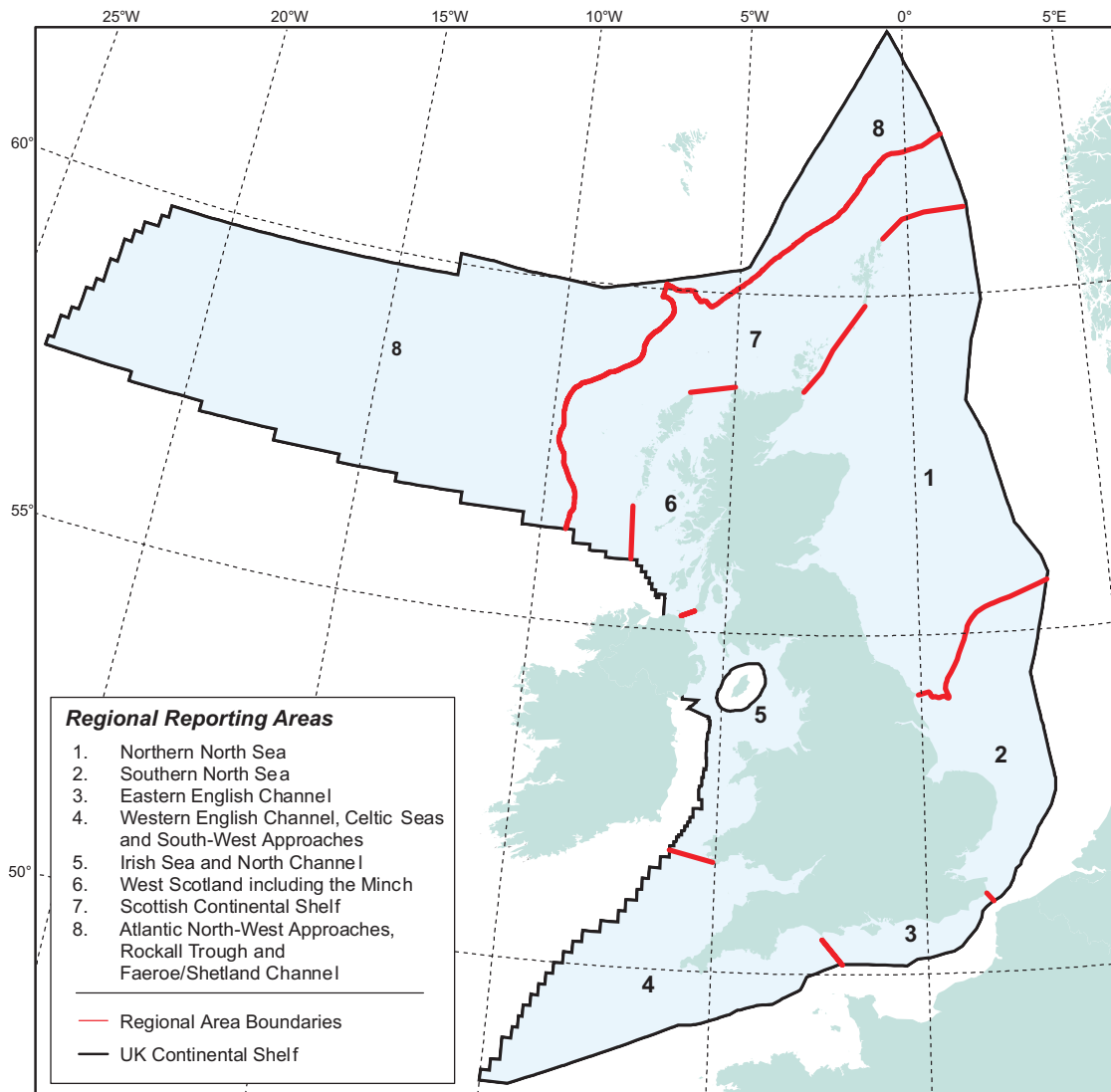


4: Marine Fish and Fisheries



The Fishery Agencies contribution to Charting Progress - an Integrated Assessment of the State of UK Seas (The 4th of 5 Reports)



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

The Regional Reporting Areas around the UK

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

The five reports in the series are as follows:

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

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

The 4th of 5 reports produced to support **Charting Progress** –
an Integrated Assessment of the State of UK Seas

Marine Fish and Fisheries

Fishery Agencies

2005

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Preface

This report is a contribution from the fisheries sector to the Defra State of the Seas Report (Defra, 2005)

It presents information on the current status of fish populations and commercial fisheries in the UK, and describes important direct and indirect effects of fishing on the marine environment. The report has been prepared by national Government Agencies with responsibilities for undertaking research and providing advice on fish and fisheries.

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Executive summary

Fishing has had the major impact on fish stocks over the past 50-100 years. In most regions, the level of fishing on demersal stocks remains too high and if maintained, will continue to lead to unsustainable fisheries in the long term. In key pelagic stocks, management action has been successful in reducing fishing mortality and these stocks have increased substantially over the past decade. Throughout the regions, valuable *Nephrops* stocks also continue to be exploited at sustainable levels.

Once stocks become depleted, then other sources of mortality such as predation and environmental factors including climate change may become more important. In these situations, it may be necessary to reduce fishing mortality even more severely in order to ensure that stocks can rebuild to safe biological levels.

- TACs alone have not been successful in regulating fishing mortality rate on a number of stocks and management increasingly includes direct effort control (days at sea), technical measures and recovery plans. The UK has actively implemented decommissioning to reduce fishing effort, and legislated for the introduction of square mesh panels in *Nephrops* trawls.
- Over the past decade the stock status of some key demersal species has deteriorated. In contrast there have been significant improvements in the state of pelagic species such as herring.
- During the past 10 years the state of the stocks for most demersal roundfish and flatfish species in the North Sea (Regions 1 and 2) has deteriorated. Only three of the eight main commercial stocks are within safe biological limits. The cod stock remains at historically low levels and is subject to emergency management measures and a recovery plan from 2005. However, herring stocks have increased substantially and *Nephrops* are exploited sustainably.

- Over the past decade Irish Sea cod and whiting stock status has deteriorated, causing concern for stock collapse. The recovery plan for Irish Sea cod includes a lower TAC, a closed area, effort regulation and other technical measures. It was introduced in 2000 and is still in place.
- Most demersal stocks in the Southwest Approaches are harvested outside precautionary limits. The northern hake stock is the subject of a management recovery plan introduced in 2004 that includes a lower TAC and technical measures (mesh size restrictions).
- Haddock and *Nephrops* in the west of Scotland are harvested sustainably but the status of many of the other demersal species are either uncertain or considered to be at low historical levels. Cod in VIa is below the Precautionary Limit Reference point (B_{lim}) and is subject to a recovery plan.

Many factors can cause changes in the abundance and distribution of fishes, including natural variation, climate change, biological interactions and human activities. Activities that are known to affect the structure and diversity of fish communities include fishing, changes to habitat quality caused by, for example, pollution, eutrophication and habitat destruction, and the introduction of non-native species. Time-series datasets have provided some valuable insights into changes in the marine environment during the past century. Determining the relative impacts of these various factors is, however, difficult and whereas many studies have demonstrated a correlation between environmental variables and biological indices, there are few cases that prove causal relationships.

Commercial exploitation of fish also has impacts on the wider marine environment. These impacts include those on the abundance, size and genetic diversity of target species, on seabed habitats and non-target animals such as marine

mammals fish and benthic fauna that are also caught during fishing operations, on the genetic diversity of both species and populations, and on the food web itself.

