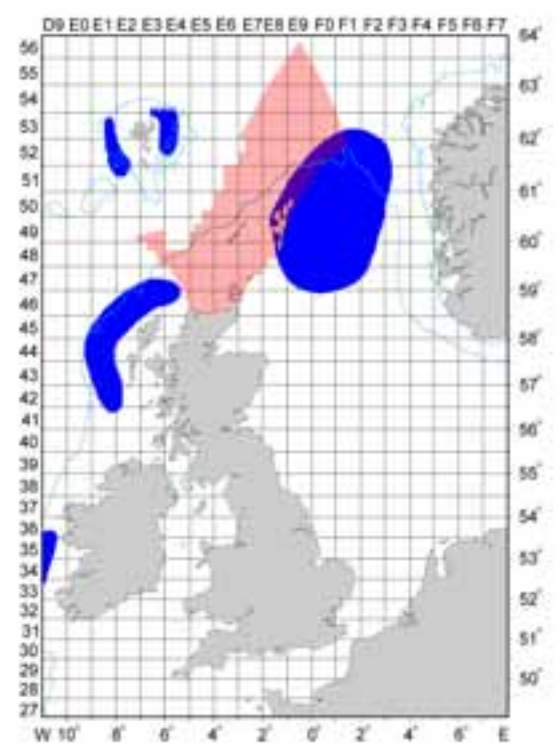

Figure 3.9.1 Haddock spawning grounds around the British Isles (modified from Coull et al., 1998)

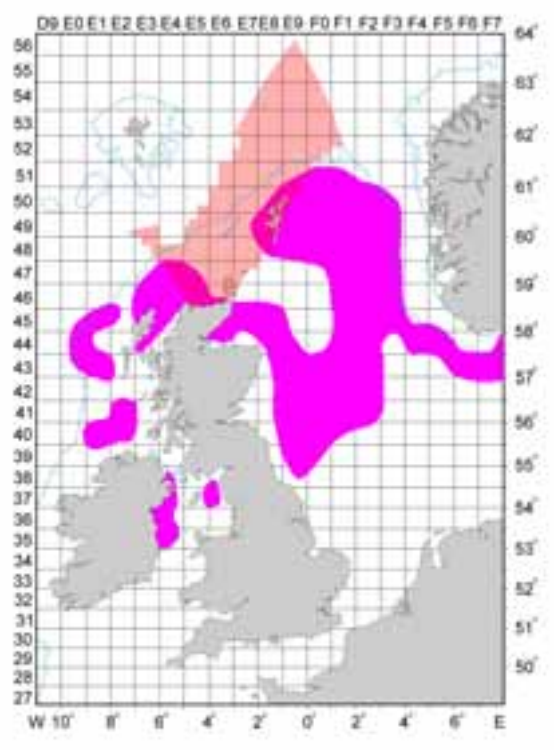

Figure 3.9.2 Haddock nursery areas around the British Isles (modified from Coull et al., 1998)

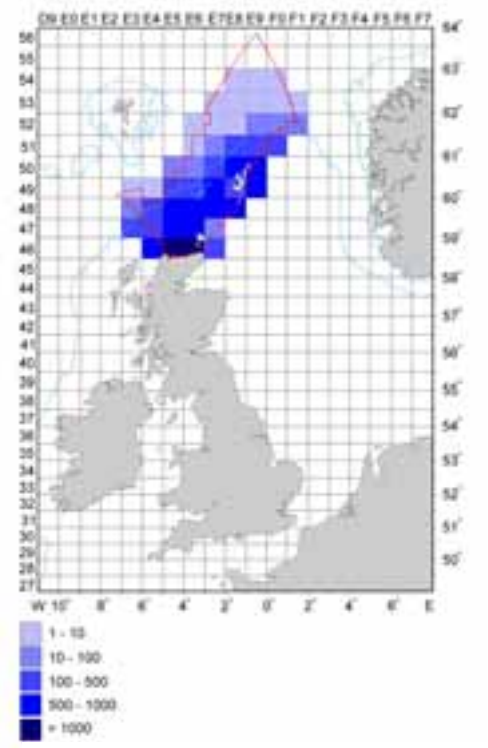

Figure 3.9.3 Mean annual landings of haddock (tonnes) by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

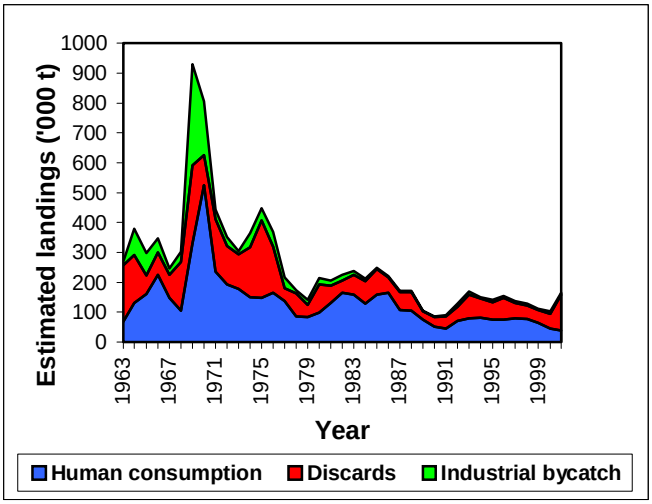

Figure 3.9.4 The ICES Working Group estimates of the landings (tonnes) of haddock from the North Sea for human consumption and in the industrial fisheries together with an estimate of the discards for the years 1963 to 2001.

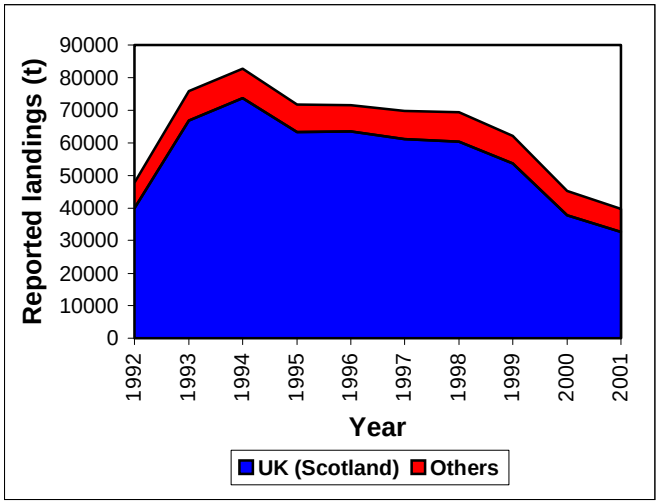

Figure 3.9.5 The reported landings of haddock for human consumption (tonnes) for Scotland and for all other nations combined for ICES Sub-area IV for the years 1992 to 2001. 2001 data are provisional and the Scottish value includes the landings for England and Wales.

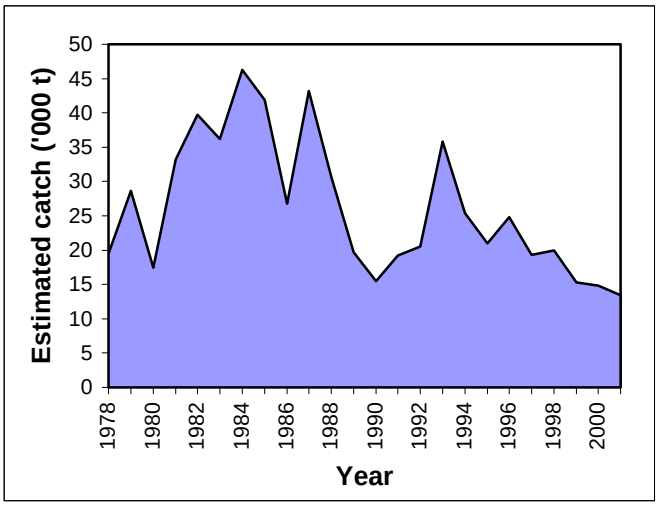

Figure 3.9.6 The ICES Working Group estimates of the landings of haddock together with the estimated weight of discards from ICES Division VIa for the years 1978 to 2001.

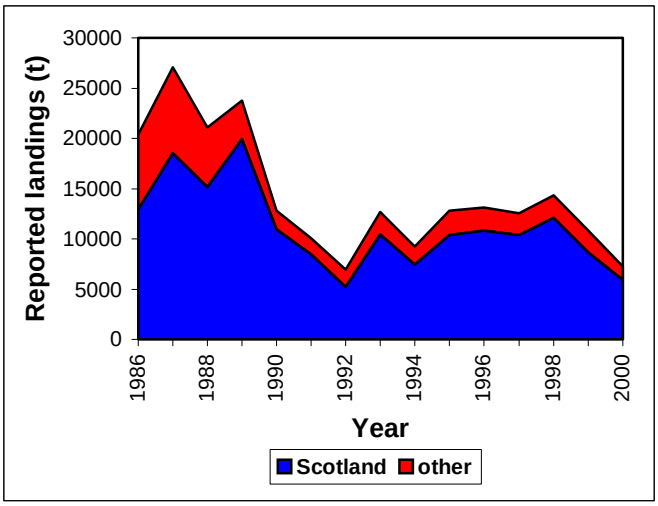

Figure 3.9.7 The reported landings of haddock (tonnes) for Scotland and all other nations combined for ICES Division VIa for the years 1986 to 2000.

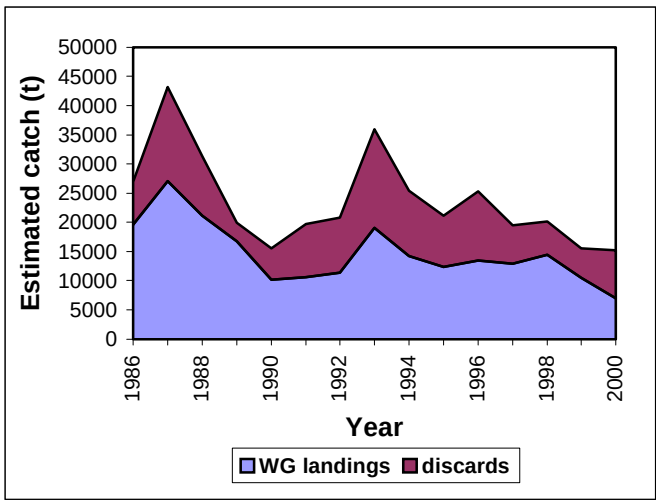

Figure 3.9.8 The ICES Working Group's estimated landings of haddock and the estimated weight of discards for Division VIa for the years 1986 to 2000.

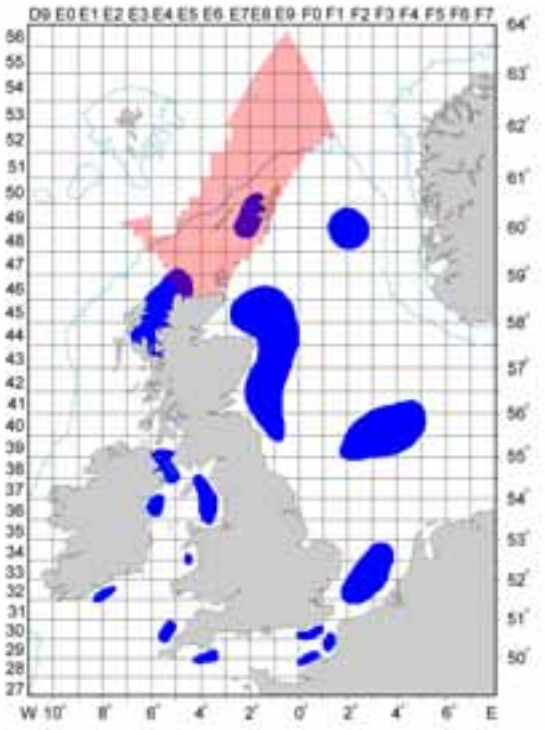

Figure 3.10.1 Whiting spawning grounds around the British Isles (modified from Coull et al., 1998).

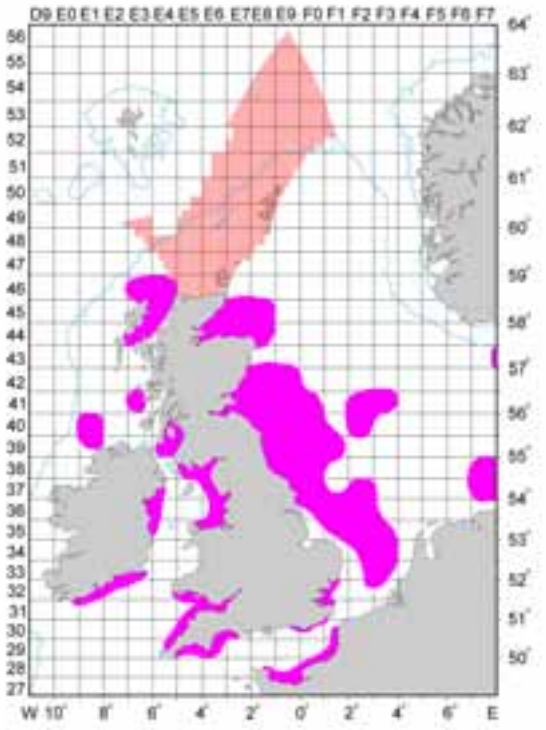

Figure 3.10.2 Whiting nursery areas around the British Isles (modified from Coull et al, 1998).

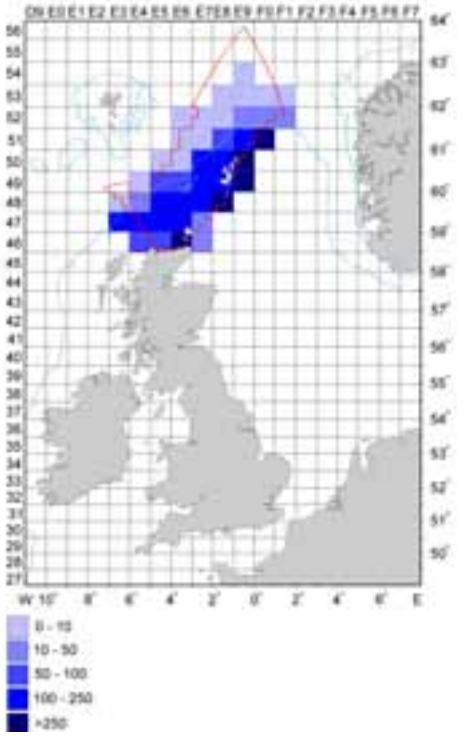

Figure 3.10.3 Mean annual landings of whiting (tonnes) by Scottish Vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

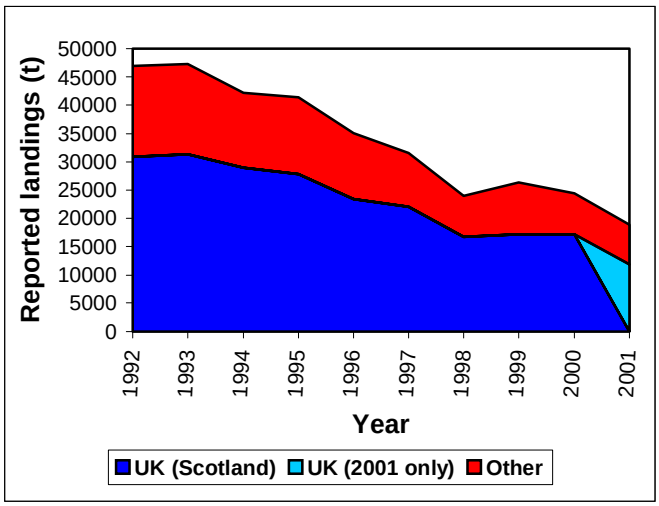

Figure 3.10.4 The reported landings of whiting (tonnes) for Scotland and all other nations combined for ICES Sub-area IV and Division VIId for the years 1992 to 2001.

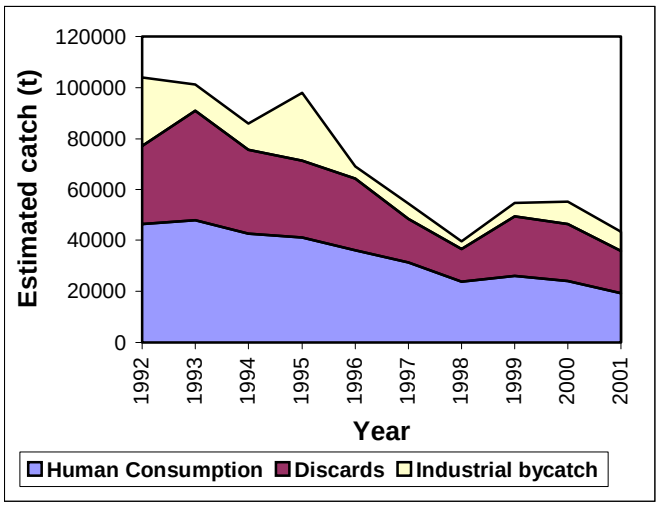

Figure 3.10.5 The ICES Working Group estimates of the landings (tonnes) of whiting for human consumption and the industrial fisheries together with an estimate of the discarded catch from for ICES Sub-area IV and Division VIId for the years 1992 to 2001.

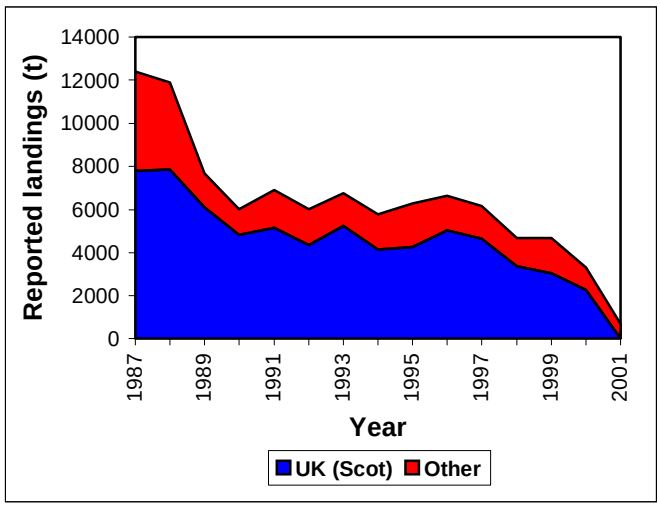

Figure 3.10.6 The reported landings of whiting (tonnes) for Scotland and all other nations combined for ICES Division VIa for the years 1987 to 2001.

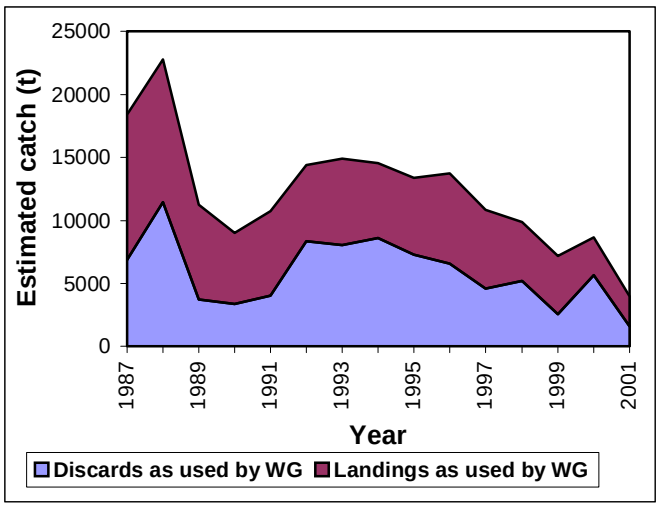

Figure 3.10.7 The ICES Working Group's estimated landings (tonnes) of whiting and the estimated weight of discards for Division VIa for the years 1987 to 2001.

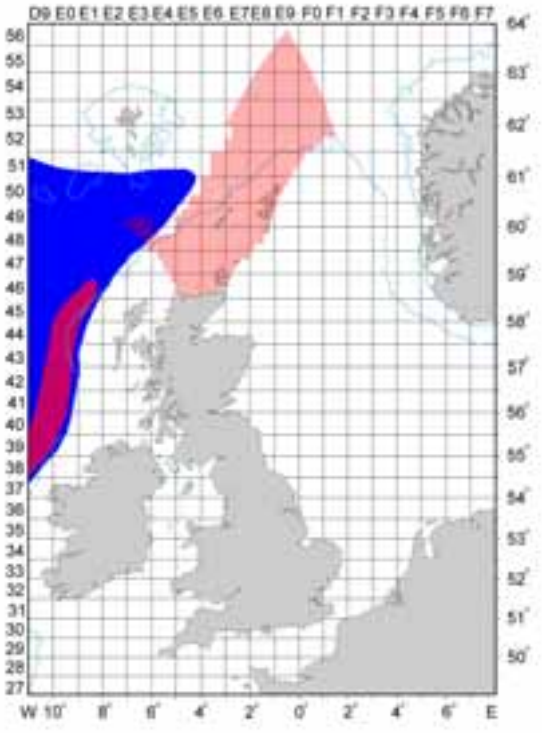

Figure 3.11.1 Blue whiting spawning grounds around the British Isles (modified from Coull et al., 1998)

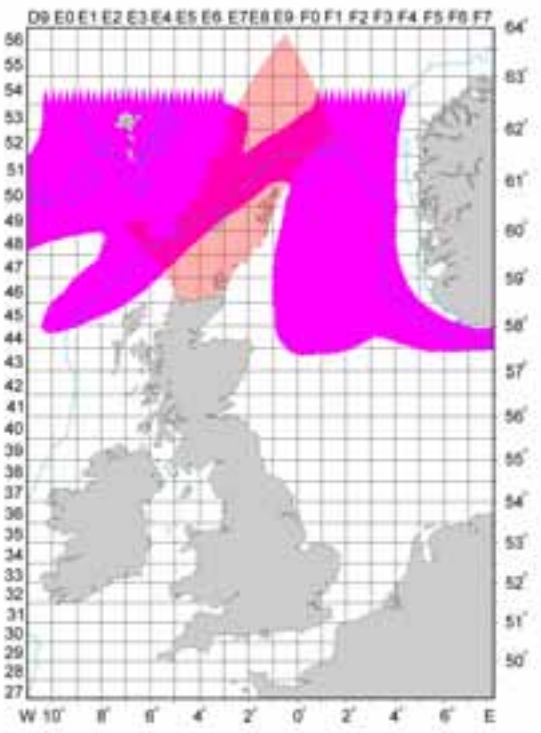

Figure 3.11.2 Blue whiting nursery areas around the British Isles (modified from Coull et al., 1998)

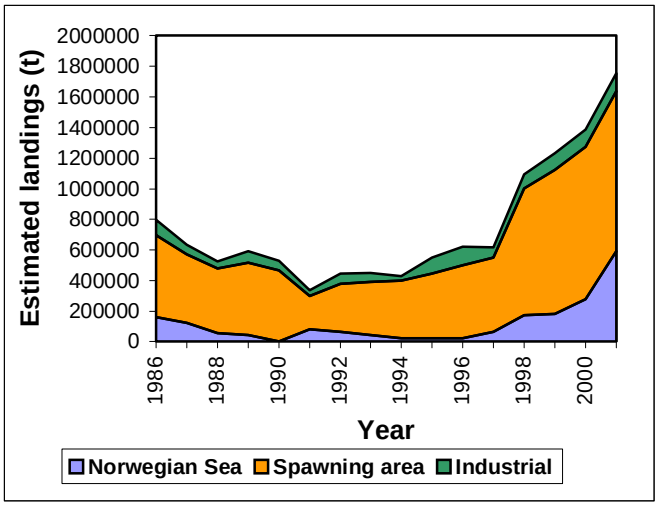

Figure 3.11.3 The ICES Working Group estimates of annual international landings (tonnes) of blue whiting for the "northern area" subdivided into the three main fisheries; spawning area, the Norwegian Sea and industrial.