- Fishing affects non-target species caught as by-catch, and has caused reductions in large bodied and vulnerable species such as skates and rays.
- Monitoring programmes to determine the quantity and composition of discarded catches are in place in many UK fisheries.
- Many larger target and bycatch species in the North Sea and Irish Sea are now reduced to <10% of their expected abundance without fishing, and the mean weight of fish has declined.
- Bycatches of common dolphins in the bass fishery and harbour porpoises in the North Sea gill net fisheries are a concern, and mortality rates are thought to exceed ASCOBANS advised limits.
- The distribution of fishing activity is patchy. Some areas are repeatedly trawled each year while others are impacted less than once in 7 years.
- Unfished areas with low levels of natural disturbance are more vulnerable to fishing than naturally dynamic areas that are trawled regularly.
- The natural biogeographic trend from the SW to NE of the British Isles, and the recent changes in climate, can lead to difficulties in identifying ecosystem changes caused by fishing.
- Life-history characteristics of some deep-sea fishes will make them susceptible to over-exploitation.

1. Introduction

More than 330 species of fish have been recorded from the continental shelf (<200 m depth) surrounding the British Isles, with many more species inhabiting the deep-water habitats off the northern and western shelf edges of Scotland and Ireland. The distribution and relative abundance of fish is affected by many factors, with physical conditions (temperature and depth) the main factors affecting the overall distribution of fish. The fish assemblages of the British Isles and the factors which affect fish distribution are summarised in Sections 2 and 3.

Sections 4, 5 and 6 describe the commercial fish species of importance in the region, the status of fisheries exploitation on the UK continental shelf, and identifies current management measures in place to regulate exploitation. The effects

of these fisheries are described in Section 7 'Fisheries Impacts', and the environmental factors which also play an important part in the distribution and abundance of fish, are shown. It has not been possible to summarise all the available information on fisheries and fishing impacts, however, a selection of key documents providing further information is provided in Appendix 1. The impact of fisheries on the marine environment has recently been comprehensively reviewed by the Royal Commission on Environmental Pollution report '*Turning the Tide*'. The Prime Minister's Strategy Unit has also reported on the future of the fishing industry; '*Net Benefits: A Sustainable and Profitable Future for UK Fishing*'. The reader is encouraged to consult these additional sources of information.

2. Fish demography and fish assemblages

2.1 FACTORS AFFECTING THE DISTRIBUTION OF FISH

The British Isles lie at a biogeographical boundary between the northerly boreal province, and the more southerly Lusitanian province (Longhurst, 1998; Dinter, 2001). Some species of fish are widespread around the British Isles, but many are restricted to either the more southerly or northerly latitudes of the British Isles. Species of fish that are more abundant in the southern waters of the British Isles include greater weever fish *Trachinus draco*, red mullet *Mullus surmuletus* and bass *Dicentrarchus labrax*, whereas species such as eelpouts (Zoarcidae) and wolf-fish *Anarhichas lupus* are more abundant in more northern waters. Due to the oceanic circulation of the North Atlantic, a warm current (North Atlantic Drift) runs northwards along the western coasts of the British Isles, and this enables some southerly species to occur further north along the western seaboard of the British Isles than in the North Sea. Those species of fish that occur along the edge of the continental shelf will also occur at more northern latitudes in westerly areas, for example blue-mouth redfish *Helicolenus dactylopterus*.

Other physical factors (e.g. salinity, hydrodynamics and substrate type) and biological interactions (e.g. predator-prey relationships) will also affect the distribution and relative abundance of fish on more localised scales. Some species have specific habitat requirements, for example red band fish *Cepola rubescens* tend to live in burrows formed in mud, and several species of demersal fish (e.g. weever fish, flatfish) prefer soft substrates for burrowing. In addition to sediment type, the structure and topography of the seabed (e.g. the presence of sand ripples, sessile invertebrates and wrecks) will also affect the local distribution of fish as such complex habitats can provide cover and therefore reduce natural mortality. It is also important to note that

the habitats favoured by any given species of fish can vary both with age and time of year.

The overall distribution of British fishes is well documented in the literature (Wheeler, 1969, 1978; Whitehead *et al.*, 1984; Knijn *et al.*, 1993) and summary information is also available on FishBase (<http://www.fishbase.org/>).

Spatial and temporal patterns in the abundance of fish are heavily dependent on environmental conditions and for many species these natural factors will be the primary determinants of their distribution. Hence, disentangling the effects of anthropogenic activities, such as fishing, on fish demography from the influence of habitat and broad scale climate variability will be complex, and require further knowledge of fish ecology.

2.2. FISH ASSEMBLAGES

Most species of fish occurring in UK waters are not targeted by commercial fisheries although some are important in recreational fisheries. For example, certain species of small shark (e.g. tope and smooth hound), which are of low value on the fish market, may be the main target species for sea anglers in some areas. Additionally, many species of fish are important prey species for other marine organisms and, therefore, are an integral part of the marine ecosystem. Broad scale descriptions of the diversity of fishes in northwest Europe are available (e.g. Rogers *et al.*, 1998, 1999), and these studies broadly support the view that fish diversity is greater in the southwest and along the western sea board of the UK, with the southern and central North Sea the least diverse areas. Descriptions of the distribution of fish assemblages in the major offshore fishing grounds surrounding the UK are given below, with summary descriptions of more defined fish communities (e.g. estuarine and deep-sea fish communities) also provided.

It should be stressed that the fish assemblages described here are based on trawl surveys, and the gears used do not catch all fish with the same efficiency.

Though the state of many commercial fish stocks are assessed, more holistic assessments of the state of fish communities are lacking. Hence, OSPAR have suggested that Ecological Quality Objectives (EcoQOs) are established for fish communities, amongst other ecosystem components. Research into this field is progressing, and baseline descriptions of the fish assemblages, an important foundation for subsequent quantitative studies, are summarised below.

The State of the Sea Reporting process requires the coastal and offshore waters of the British Isles to be subdivided into regions. The following sections of this report describe the fish fauna of these regions, with cross-reference to the ICES areas in which management is undertaken. These sections provide a brief summary of species that occur in each area and an overview of fish demography, with emphasis on those species at risk, such as the elasmobranchs.

2.3 NORTH SEA AND EASTERN ENGLISH CHANNEL

The fish fauna of the North Sea has been studied for over 100 years, ranging from the early account by Garstang (1905), to more contemporary studies by Yang (1982a-c), Daan *et al.* (1990), Knijn *et al.* (1993), Greensteet and Hall (1996), Rice and Gislason (1996), Greenstreet *et al.* (1999a), Jennings *et al.* (1999, 2002) and Callaway *et al.* (2002).

2.3.1 NORTHERN NORTH SEA

Region 1 includes the northern North Sea (ICES Division IV a) and northern parts of the Central North Sea (ICES Division IV b). The fish assemblages in these areas are very different to those further south (Callaway *et al.*, 2002), which is a function of depth and temperature. The dominant fish species include demersal species such as whiting *Merlangius merlangus* and haddock *Melanogrammus aeglefinus*, and pelagic species including mackerel *Scomber scombrus* and horse mackerel *Trachurus*

trachurus. In shallow waters (50–100 m depth), populations are dominated by haddock, whiting, herring *Clupea harengus*, dab *Limanda limanda* and plaice *Pleuronectes platessa*, while at greater depth (100–200 m), Norway pout *Trisopterus esmarki* dominate (Callaway *et al.*, 2002). The northern North Sea also contains a number of boreoarctic species that are rarely found further south (e.g. Vahl's eelpout *Lycodes vahliei* and Esmark's eelpout *L. esmarkii*). Further north, deep-water species dominate and these are described briefly in Section 2.6.

Common skate *Dipturus batis*, a species of conservation interest, occurs in this region, primarily off the Shetland Isles (Ellis *et al.*, in press). Another species that may become of conservation interest in the future is the wolf-fish (*Anarhichas lupus*). This large-bodied demersal species has a comparatively low fecundity, and similar taxa in Canadian Atlantic waters have declined dramatically due to over-exploitation (O'Dea and Haedrich, 2003) (see Section 7).