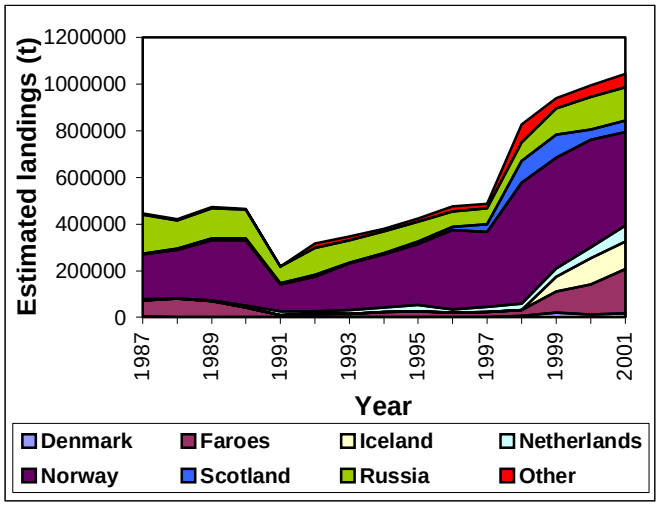

Figure 3.11.4 The ICES Working Group estimates of annual landings (tonnes) of blue whiting by selected countries for the spawning fishery.

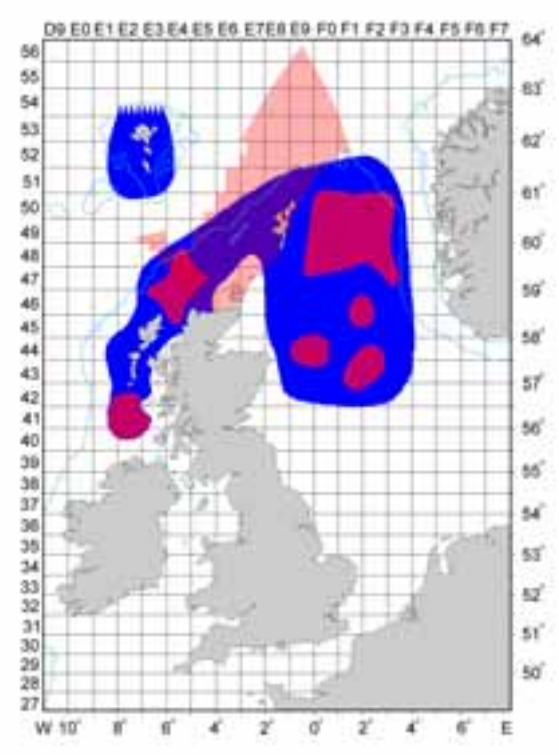

Figure 3.12.1 Norway pout spawning grounds around the British Isles (modified from Coull et al, 1998).

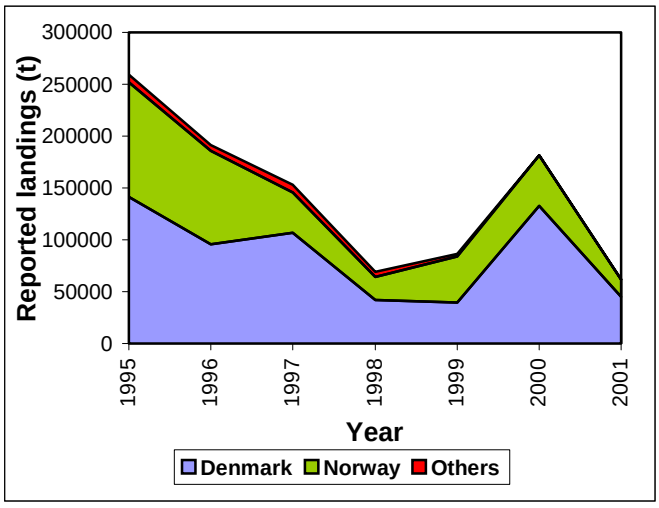

Figure 3.12.2 The reported annual landings (tonnes) of Norway pout from ICES Division IVa for Denmark, Norway and for other countries combined for the years 1995 to 2001.

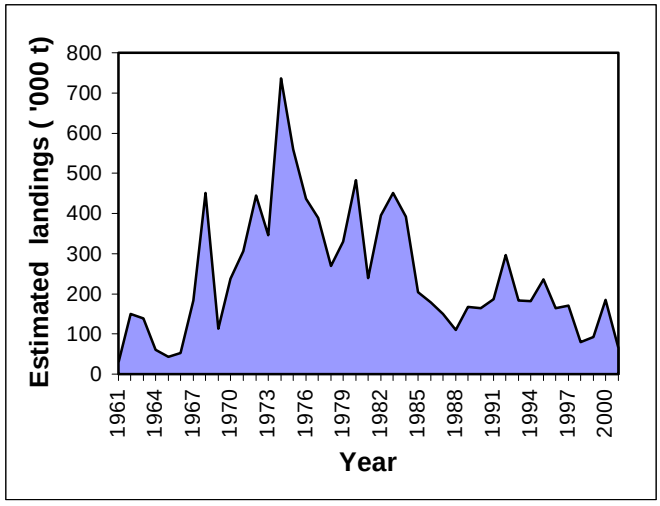

Figure 3.12.3 The ICES Working Group estimates of total international landings (tonnes) of Norway pout for ICES Sub-area IV and Division IIIa (Skagerrak) for the years 1961 to 2001.

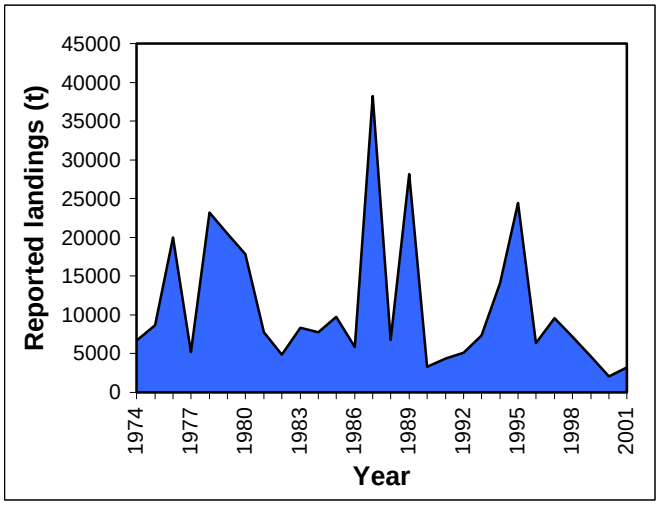

Figure 3.12.4 The reported landings (tonnes), mostly by Denmark, of Norway pout for ICES Division VIa from 1974 to 2001.

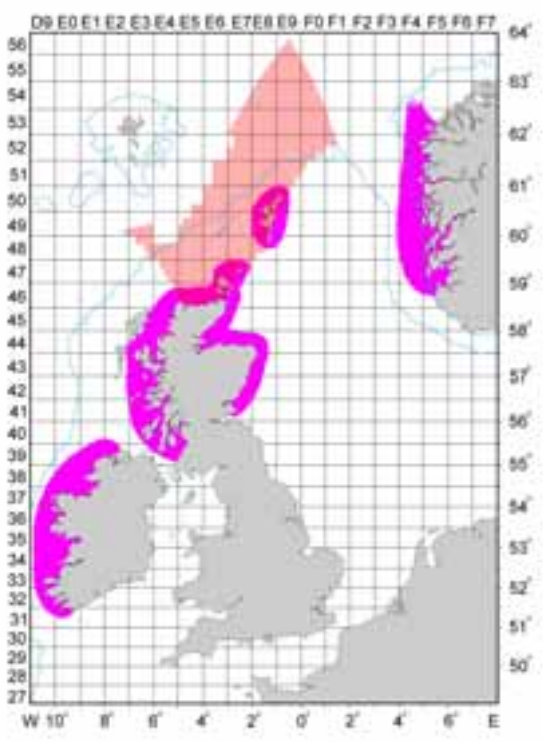

Figure 3.13.1 Saithe nursery areas around the British Isles (modified from Coull et al., 1998).

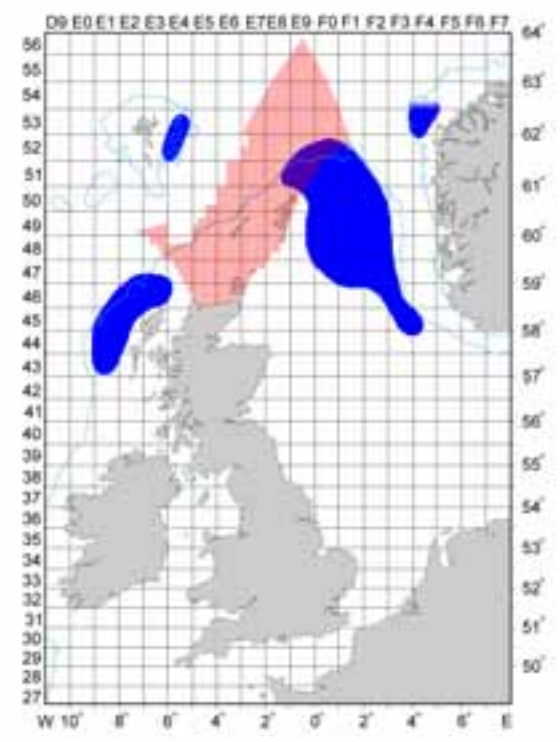

Figure 3.13.2 Saithe spawning grounds around the British Isles (modified from Coull et al., 1998).

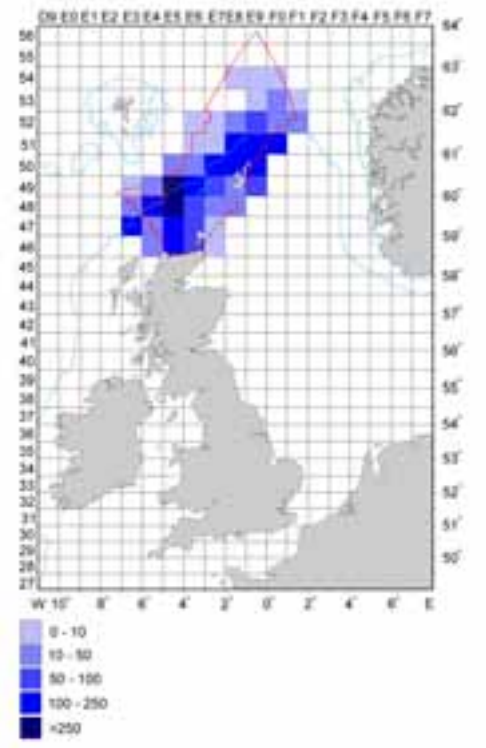

Figure 3.13.3. Mean annual landings of saithe (tonnes) by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

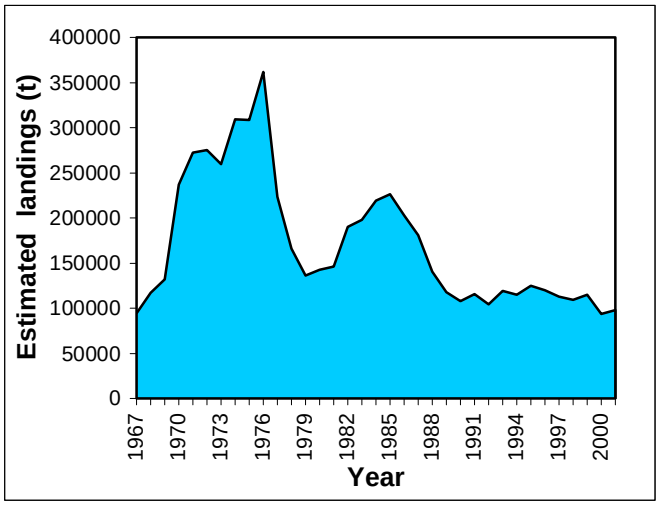

Figure 3.13.4 The ICES Working Group estimates of total international landings (tonnes) of saithe for ICES Sub-areas IV and VI and Division IIIa from 1967 to 2001.

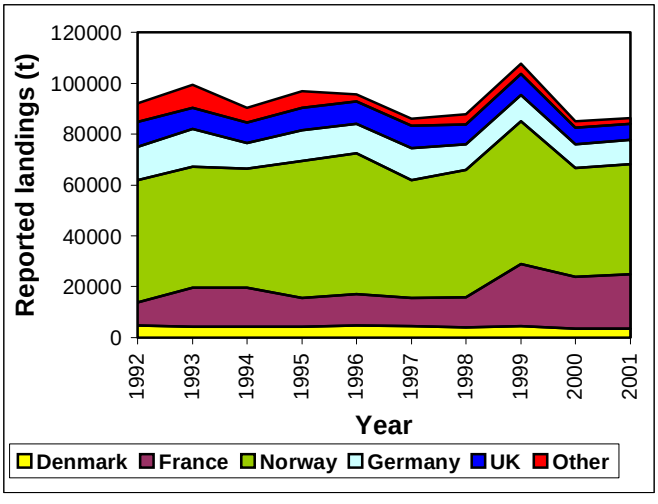

Figure 3.13.5 The reported landings (tonnes) of saithe by country from ICES Sub-area IV and Division IIIa combined for the years 1992 to 2001.

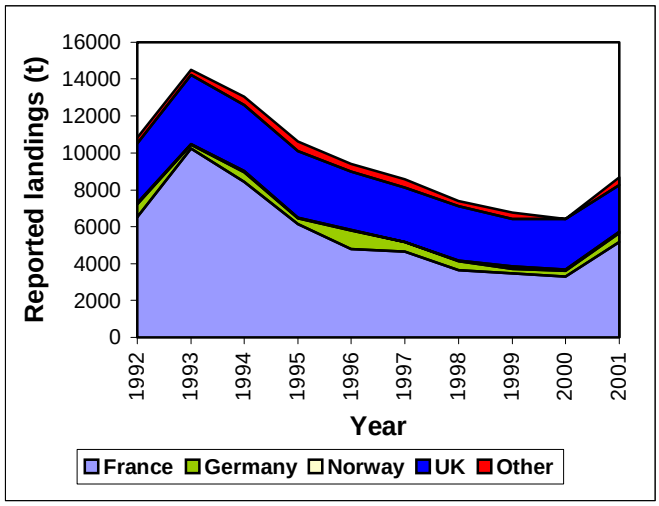

Figure 3.13.6 The reported landings (tonnes) of saithe by country from ICES Sub-area VI for the years 1992 to 2001.

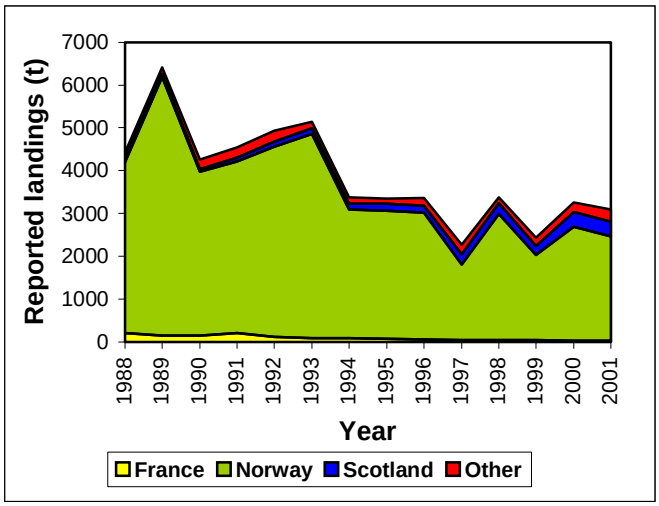

Figure 3.14.1 The reported landings (tonnes) of tusk by country from ICES Division IVa for the years 1988 to 2001.

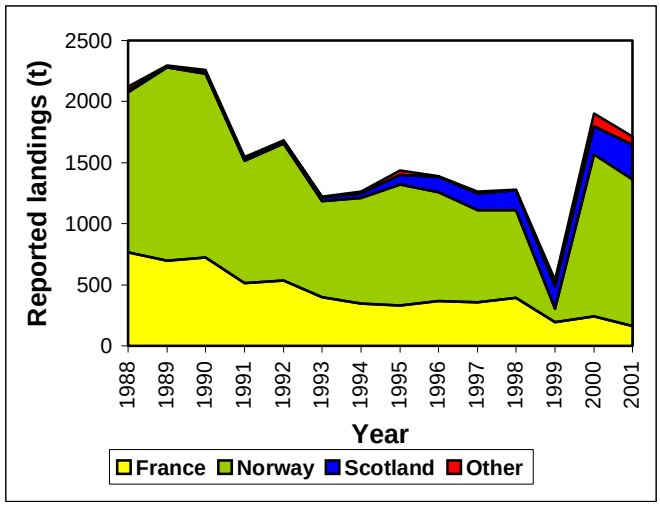

Figure 3.14.2 The reported landings (tonnes) of tusk by country from ICES Division VIa for the years 1988 to 2001.

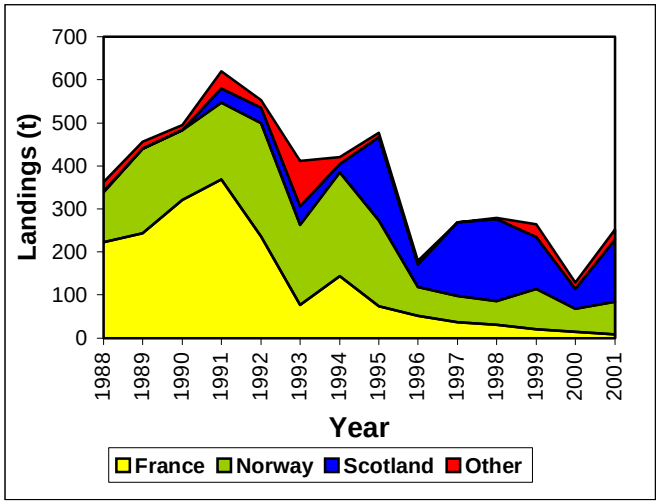

Figure 3.15.1 The reported landings (tonnes) of blue ling by country from ICES Division IVa for the years 1988 to 2001.

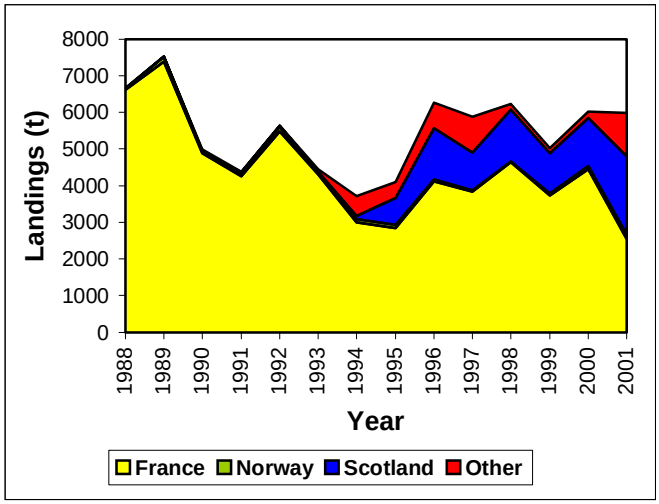

Figure 3.15.2 The reported landings (tonnes) of blue ling by country from ICES Division VIa for the years 1988 to 2001.

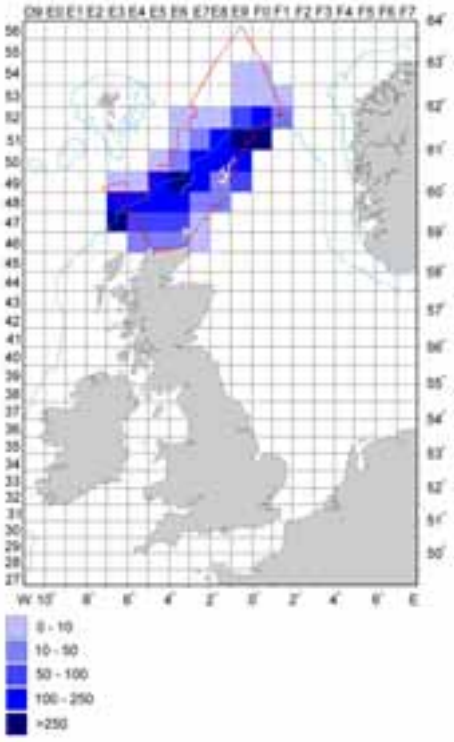

Figure 3.16.1 Mean annual landings of ling (tonnes) for by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 to 2001 (data from Fisheries Research Services)

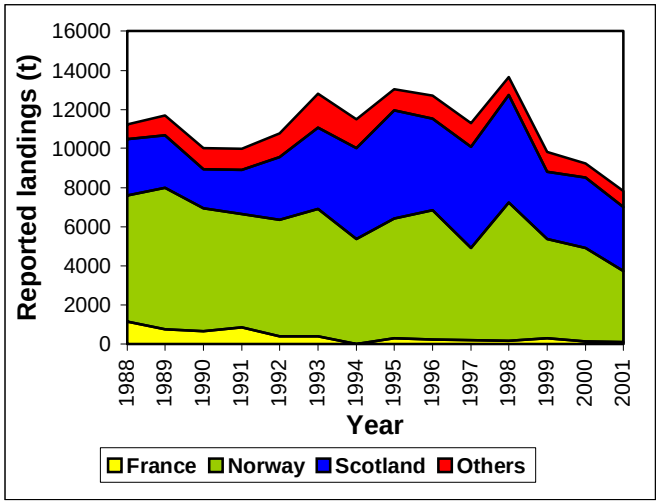

Figure 3.16.2 The reported landings (tonnes) of ling by country from ICES Division IVa for the years 1988 to 2001.

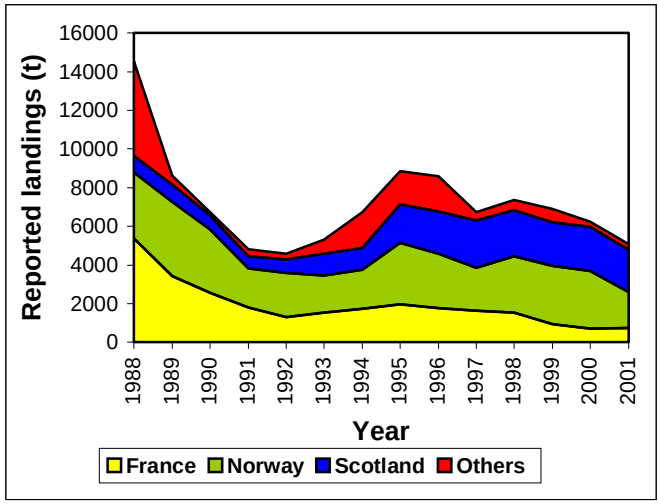

Figure 3.16.3 The reported landings (tonnes) of ling by country from ICES Division VIa for the years 1988 to 2001.