2.3.2 SOUTHERN NORTH SEA

The southern North Sea (Region 2) overlaps broadly with ICES Division IVb, and is generally shallower (<50 m deep) than more northerly waters. Correspondingly, the dominant fish species are those that are more characteristic of inshore waters. Plaice *Pleuronectes platessa*, sole *Solea solea*, dab *Limanda limanda* and whiting *Merlangius merlangus* are some of the dominant commercial species, and non-commercial species such as lesser weever *Echiichthys vipera*, grey gurnard *Eutrigla gurnardus* and solenette *Buglossidium luteum* are also an important component of the fish assemblage (Callaway *et al.*, 2002). Species such as sandeels (Ammodytidae) and sand gobies (*Pomatoschistus* spp.), which are sampled poorly by trawls, are also abundant and are important prey species for many species of demersal fish.

Skates and rays have declined in the North Sea (Walker and Heessen, 1996; Walker and Hislop, 1998; ICES 2002a, 2003b), although the south-western North Sea, from the Thames Estuary to The Wash, is still an important area for rays, especially the thornback ray *Raja clavata* (Ellis *et al.*, in press). Other species of conservation interest in the area include sea lamprey *Petromyzon*

marinus, which is an anadromous species (i.e. it lives in the sea, but migrates up rivers to breed). Sea lamprey were once common in the Thames, but have declined, possibly as a result of habitat deterioration. Lamprey are now thought to be returning to the Thames to spawn (<http://www.thames-explorer.org.uk/news/lamprey.html>).

2.3.3 EASTERN ENGLISH CHANNEL

The English Channel (ICES Division VII d-e) is a biogeographical boundary for many species of marine organism. The fish assemblages of the eastern English Channel are relatively similar to those occurring in the southern North Sea, and many species of fish (e.g. plaice) migrate between the southern North Sea and eastern English Channel (Arnold and Metcalfe, 1996). In contrast, the assemblages and stocks of fishes in the western English Channel are more closely linked to the Celtic Seas (Pawson, 1995).

The eastern English Channel (Region 3) is relatively shallow (<50 m deep), although there are deeper areas (ca. 70 m deep) in mid-Channel. The habitats in the Dover Straits and 'the narrows' (the area between the Isle of Wight and the Cherbourg Peninsula) are different to most other parts of the English Channel (Kaiser *et al.*, 1999), with greater tidal streams, coarser grounds and a high diversity of filter-feeding invertebrates occurring. These complex habitats support a variety of small gadoids, including poor cod *Trisopterus minutus* and bib *Trisopterus luscus*. The deeper waters in mid-Channel also have relatively coarse grounds (gravel and shell debris), and these areas are dominated by thickback sole *Microchirus variegatus* and red gurnard *Aspitrigla cuculus*. The inshore waters are dominated by flatfish (plaice, dab, sole, solenette) and other inshore species, including lesser weever fish and common dragonet *Callionymus lyra* (Kaiser *et al.*, 1999).

Species of conservation interest that also occur in the area include sea horses *Hippocampus* spp. These species are occasionally caught in English waters, although they are more frequently recorded along the north coast of France (ICES, 2003a).

2.4 SOUTH-WESTERN APPROACHES

The south-western approaches (Region 4) includes the western English Channel, parts of the Celtic Sea and the Bristol Channel. The fishes of these areas include several south-western species, and given the proximity of this area to the Atlantic Ocean, warm temperate and sub-tropical pelagic fish species are also reported occasionally (e.g. Stebbing *et al.*, 2002).

Several southerly species have increased in frequency of occurrence and/or relative abundance in surveys in the south-west in recent years, including John dory *Zeus faber* and boarfish *Capros aper* (Figure 2.1). Some southerly species, however, have decreased in abundance during the second half of the 20th Century. Red seabream *Pagellus bogaraveo* were historically common in the western English Channel, Celtic Sea and Irish Sea, although few were recorded during surveys in the later 1980s and 1990s.

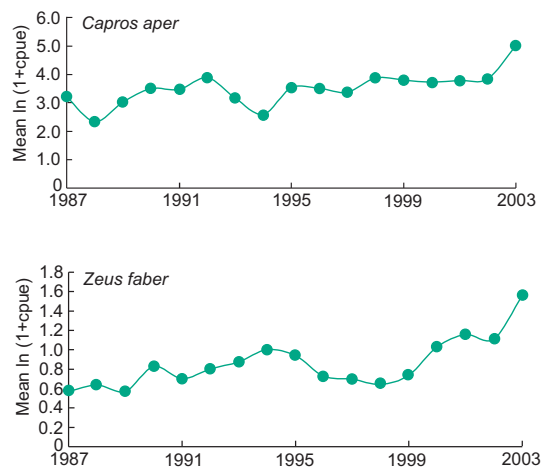


Figure 2.1. Relative abundance of boarfish (top) and John dory (bottom) in the Celtic Sea (1987-2003), showing a general increase in abundance. Data from CEFAS research vessel surveys

2.4.1 WESTERN ENGLISH CHANNEL

The western English Channel is generally deeper than the eastern English Channel, with the Hurd Deep more than 100 m deep. The seafloor, much of which is relatively coarse, is steeply shelving, so the coastal zone of shallow water is relatively narrow. Many species of fish that are absent or rare in the eastern English Channel, such as anglerfish *Lophius piscatorius* and cuckoo ray *Leucoraja naevus*, are relatively common in the western Channel (Pawson, 1995). The western Channel also contains numerous wrecks, and these can be locally important for several species of fish that associate with 'reefs', such as conger eel *Conger conger* and pollack *Pollachius pollachius*.

The western English Channel is also an important site for basking shark *Cetorhinus maximus*, and this protected species can often be found in association with the fronts that occur in the area during the summer (Sims *et al.*, 2000). Angel shark *Squatina squatina* was historically abundant in parts of the western English Channel (e.g. Start Bay), although there are few recent records (Rogers and Ellis, 2000).

2.4.2 CELTIC SEA

The distribution of the more common fishes of the Celtic Sea were described by Warnes and Jones (1995), and more recent studies of the fish community of this area include Pinnegar *et al.* (2002), Rochet and Trenkel (2003) and Trenkel and Rochet (2003). The fish assemblages of the Celtic Sea (ICES Divisions VII g-h) are relatively similar to those in the western English Channel, although offshore species become increasingly abundant as depth increases. Such species include hake *Merluccius merluccius*, megrim *Lepidorhombus whiffiagonis*, long-rough dab *Hippoglossoides platessoides*, blue whiting *Micromesistius poutassou* and boarfish *Capros aper* (Warnes and Jones, 1995). Several species of conservation interest occur in the Celtic Sea, including basking shark *Cetorhinus maximus* (Sims *et al.*, 2000) and common skate *Dipturus batis*. Pelagic sharks also occur in the area, including blue shark *Prionace glauca* and porbeagle *Lamna nasus*, and these species will also occur seasonally in the western English Channel and outer Bristol Channel. Further offshore, and at the edge of the continental shelf, deep-water species dominate and these are described briefly in Section 2.8.

2.4.3 BRISTOL CHANNEL

The fish fauna of the Bristol Channel (ICES Division VII f) is relatively similar to that occurring in the western English Channel and Irish Sea. One noteworthy difference between the Bristol Channel and other areas, however, is the presence of large numbers of smalleyed ray *Raja microocellata*. Although this species does occur in small numbers in the English Channel and off southern Ireland, it is most abundant in the Bristol Channel (Ellis *et al.*, in press). The grounds off Trevoise Head (North Cornwall) are an important spawning ground for several species of teleost (Horwood *et al.*, 1998), and Carmarthen Bay, an extensive sandy area between Pembrokeshire and The Gower, is an important nursery ground for several species of flatfish and ray. Species of conservation interest in the area include shad *Alosa* spp., and lampreys, which migrate up some of the rivers feeding into the Bristol Channel. Many of the rivers in this area are also important for common eel *Anguilla anguilla*.