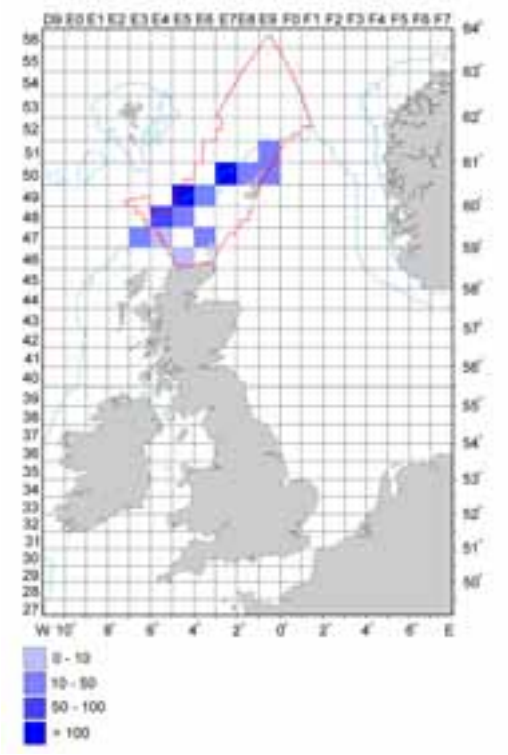

Figure 3.18.1 Mean annual landings of horse mackerel (tonnes) for by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

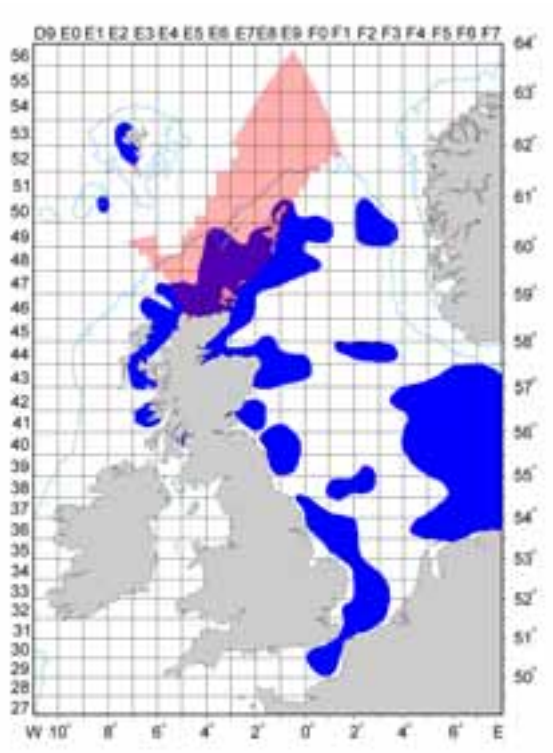

Figure 3.19.1 Sandeel spawning grounds around the British Isles (modified from Coull et al., 1998).

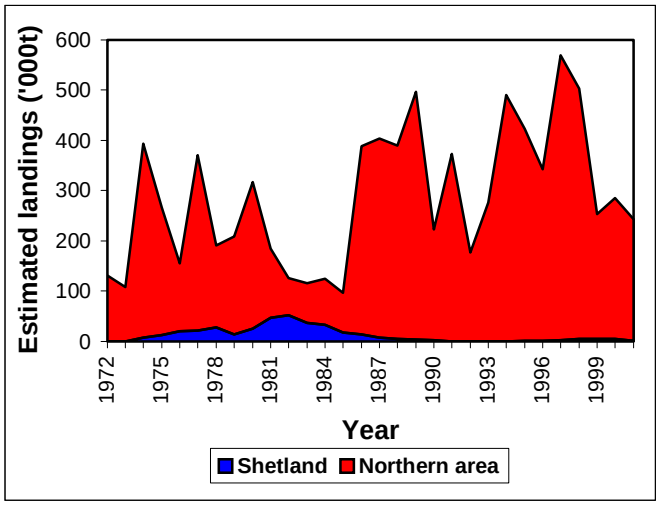

Figure 3.19.2 Estimated landings ('000 tonnes) of sandeel from the Shetland box and from the 'northern' management area for the years 1972 to 2001.

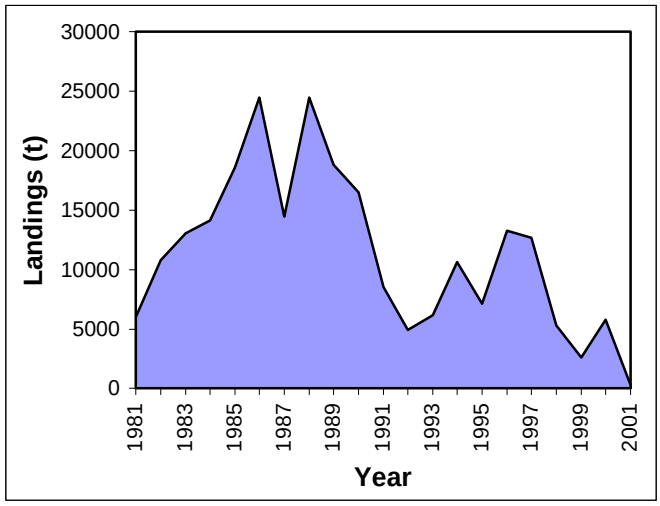

Figure 3.19.3 Reported Scottish landings (tonnes) of sandeel from the ICES Division VIa for the years 1981 to 2001.

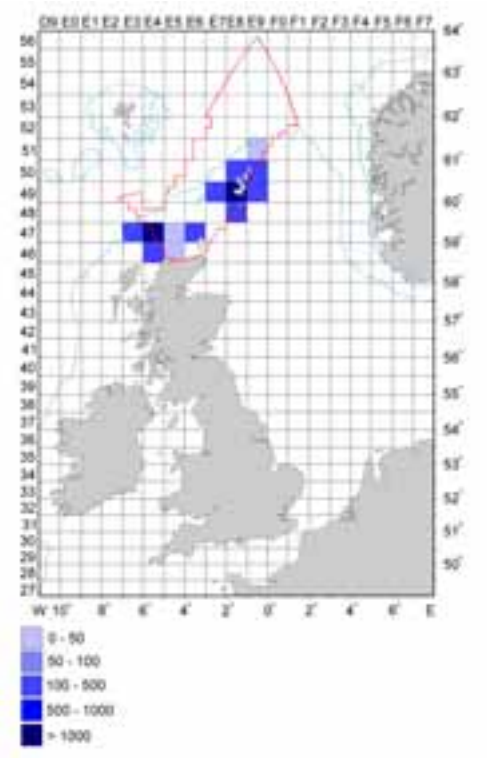

Figure 3.19.4 Mean annual landings of sandeel (tonnes) for by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

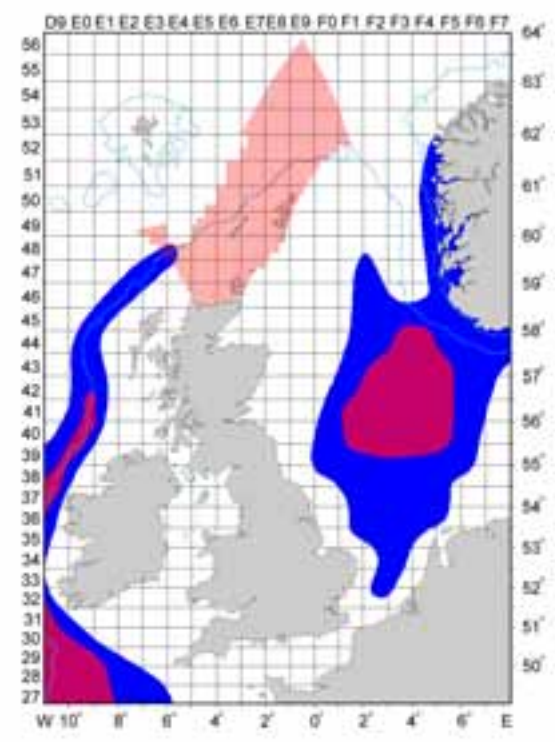

Figure 3.20.1 Mackerel spawning areas around the British Isles (modified from Coull et al., 1998).

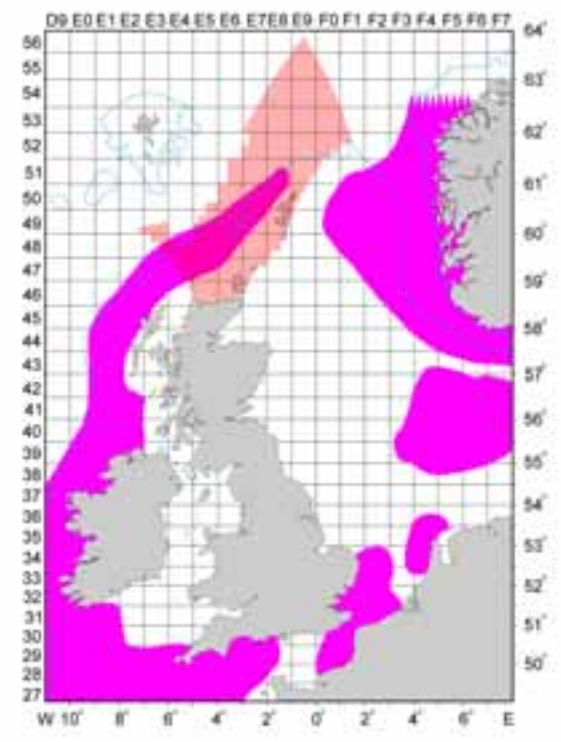

Figure 3.20.2 Mackerel nursery grounds around the British Isles (modified from Coull et al., 1998).

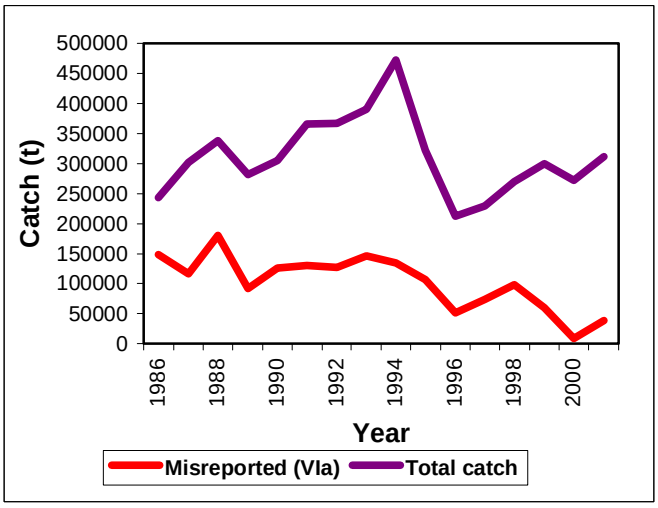

Figure 3.20.3 Estimated total catch of Mackerel in North Sea, Skagerrak and Kattegat (Sub-areas IV and III) and the amount of that total catch that was estimated to have been misreported to VIa

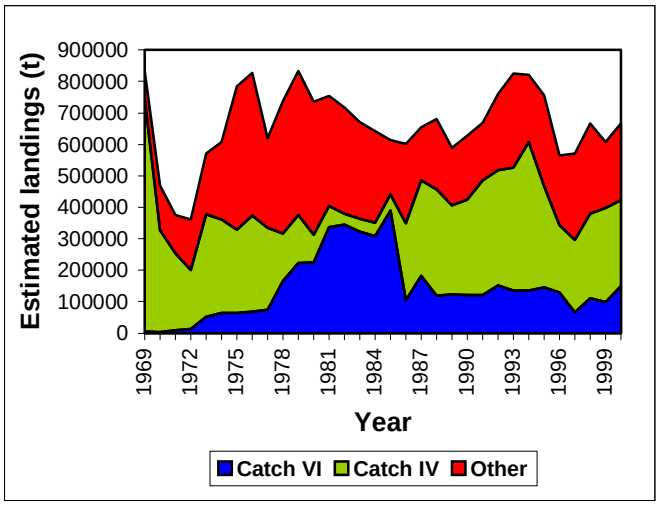

Figure 3.20.4 Estimated total catch of mackerel (tonnes) for ICES Sub-areas IV, VI and all other areas combined for the years 1969 to 2000.

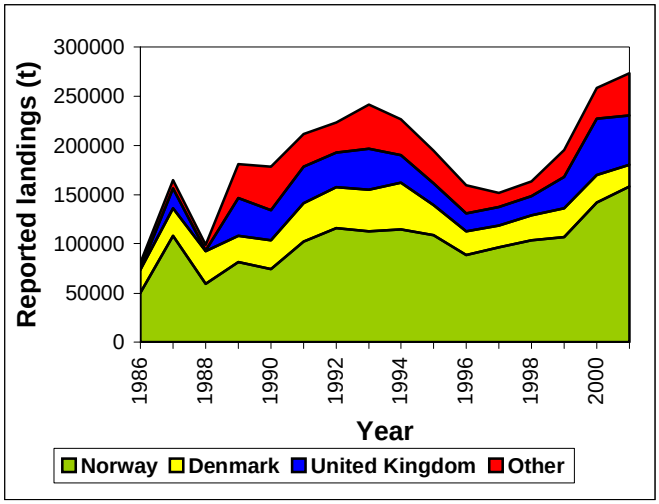

Figure 3.20.5 Reported landings of mackerel (tonnes) by country for the North Sea (Sub-areas IV and III) for the years 1986 to 2001.

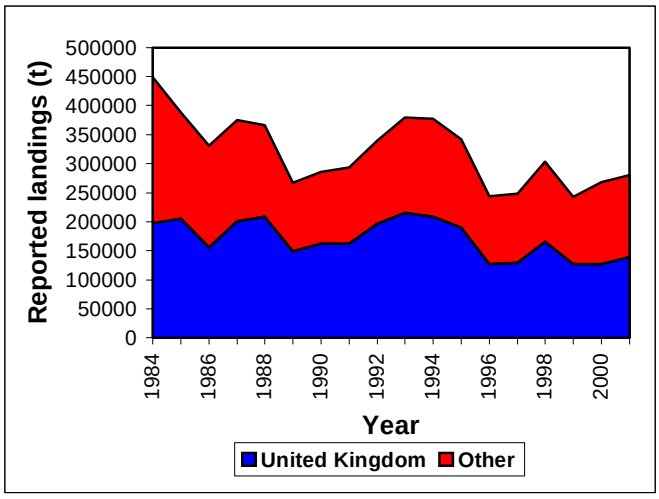

Figure 3.20.6 Reported landings of mackerel (tonnes) by country for the Western area (Sub-areas VI, VII and Division VIIIa,b,d and e) for the years 1984 to 2001.

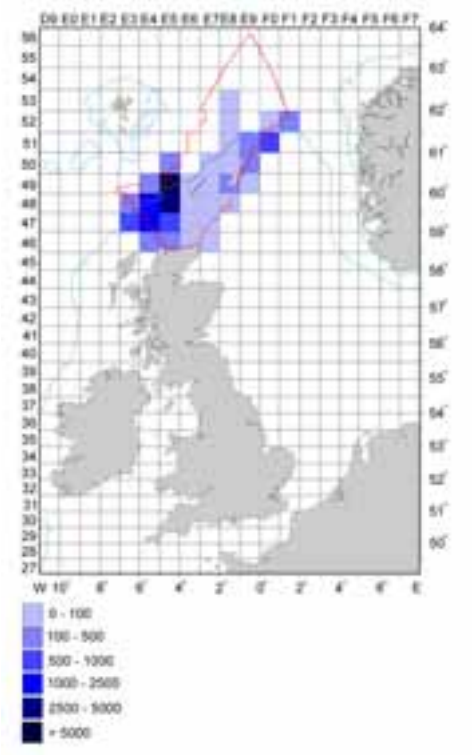

Figure 3.20.7 1 Mean annual landings of mackerel (tonnes) for by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

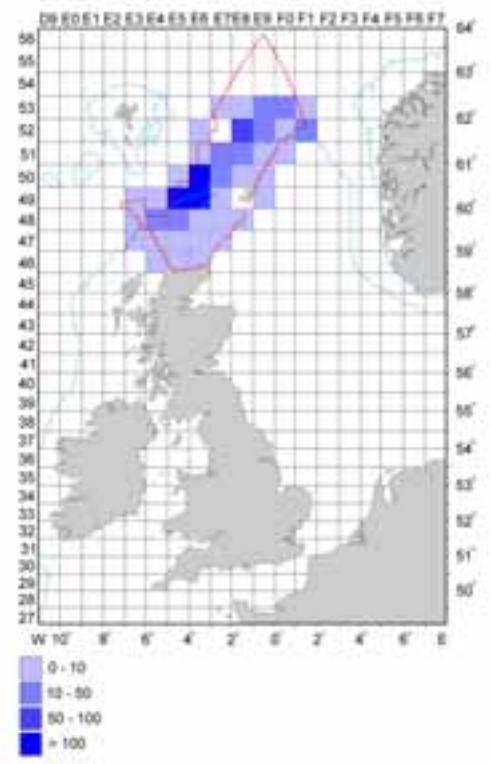

Figure 3.21.1 Mean annual landings of redfish (tonnes) for by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

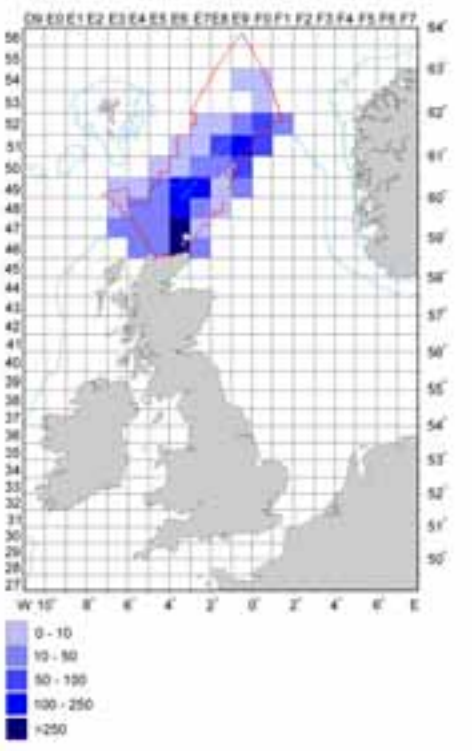

Figure 3.22.1 Mean annual landings of megrim (tonnes) for by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

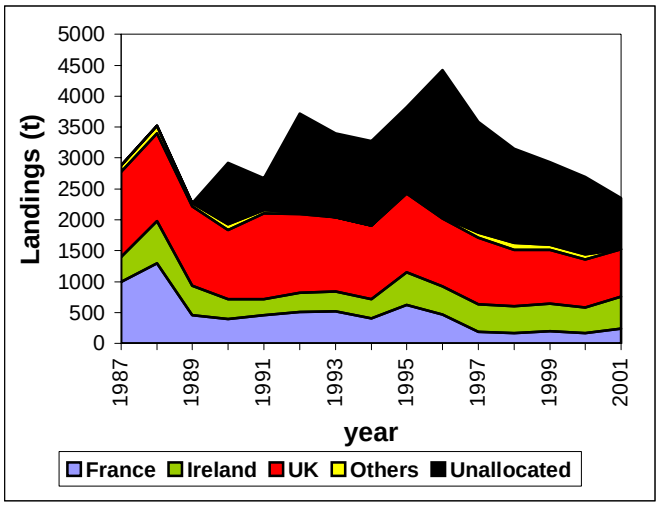

Figure 3.22.2 Reported landings (tonnes) of megrim by country for ICES Division VIa for the years 1987 to 2001 together with the estimate of unallocated landings.

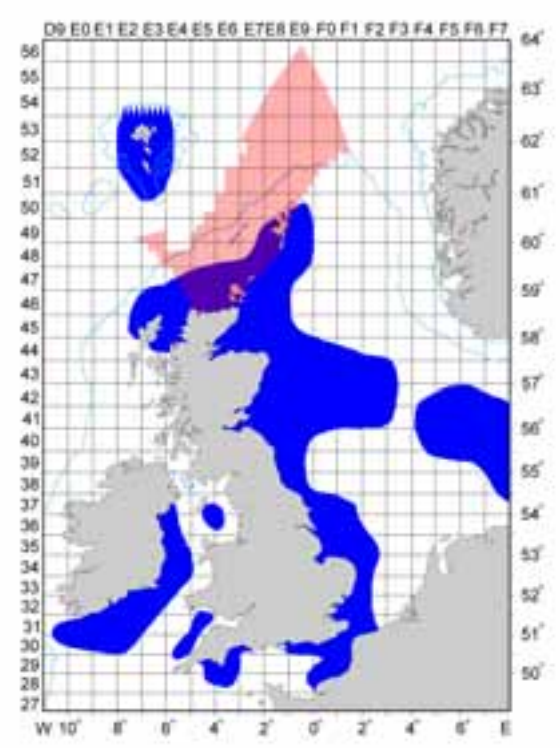

Figure 3.23.1 Lemon sole spawning areas around the British Isles (modified from Coull et al., 1998).

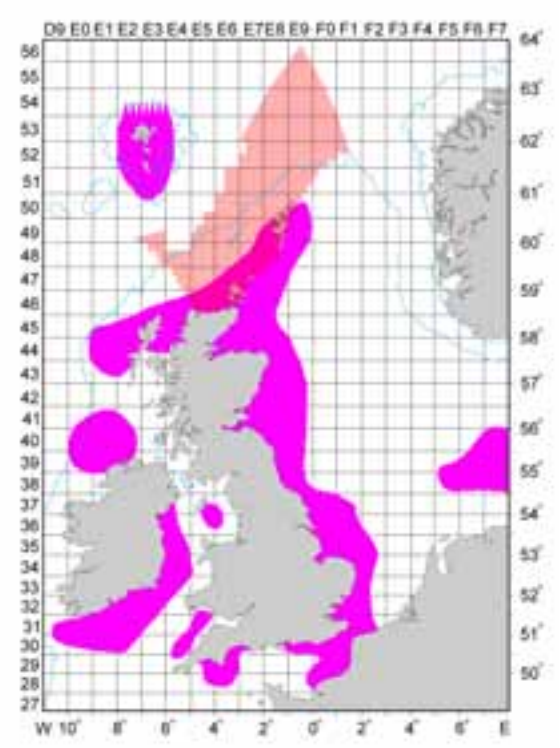

Figure 3.23.2 Lemon sole nursery grounds around the British Isles (modified from Coull et al., 1998).

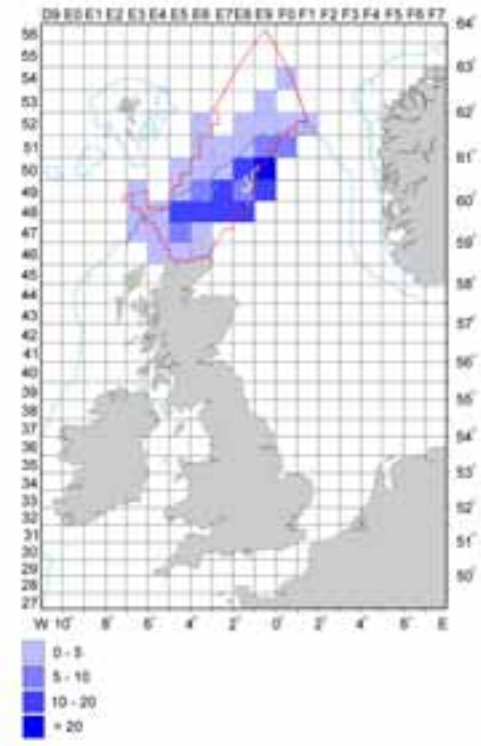

Figure 3.23.3 Mean annual landings of lemon sole (tonnes) for by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

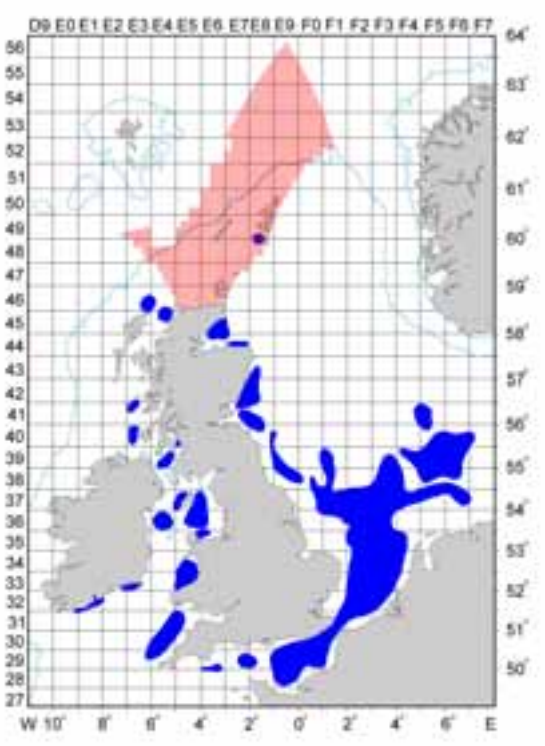

Figure 3.24.1 Plaice spawning areas around the British Isles (modified from Coull et al., 1998).