2.5 IRISH SEA

The Irish Sea (Region 5) broadly corresponds with ICES Division VIIa, and contains several distinct fish assemblages. (Ellis *et al.*, 2000, 2002). The grounds in the inshore waters of the eastern and western Irish Sea are generally sandy, with flatfish (plaice, dab, solenette and sole), tub gurnard *Trigla lucerna*, lesser weever *Echiichthys vipera*, common dragonet *Callionymus lyra* and sand gobies *Pomatoschistus* spp. all abundant. Further offshore, the grounds become coarser, and spotted ray *Raja montagui*, cuckoo ray *Leucoraja naevus*, lesser-spotted dogfish *Scylliorhinus canicula*, red gurnard *Aspitrigla cuculus* and thickback sole *Microchirus variegatus* dominate the fish assemblage. The *Nephrops* grounds in the north-western Irish Sea and off Cumbria, have a distinct fish community, with witch *Glyptocephalus cynoglossus* and Fries's goby *Lesuerigobius friesii* restricted to these muddy grounds. The deeper waters in the western Irish Sea are also inhabited by long-rough dab *Hippoglossoides platessoides* and Norway pout *Trisopterus esmarki*, and boarfish *Capros aper* may occur in small numbers.

There have been some recent changes in the skate and ray community, with white skate *Rostroraja alba* no longer caught (Dulvy *et al.*, 2000) and common skate only occasionally

caught in the area, typically in the vicinity of the North Channel (Ellis *et al.*, 2002). Angel shark *Squatina squatina* was historically caught in parts of the Irish Sea (e.g. Cardigan Bay), although there are few recent records. The rough grounds around Anglesey and the Llyn Peninsula are an important site for greater-spotted dogfish *Scyliorhinus stellaris* (Ellis *et al.*, in press).

2.6 WEST OF SCOTLAND AND ROCKALL

The fishes of the west of Scotland (ICES Division VIa) were described by Gordon and Silva (1980) and Gordon (1981), and these works provide an annotated inventory of the fishes in the area. The fish assemblages in the Minches and the Firths along the west coast, which broadly equates with Region 6, are composed primarily of whiting *Merlangius merlangus*, sprat *Sprattus sprattus*, Norway pout *Trisopterus esmarki*, hake *Merluccius merluccius* and haddock *Melanogrammus aeglefinus*. West of the Hebrides and off northern Scotland (Regions 7–8) is generally deeper, usually greater than 100 m deep, and haddock, poor cod *Trisopterus minutus*, Norway pout, whiting and grey gurnard *Eutrigla gurnardus* dominate the fish assemblage. The fish assemblages along the shelf edge (300–450 m deep) are dominated by silvery pout *Gadiculus argenteus*, blue-mouth redfish *Helicolenus dactylopterus* and hollowsnout rattail *Caelorinchus caelorhincus*, and other deep-water species also occur in small numbers. Further offshore, deep-water species dominate and these are described briefly in Section 2.8.

Basking shark *Cetorhinus maximus*, a species of conservation importance, are frequently reported from the west coast of Scotland, where they were once subject to targeted commercial fisheries. Common skate *Dipturus batis* are locally abundant at certain sites, including sea lochs, and a tag and release programme for them is run in association with the Kelvingrove Art Gallery and Museum in Glasgow (see <http://www.thecatchalot.co.uk/tagging/skate.htm>).

2.7 ESTUARINE FISHES

There are distinct fish assemblages in coastal and estuarine waters, and many aspects of the ecology of estuarine fishes were reviewed by Elliot and Hemingway (2002). The marine fishes that occur in such waters are generally either the

juvenile life-history stages of inshore species that move into deeper waters when large enough, or species that are more dependent on estuarine conditions, such as grey mullet (Mugilidae) and flounder *Platichthys flesus*.

Several species of fish migrate between fresh and marine environments, and such diadromous species may be exposed to a variety of human activities. Some species, such as common eel *Anguilla anguilla*, migrate from rivers to the sea in order to breed (catadromous), whilst others migrate from the sea to rivers to spawn (anadromous) upstream. The latter are more common and this life-history strategy is exhibited by salmon *Salmo salar*, sea trout *Salmo trutta*, twaite shad *Alosa fallax*, allis shad *Alosa alosa* and sea lamprey *Petromyzon marinus*. Many of these species have seen significant declines in distribution and/or abundance, often as a result of human impacts in estuaries and rivers (e.g. water pollution, physical obstructions, habitat modification). Although the endangered Atlantic sturgeon *Acipenser sturio* has historically been reported from UK rivers and estuaries, it is not known to have bred in the UK in recent times. This species is protected under the Wildlife and Countryside Act and under CITES (ICES, 2003a).

As part of a broader series of measures to protect UK water resources, the Environment Agency is developing a fish community classification scheme to meet the requirements of the Water Framework Directive (WFD) in transitional waters (estuaries). As one of five biological quality elements, fish populations are to be assessed by taking account of the composition and abundance of the fish fauna. In order to monitor the fish faunal assemblages within an estuary, the EA have established a multi-method monitoring programme based on work undertaken in the Thames. This technique has now been recognised as an example of European Best Practice, and will form the basis of the future development of fish monitoring programmes throughout the UK.

Work on the development of an Estuarine Fish Community Index (EFCI) has recommended that an estuarine fish classification scheme should include a variety of biological measures including functional guilds. Each measure must respond in a predictable way to environmental stress and in order to view fish community data in context,

reference or baseline conditions are needed against which these data can be compared. Several approaches to establishing reference conditions are being considered, including the use of historical records, predictive models, expert opinion, or the selection of sites that are least impacted.

2.8 DEEP-WATER FISHES

The biology and fisheries of deep-sea fish (i.e. those occurring in waters more than 200m deep) have recently been reviewed (see Hopper, 1994; Randall and Farrell, 1997; Haedrich and Merrett, 1988; Merrett and Haedrich, 1997), and the status of European deep-sea fisheries summarised by ICES (2002b, 2003c, 2004). The proceedings from symposia on deep-water fisheries have also been produced recently (Gordon, 2001; Moore and Gordon, 2003).

The most studied deep-sea communities around the British Isles are in the Porcupine Seabight (Merrett *et al.*, 1991a,b) and Rockall Trough (Gordon, 1986; Gordon and Duncan, 1985, 1987; Gordon and Bergstad, 1992), the latter equating with Region 8). Gordon and Bergstad (1992) described the fishes of the Rockall Trough and their bathymetric zonation. The dominant species at 250 m were silvery pout *Gadiculus argenteus*, blue-mouth redfish *Helicolenus dactylopterus* and blue whiting *Micromesistius poutassou* (as discussed in Section 2.6), whereas in deeper waters, various species of morid cod, grenadier (rat-tails), arrowtooth eels and deep-sea squaliform sharks dominate.

The life-history characteristics of many deep-water fishes make them susceptible to over-exploitation. Given the low water temperature, which reduces the metabolic rate, and variable food availability, growth rates are generally very slow although deep-water species can also have a high longevity. These slow growth rates are also reflected in the high age at maturity. Larval dispersal is relatively low for some deep-water species, and adult fish may aggregate at certain sites, such as sea-mounts, so localised depletions may occur. One deep-water fish, orange roughy *Hoplostethus atlanticus*, was included in the provisional OSPAR list of threatened and declining species, and concern has also been raised for other deep-water species, including deep-water squaliform sharks.

2.9 REEF COMMUNITIES

Most of the data collected during groundfish surveys is based on sampling those grounds that can be trawled. Reefs, whether natural rocky and/or biogenic reefs, or artificial structures (e.g. oil platforms and wrecks) also provide important habitats for many species of fish that prefer rough grounds, including wrasse (Labridae), clingfish, conger eel, topknots, and various species of goby and gadoid (Sarno *et al.*, 1994; Nickell and Sayer, 1998; Magill and Sayer, 2002). Such communities tend to be most common off the rocky coastlines along the western coast of the UK (Regions 4-7).

2.10 FISH ASSEMBLAGE METRICS

Given the increased focus on the ecosystem approach to fisheries management, there is currently much international activity to develop indices that will assess the status of fish assemblages as a whole, to complement the single-species assessments undertaken for the various commercial fish stocks. Foremost amongst such studies is work in OSPAR and ICES to develop Ecological Quality Objectives (EcoQOs) for fish communities using changes in the proportion of large fish in the population. This element can be more easily interpreted as changes in the average weight and average maximum length of the fish community. The basis for this work is that fishing activity exerts pressure on the entire fish community, and this may lead to undesirable consequences.

Although the average weight of fish and the average maximum length of fish are considered to be indicators of the proportion of large fish in the community, they in fact represent different but inter-related aspects of the community. The average weight of a fish represents changes in the size structure of the community, while the average maximum length represents changes in the species composition.

The proposed metrics will respond to human impacts such as fishing activity, however, there is a low probability of detecting short-term changes in the metrics, which makes it difficult to establish objectives that managers can act upon. More importantly, there is evidence that the response time of the metrics to changes in fishing effort is considerable, and the existing

time-series are generally too short to establish meaningful reference levels. Also, the values may be affected by environmental conditions, will be highly specific to the gear used, the area which is surveyed, and to the selection of species that are used in the analyses.

At this stage it is unlikely that this Ecological Quality Element will be available for use in short term fisheries management, but there is potential for its use as a more qualitative indicator of fish community status over the longer term. Work to develop such qualitative indicators is currently in progress, and is being considered together with the use of trophic and taxonomic indicators of fish community structure.

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3. Commercial fishes

The NE Atlantic and seas around the UK include some of the most productive fisheries in the world. The annual harvest of fish and shellfish amounts to about 10 million tonnes (FAO, 2003) of which more than 3 million comes from the North Sea alone. The annual landings of fish and shellfish from the NE Atlantic contribute around 11% of the total world production of fish.

Four major fisheries exploit the commercial species. These are:

- Demersal fisheries for human consumption that target roundfish species such as cod, haddock and hake, flatfish species such as plaice, sole and megrim, and other demersal species such as anglerfish and rays.
- Human consumption fisheries for pelagic fish target species that occur in large shoals such as herring, mackerel and horse mackerel.
- Industrial fisheries targeting fish for processing into oil and fish meal.
- Shellfish fisheries exploiting molluscs and crustacea.

The government laboratories undertaking research into the status of marine fishes include CEFAS for England and Wales (<http://www.cefas.co.uk/>), Fisheries Research Services for Scotland (<http://www.marlab.ac.uk/>), and the Agriculture, Food and Environmental Science Division of the Department for Agriculture and Rural Development for Northern Ireland (<http://www.dardni.gov.uk/>). Estuarine and diadromous fishes will also be subject to

investigations by the Environment Agency (<http://www.environment-agency.gov.uk/>). All these institutes liaise with equivalent laboratories in other European countries, including the Marine Institute in the Republic of Ireland (<http://www.marine.ie/>), and participate in working groups overseen by the International Council for the Exploration of the Sea (<http://www.ices.dk>). The ICES Advisory Committee on Fishery Management (ACFM, see: <http://www.ices.dk/committe/acfm/comwork/report/asp/acfmrep.asp>) coordinates the production of annual scientific advice on fish stocks to national governments and the European Union.

The primary assessment groups for UK demersal stocks are:

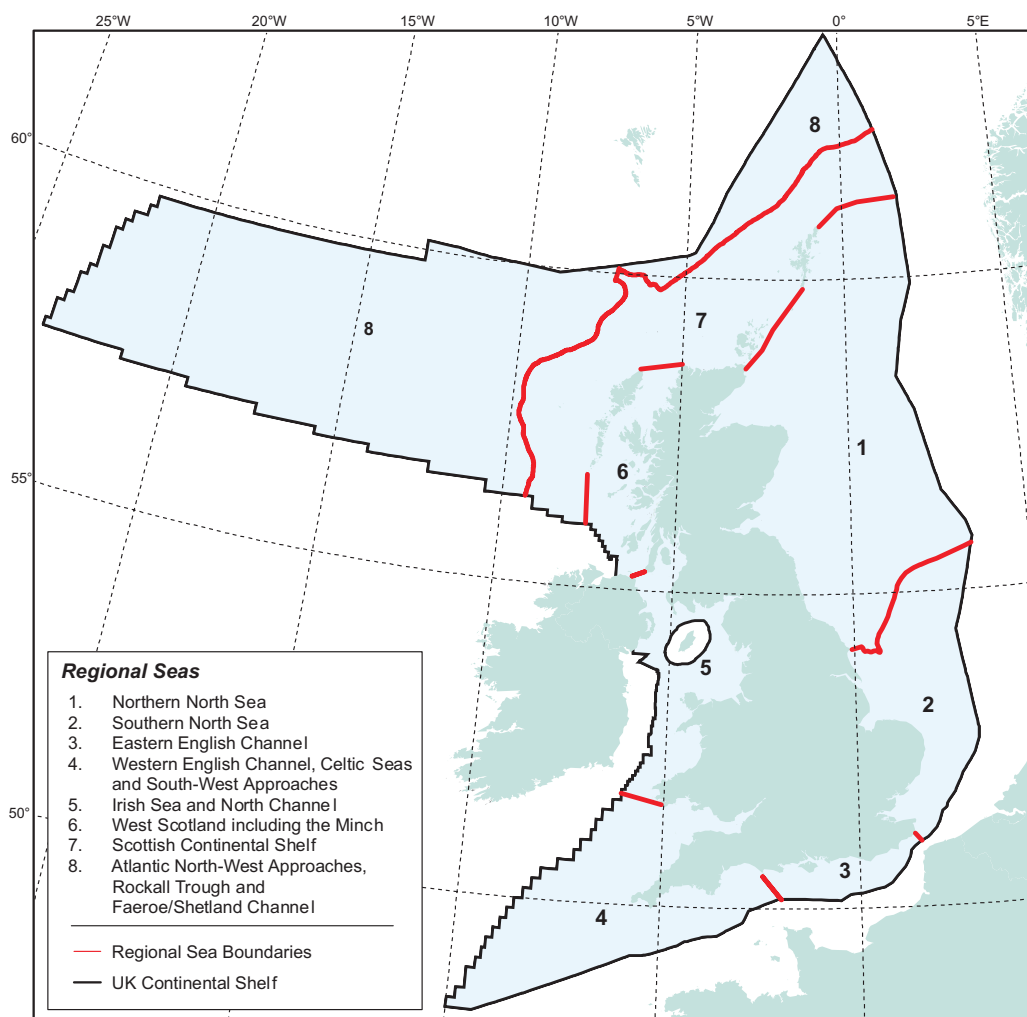
1. Working Group on the Assessment of Northern Shelf Demersal Stocks, which conducts assessments for stocks occurring within ICES sub-area VI and division VIIa (Irish Sea) <http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGNSDS>
2. Working Group on the Assessment of Southern Shelf Demersal Stocks, which conducts assessments for stocks within ICES divisions VIIe-k <http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGSSDS>
3. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (<http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGNSSK>).

In addition to these working groups there are other working groups that deal with more specific stocks:

Herring	Herring Assessment Working Group for the area south of 62°N (http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=HAWG)
Eels	Working Group on Eels (http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGEEL)
Cephalopods	Working Group on Cephalopod fisheries and life history (http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGCEPH)
Elasmobranchs	Working Group on Elasmobranch Fisheries (http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGEF)
Atlantic Salmon	Working Group on North Atlantic salmon (http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGNAS)

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Commercial fishes

Mackerel and other pelagic species	Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGMHSA)
Hake, Anglerfish and megrim	Working Group on the Assessment of Southern Shelf Stocks of Hake, Anglerfish and Megrim (http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGMM)
Deep-sea fish	Working Group on the Biology and Assessment of Deep Sea Fisheries Resources (http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGDEEP)
Bass	Study Group on Sea Bass (http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=SGBASS)
<i>Nephrops</i>	Working Group on <i>Nephrops</i> stocks (http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGNEPH)



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

Figure 3.1. Map showing the distribution of the regions used in the State of the Seas sectoral reports

The boundaries used in this State of the Seas Report (Figure 3.1) are broadly comparable to those used by ICES (Figure 3.2), although the borders do vary slightly. Nevertheless, these borders, and

those used by OSPAR (<http://www.ospar.org/eng/html/welcome.html>) tend to mirror the broad biogeographical boundaries that occur and which have been described elsewhere in this section.