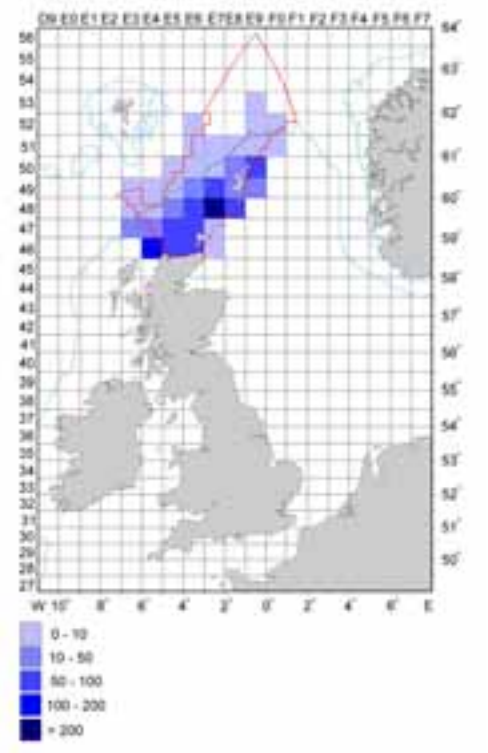

Figure 3.24.2 Mean annual landings of plaice (tonnes) by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

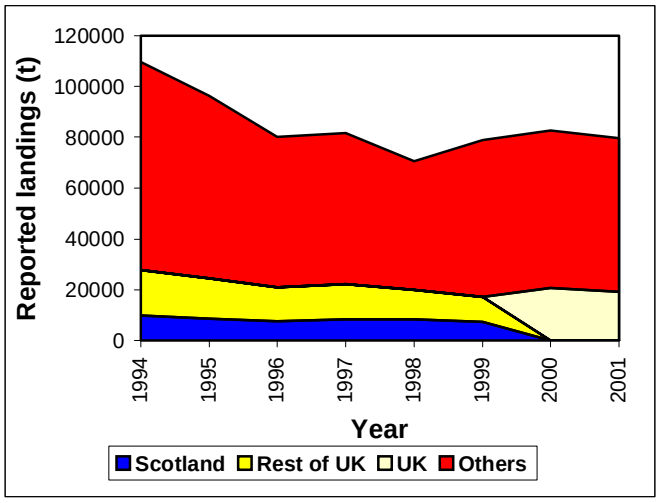

Figure 3.24.3 The reported landings of plaice by Scotland, the rest of the UK and all others combined for the years 1994 to 2001

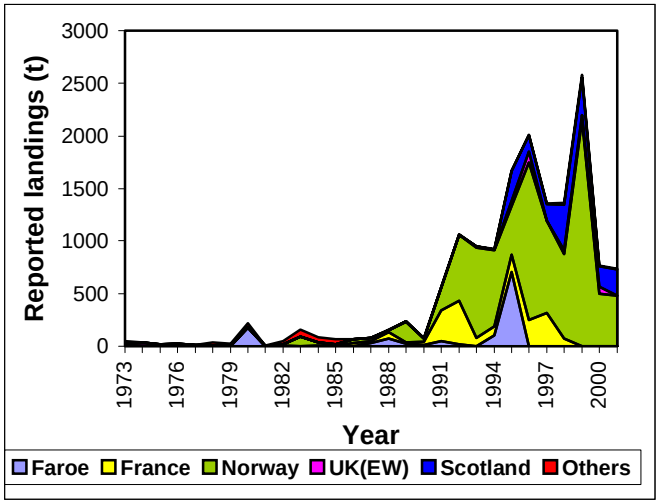

Figure 3.25.1 The reported landings (tonnes) by country of Greenland halibut for ICES Sub-area IV for the years 1973 to 2001.

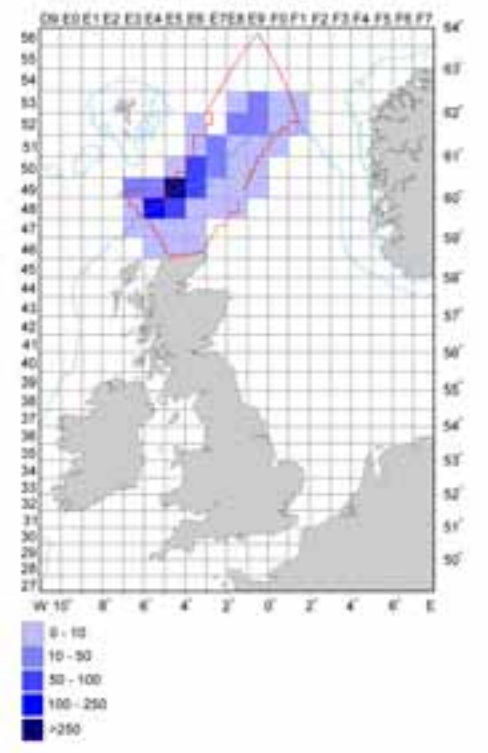

Figure 3.25.2 Mean annual landings (tonnes) of Greenland halibut by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997-2001 (data from Fisheries Research Services).

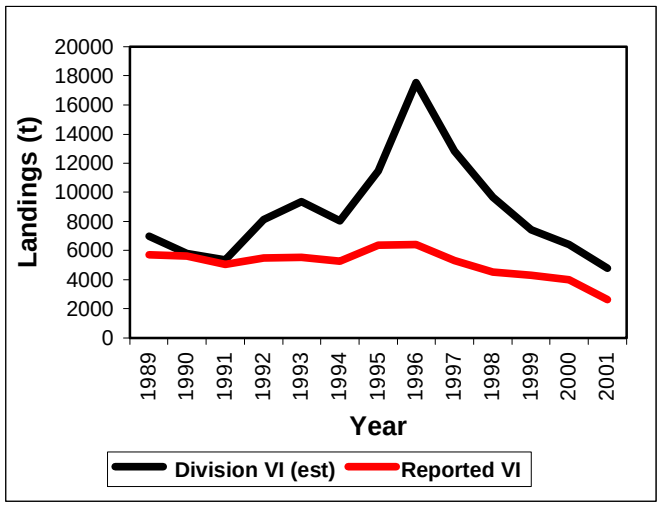

Figure 3.26.1 The reported landings of anglerfish for ICES Division VIa and the ICES Working Group's estimated landings for the years 1988 to 2001

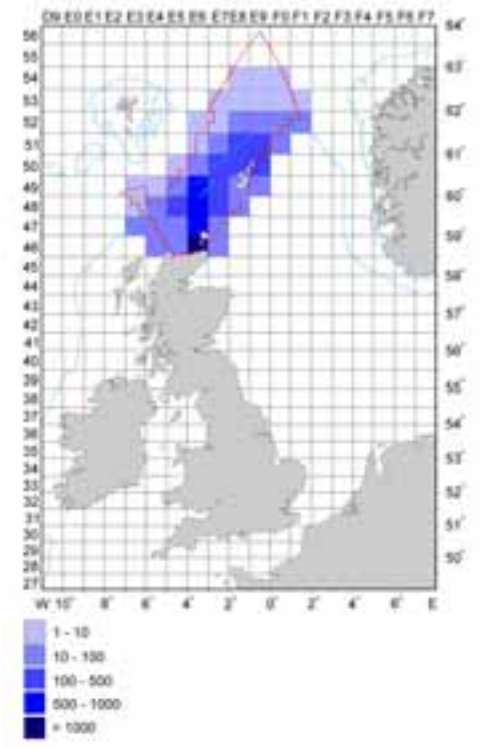

Figure 3.26.2 Mean annual landings of anglerfish (tonnes) by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

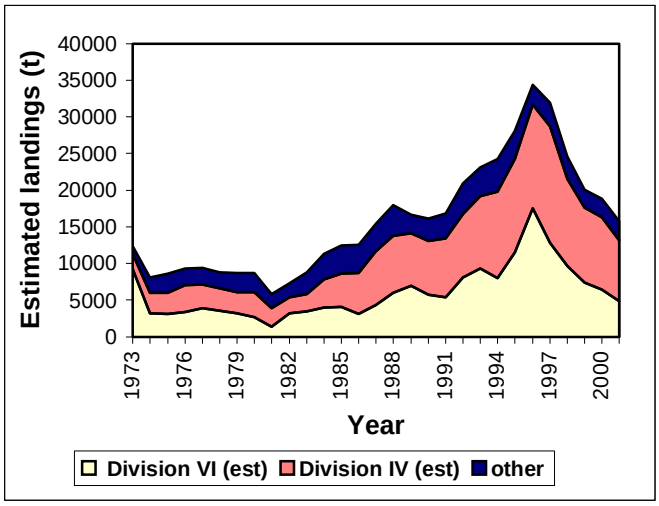

Figure 3.26.3 The estimated landings of anglerfish by Sub-area for the years 1973 to 2001.

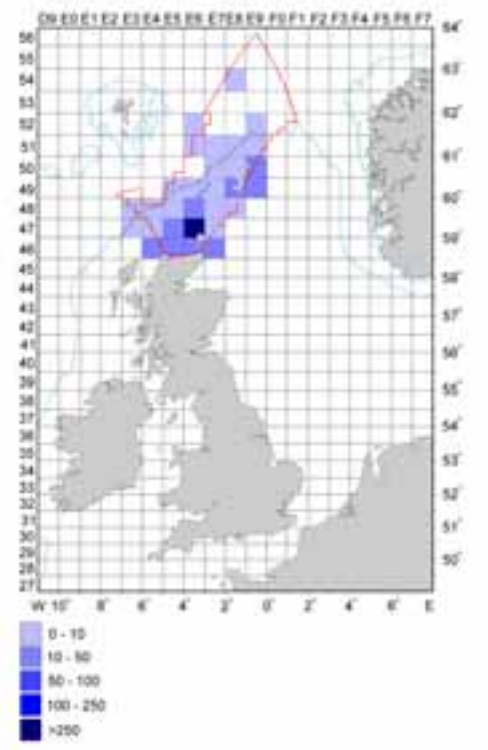

Figure 3.27.1 Mean annual landings of *Nephrops* (tonnes) by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

4.1 The fish communities of the North Sea (from Daan et al., 1990) Group 1 – shelf edge. Group 2 - central/northern assemblage.