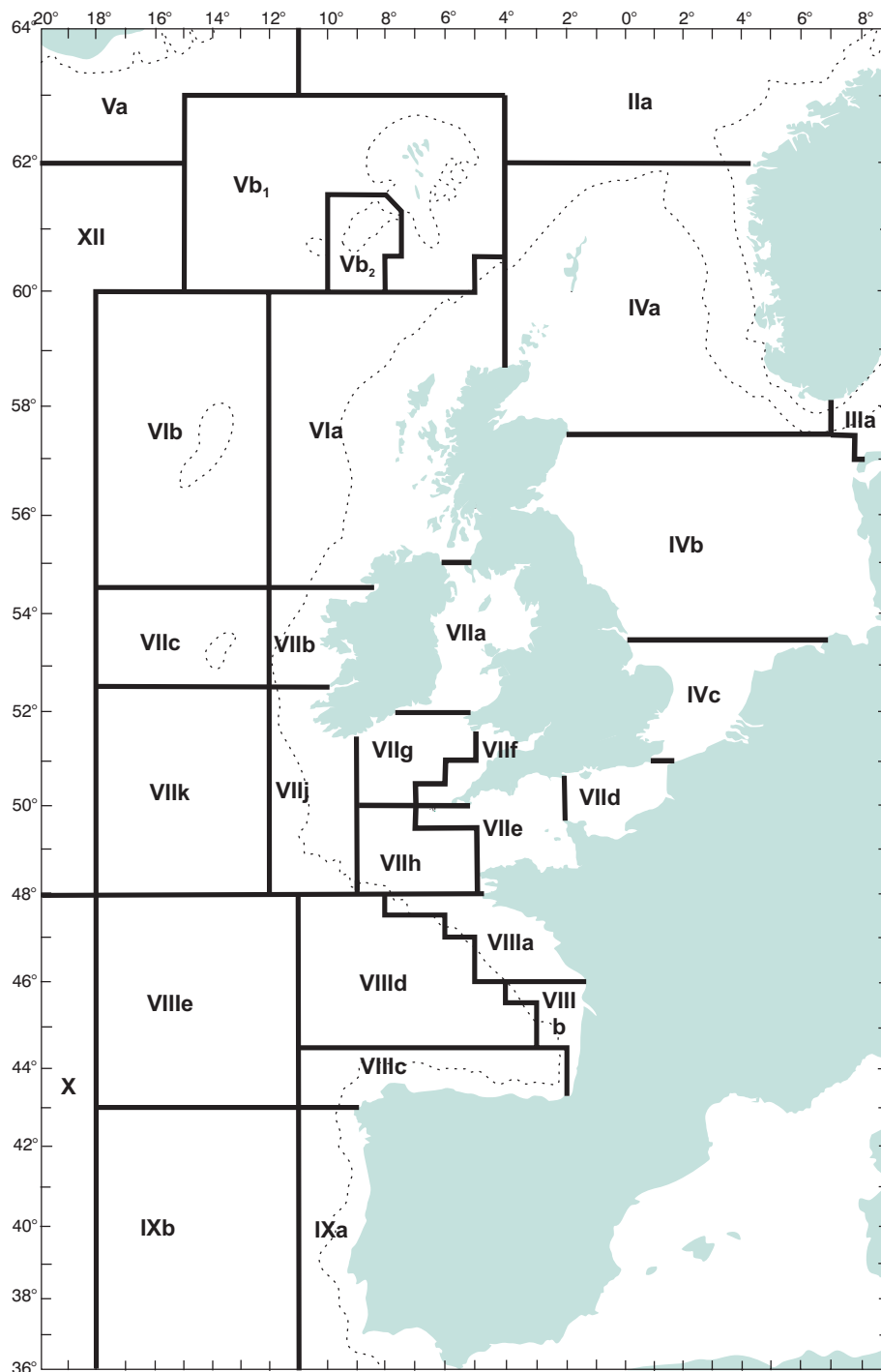


Figure 3.2. Map of ICES regions in the North-east Atlantic.
Adapted from <http://www.ices.dk/committe/acfm/comwork/report/2002/oct/Fishing%20areas.pdf>

3.1 NORTH SEA AND EASTERN ENGLISH CHANNEL (SECTORS 1 - 3)

The largest and most productive demersal fisheries in UK waters occur in the North Sea in water shallower than 200 m and are for mixed roundfish species including cod, haddock and whiting and flatfish species dominated by plaice and sole. Although there is considerable overlap in the distributions of the demersal species, the main concentrations of cod and haddock are in the central and northern North Sea, whereas sole occurs predominantly south of the 50 m contour and its distribution is limited by winter temperatures remaining above about 4°C. Plaice is widely distributed throughout the North Sea in water shallower than 200 m. Mixed fisheries for plaice and sole occur in the shallower areas of the southern North Sea but plaice is targeted extensively in the deeper waters north of the Dogger Bank by beam trawlers which also catch lemon sole, turbot, brill and anglerfish as by-catch. Landings of demersal species peaked in the 1970s at around 1 million tonnes (Figure 3.3) and have declined steadily since then to reach historically low levels in 2002. There are heavy discards of a range of species including whiting and at times haddock in the mixed demersal fisheries and also extensive discarding of plaice in the beam trawl fisheries where sole is the main target species.

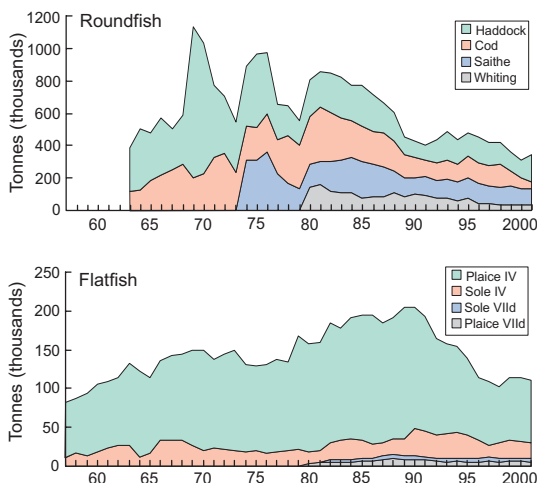


Figure 3.3. Landings of roundfish and flatfish from the North Sea and eastern Channel (VIIId). Species shown are: haddock, cod, saithe, whiting, plaice and sole

Despite their commercial importance, the demersal species targeted by bottom fisheries make up a relatively small part of the fish biomass in the North Sea. The main landings of commercial species are taken in the pelagic and industrial fisheries. In contrast to the decline in demersal species, the pelagic species, in particular herring, have shown substantial increases over the past 20 years. The landings of both herring and mackerel declined sharply in the 1970s (Figure 3.4) under high fishing pressure, leading to a four-year closure of the fishery for herring in the mid-1970s. Herring has since recovered following management measures that have reduced fishing pressure on the juveniles. The North Sea mackerel stock has not recovered and the fishery remains closed.

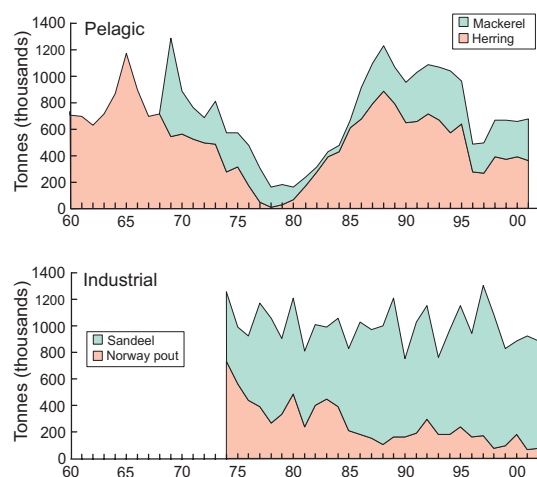


Figure 3.4. Landings of pelagic and industrial species from the North Sea. Species shown are: mackerel, herring, sandeel and Norway pout

The industrial fishery is carried out by vessels using small meshed nets fishing for sandeel and Norway pout in the northern and central North Sea. Landings have averaged close to 1 million tonnes over the past two decades (Figure 3.4). The sandeel fishery has a low by-catch of other demersal species but higher levels of by-catch occur in the Norway pout fishery.

The main shellfish fisheries in the North Sea are for *Nephrops* and pink shrimp (*Pandalus borealis*). Targeted *Nephrops* fisheries occur on muddy deposits in discrete areas of the North Sea. The

main fisheries are on inshore grounds along the coast of the UK (Moray Firth, Noup, Firth of Forth and Farn Deep) and on the offshore Fladen and Botney Gut grounds. The Fladen Ground is a particularly large area with a large estimated biomass. Vessels fishing for *Nephrops* use trawls with a smaller mesh size than is permitted for whitefish and this can result in discarding of undersize fish. The use of technical measures such as square meshed panels help to mitigate this. There is a targeted *Pandalus* fishery on the Fladen ground involving Danish and UK vessels fishing with small (35-40 mm) mesh cod-ends. Despite the small mesh used, there is a relatively low bycatch of other species in the fishery. There are valuable pot fisheries for edible crab and lobster on rocky coasts along much of the UK coast line of the North Sea as well as offshore fisheries for crab along the Yorkshire and Lincolnshire coasts. Scallops are important in the Moray Firth although stock size has declined recently following a number of poor recruitments.

3.2 IRISH SEA (SECTOR 6)

There are no industrial fisheries in the Irish Sea and landings of pelagic species have declined from an average of around 20,000 t in the 1970s to below 6,000 t for the past 20 years. The main demersal fisheries are for *Nephrops* with by-catches of whiting, cod, haddock and plaice. There are considerable discards of whiting and plaice. Figure 3.5 shows the trends in landings for the main finfish species. In the shallower western Irish Sea, there is a seasonal beam trawl fishery for sole in the spring with plaice as a by-catch. The decline in sole abundance since the mid-1980s has resulted in a reduction in fishing pressure from beam trawlers. Cod and whiting in the Irish Sea are both seriously depleted, although cod has shown a modest recovery since reaching the lowest stock size on record in 2001.

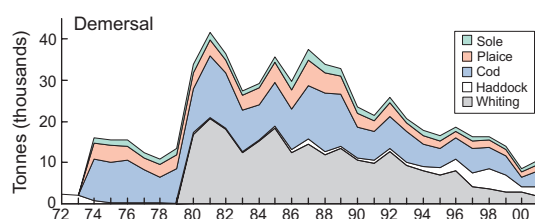


Figure 3.5. Landings of demersal species from the Irish Sea. Species shown are: sole, plaice, cod, haddock and whiting

In addition to the valuable *Nephrops* fishery in the NW Irish Sea, there are several other important shellfisheries in the area, including the fishery for scallop *Pecten maximus* off the Isle of Man. There are also important grounds for queen scallop *Aequipecten opercularis* in the central Irish Sea. Mussels *Mytilus edulis* are harvested in the Menai Strait and the rough grounds off the Welsh coasts are fished by pot for edible crab *Cancer pagurus* and lobster *Homarus gammarus*.

3.3 SOUTH WESTERN APPROACHES (SECTOR 4)

The south west approaches which includes the Celtic Sea, Bristol Channel and western Channel represent a bio-geographically intermediate area between typical Boreal fauna in the North Sea and the more southerly Mauritanian fish species. Although cod is an important commercial species in the western Channel and Bristol Channel, it is increasingly replaced by hake as the main target species in commercial catches especially in Atlantic waters off the French coast. Similarly with increasing water depth megrim and anglerfish become significantly more important compared with the typical plaice and sole mixed fisheries of the North Sea, Irish Sea and Bristol Channel. The major pelagic species remain the same, dominated by mackerel, horse mackerel and herring. Most fisheries in the Celtic Sea are mixed demersal fisheries targeting hake but catching variable amounts of cod, whiting, anglerfish, megrim, sole and plaice. In the Bristol Channel, there are seasonal fisheries for plaice and sole. Trends in the landings of the main demersal and pelagic species are shown in Figure 3.6 and 3.7.

There are some important grounds for *Nephrops* in parts of the Celtic Sea, although the fishing grounds in the western Channel and south-western approaches tend to be quite coarse, and the dominant shellfisheries are for scallop and, closer to shore, edible crab and lobster. Crawfish *Palinurus elephas* are subject to exploitation, and are a high-value species. Fisheries for velvet swimming crab *Necora puber*, spider crab *Maja squinado* and cuttlefish *Sepia officinalis* have increased in recent years, primarily for export to France and Spain.

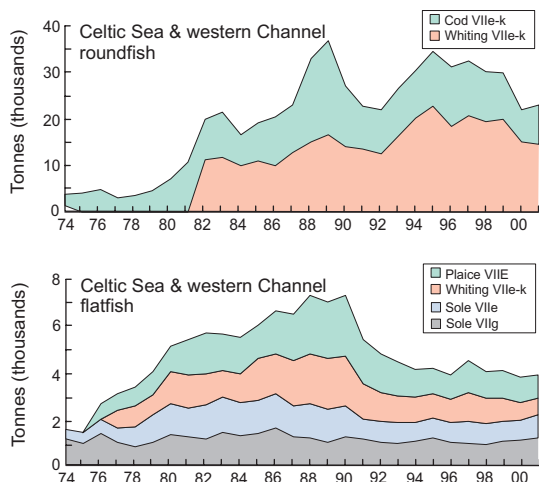


Figure 3.6. Landings of roundfish and flatfish from the Celtic Sea and western Channel. Species shown are: cod, whiting, plaice and sole

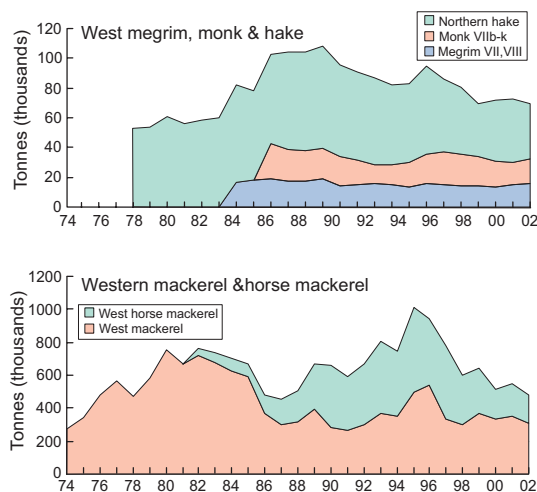


Figure 3.7. Landings of widely distributed stocks from the Celtic Sea and western Channel. Species shown are: northern hake, megrim, western mackerel and horse mackerel

3.4 WEST OF SCOTLAND AND ROCKALL (SECTOR 7 & 8)

The distribution of commercial fish species on inshore grounds along the west coast of Scotland is similar to the Scottish North Sea coast. The main demersal species are cod, haddock and whiting on harder sediment areas and *Nephrops* in areas with softer muddy deposits such as the Firth of