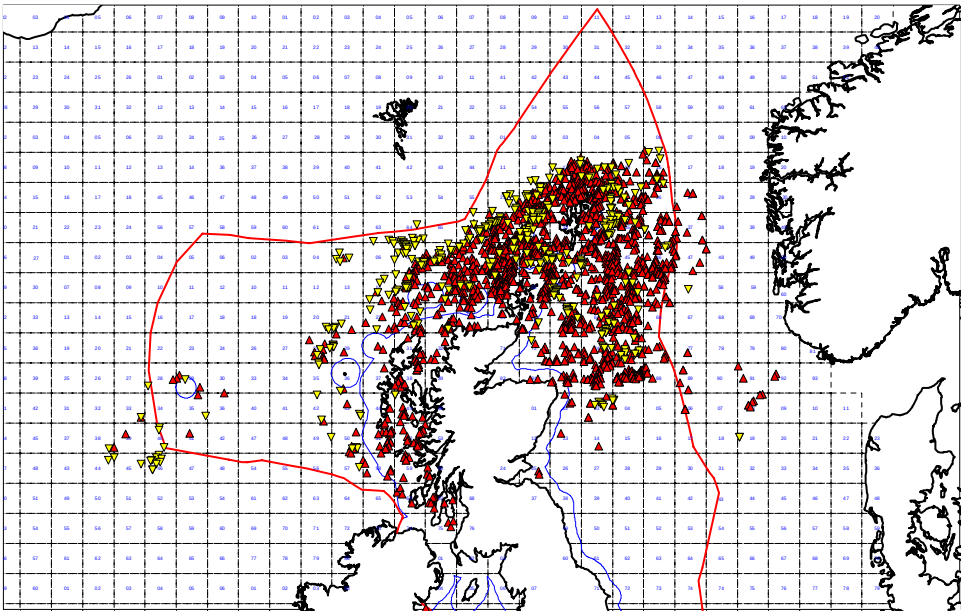

Figure 5.1 Aircraft sightings of fishing vessels – 3month period. Red – UK vessels; yellow Foreign vessels (Reproduced with permission of the Scottish Fisheries Protection Agency)

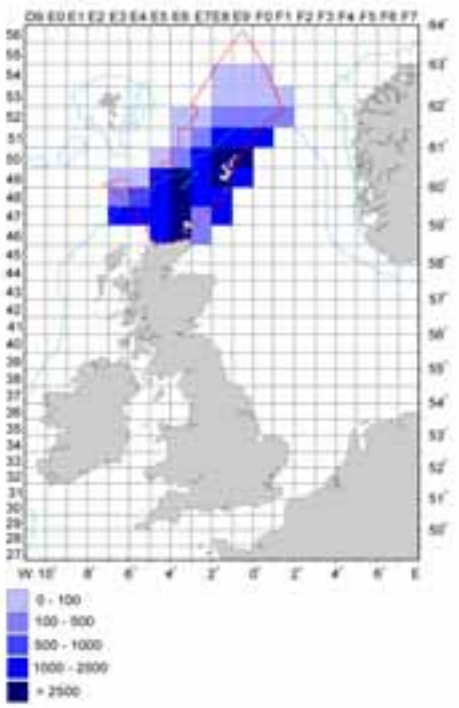

Figure 5.2 Mean annual landings of all demersal species (tonnes) by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

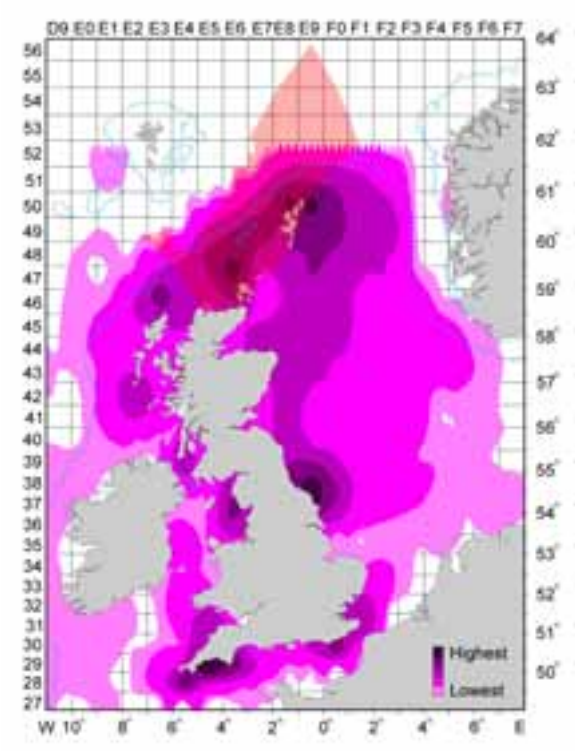

Figure 5.3 The distribution of fishing effort for demersal species (modified from Coull et al. (1998)

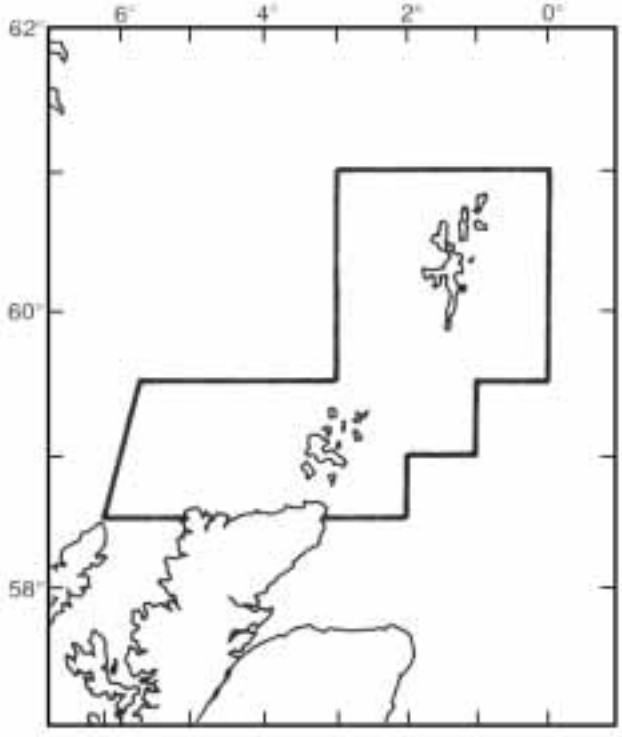

Figure 5.4 The Shetland box

Figure 5.5 The 2001 seasonal closed area for cod in the SEA4 area

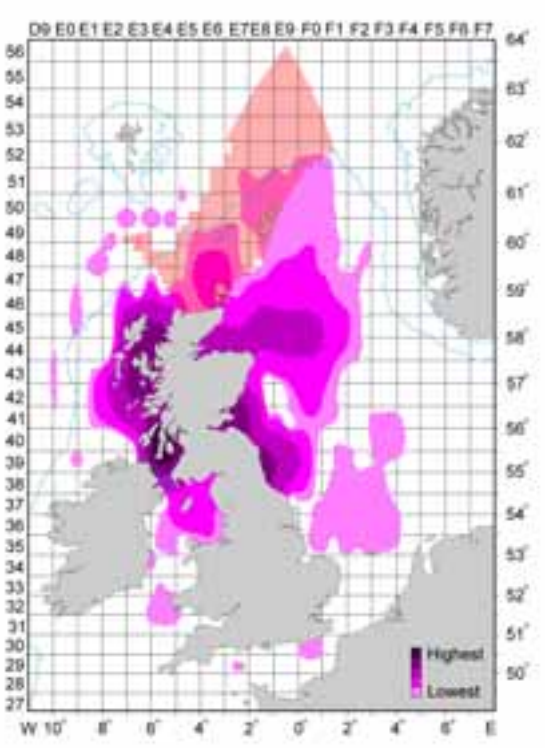

Figure 5.6 The distribution of fishing effort by Nephrops/shrimp trawlers (modified from Coull et al. (1998)

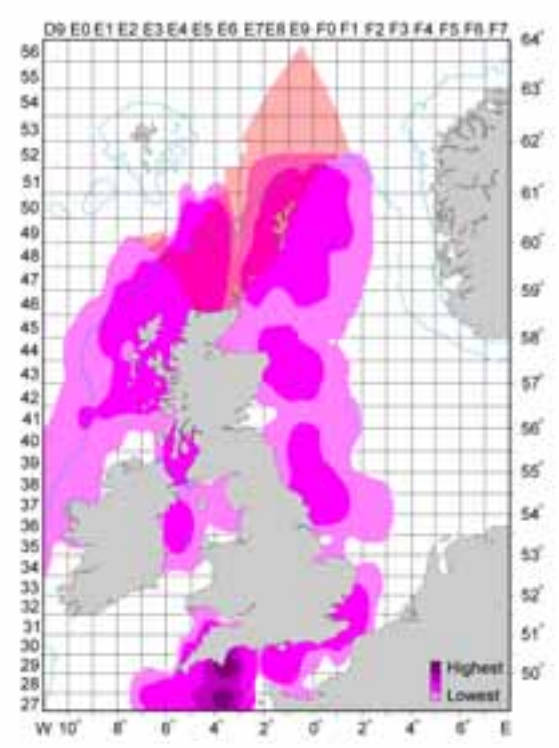

Figure 5.7 The distribution of fishing effort for pelagic species (modified from Coull et al. (1998)

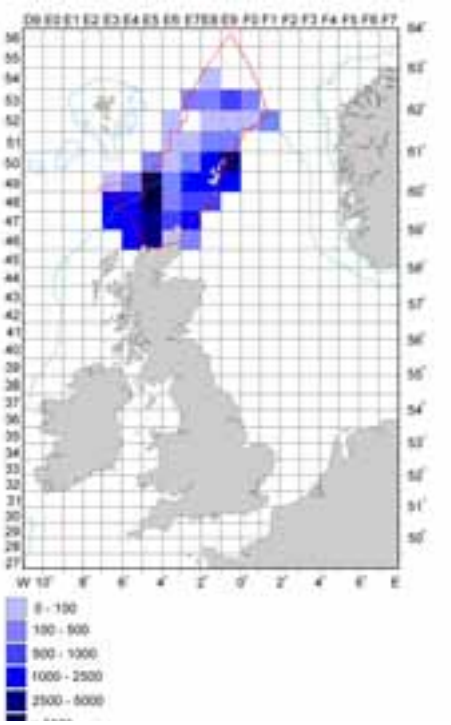

Figure 5.8 Mean annual landings of all pelagic species (tonnes) by Scottish vessels for the SEA4 area by statistical rectangle for the years 1997 – 2001 (data from Fisheries Research Services)

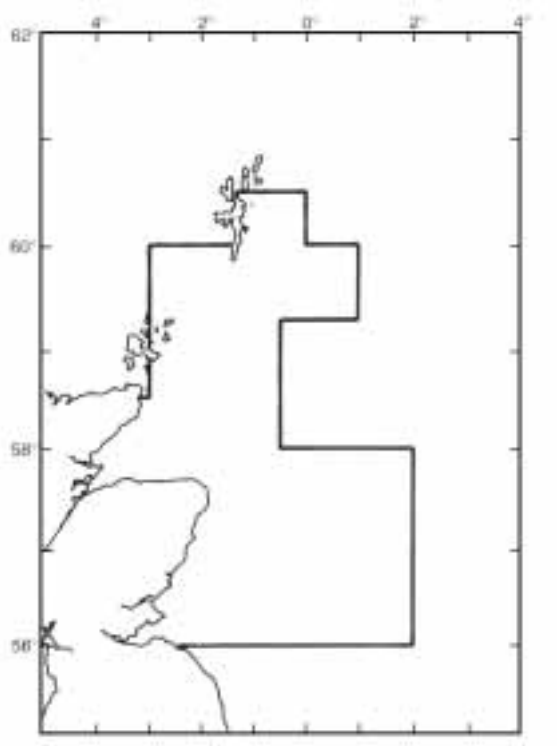

Figure 5.9 The Norway pout box

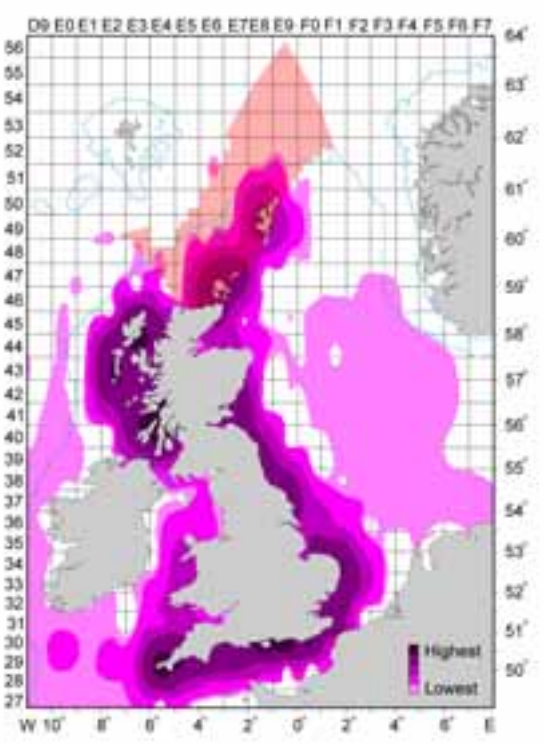

Figure 5.10 The distribution of fishing effort by static gear (modified from Coull et al. (1998)