Clyde, South Minch and North Minch. The fisheries exploiting these species use otter trawls to catch cod, haddock, anglerfish and whiting, with by-catches of saithe, megrim and lemon sole. Vessels fishing for *Nephrops*, the most valuable species, use 70 mm and 80 mm mesh trawls resulting in large discards of whiting and haddock. Increasingly trawlers have been moving into deep water using large twin-rigged otter trawlers in order to target anglerfish. The fishery results in by-catches of megrim, ling and tusk and has led to a reduction in activity on the inshore grounds. Saithe is another species which is targeted in deep water along the shelf edge to the west and northwest of Scotland. This fishery has decreased in recent years although the stock itself has shown evidence of a strong increase in abundance. Haddock are also a target species for large vessels fishing around Rockall (ICES area VIb). The main pelagic fisheries are for herring, mackerel and horse mackerel. Juvenile herring occur in shallower areas of ICES area VI principally around the Minches and Island of Barra, while older fish are found near the shelf edge along with extensive mackerel and horse mackerel shoals. The industrial fishery for sandeel and Norway pout is substantially smaller than in the North Sea. Landings have fluctuated with wide variation for both species from a peak of about 50,000 t in 1987 down to 3500 t in 2001. Trends in the landings of the main demersal and industrial species are shown in Figure 3.4.

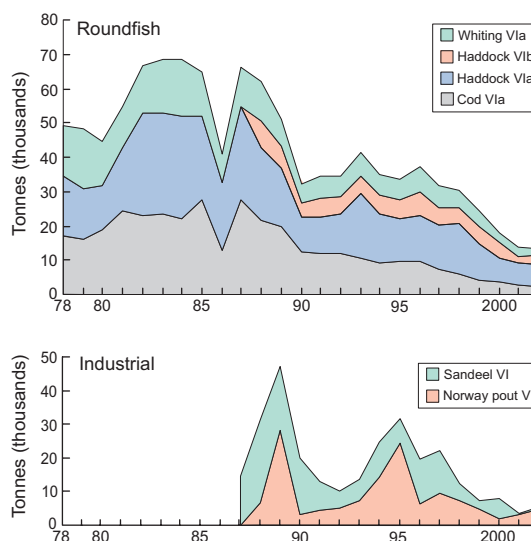


Figure 3.8. Landings of roundfish and industrial species from the west of Scotland. Species shown are: whiting, haddock, cod, sandeel and Norway pout

In addition to *Nephrops*, the west of Scotland supports a number of other valuable fisheries the most significant of which is for scallops. Edible crabs, velvet crabs and lobsters are also important throughout the region especially in the Western Isles.

3.5 DEEP-WATER FISHERIES

Deep-water fisheries occur along the western seaboard of the British Isles, off the shelf edge of both the Celtic Sea and off north-west Scotland (Regions 7 and 8). Hake, megrim, anglerfish are targeted along the shelf edge and are taken by a variety of gears (trawl, gillnet and long-line), with larger vessels operating in deeper waters. Scottish trawlers occasionally operate on deep-water fishing grounds, and French and Spanish liners, netters and trawlers also operate in these areas. The main species taken are ling (*Molva molva*), blue ling (*Molva dypterygia*), tusk (*Brosme brosme*), greater silver smelt (*Argentina silus*), orange roughy

(*Hoplostethus atlanticus*), grenadiers (Macrouridae), black scabbardfish (*Aphanopus carbo*), beryx (*Beryx* spp.), red seabream (*Pagellus bogaraveo*), greater forkbeard (*Phycis blennoides*) and deep-water squaliform sharks, including Portuguese dogfish (*Centroscymnus coelolepis*) and leafscale gulper shark (*Centrophorus squamosus*).

Biological data for many of these species are limited, and given that there have been spatial changes in fishing effort, increased catch efficiency in commercial fleets and that landings data may be aggregated for some taxa, assessments for most species have been problematic (ICES, 2004a). Some stocks (e.g. blue ling and tusk) are considered to be at low levels, with the status of most species uncertain, though likely at low levels. Orange roughy is considered to be 'heavily depleted' in ICES sub-area VI, and this species, which aggregate on seamounts, may require discrete management units. Current management measures for deep-water fisheries in EC waters include TACs and licensing systems.

4. Status of commercial fish stocks

Since 1999, ICES has provided advice on the status of commercially exploited fish stocks in terms of the precautionary approach. The basis of this advice is that in order to ensure sustainable fisheries, both the stock abundance and the fishing mortality on the stock should be set within safe biological limits. The limits are set to ensure that there is a high probability that:

- 1) the spawning stock biomass (SSB) is above a threshold where recruitment is not impaired. This limit is defined as B_{lim} , and
- 2) the fishing mortality (F) is below that which will drive the spawning stock to the biomass threshold which must be avoided. The F limit is defined as F_{lim} (ICES, 1999).

In order to provide a margin of safety, a set of precautionary reference points are defined. These should ensure that there is a high probability that the limit points will not be reached. The precautionary reference point for the spawning stock is B_{pa} and for the fishing mortality it is defined as F_{pa} . Stocks in which both the fishing mortality is unsustainable and the stock abundance is below the precautionary level are considered to be outside safe biological limits (SBL). If the stock abundance is in a healthy condition (above B_{pa} but the fishing intensity is too high (above F_{pa}), the stock is said to be harvested outside SBL. Since 2004, ICES has recognised that it needs to include ecosystem considerations into its advice. In terms of fisheries, this is a three-stage process. Initially, the status of individual stocks will be assessed separately and evaluated against the precautionary reference points identified above. On the basis of this, boundaries for exploitation can be set which are consistent with the Precautionary Approach. The second stage will involve consideration of mixed fisheries issues. For those stocks harvested in mixed fisheries such as cod, haddock and whiting in the North Sea, the stock in the most

critical state may determine the management advice applying to all three stocks. The final consideration will include ecosystem concerns which are not related to one specific stock, such as impacts on habitat or incidental by-catches of non-commercial species where such impacts are known to occur.

NEW TERMINOLOGY FOR FISHERIES ADVICE

ICES has redefined the terminology used to assess the status of stocks in terms of its reproductive potential. Stocks which were previously considered to be “outside safe biological limits” are now defined as “at risk of reduced reproductive capacity” or “suffering reduced reproductive capacity”. Stocks where the spawning stock is below B_{pa} but fishing is at an unsustainable level are defined as “harvested outside precautionary limits”.

LANGUAGE OF FISHERIES ADVICE

The framework used to phrase the advice in relation to the precautionary approach relies on the assessment of the status of the stock relative to precautionary reference points. When an assessment estimates that the spawning biomass is below B_{pa} ICES classifies the stock as being outside safe biological limits, regardless of the fishing mortality rate. When a stock is below B_{pa} ICES will provide advice to increase the spawning biomass above B_{pa} , which may involve reducing fishing mortality to levels below F_{pa} , possibly by a large amount. If B_{pa} cannot be achieved in the short term, ICES will recommend the development of a recovery plan specifying measures to increase SSB above B_{pa} in an appropriate time scale, depending on the biological characteristics of the stock and other relevant factors. When an assessment shows that the stock is above B_{pa} but that the fishing

mortality is above F_{pa} , the stock is classified as harvested outside safe biological limits. ICES will then recommend that the fishing mortality be reduced below F_{pa} in the short term.

However, referring to safe biological limits has in some cases mislead clients and other stakeholders to consider stocks described as being outside safe biological limits to be biologically threatened (i.e. close to extinction). The term outside safe biological limits is used in international agreements and has been used by ICES in the past to classify stocks for which the spawning biomass is below B_{pa} . While ICES considers this language to be perfectly justified and in accordance with international practices the attention of ICES has also been drawn to instances of confusion in the public debate where outside biological limits has been equated to biological extinction. ICES has therefore from 2004 used a phrasing which more specifically refers to the concept on which this classification is based by referring to the reproduction capacity of the stock in relation to spawning stock biomass, and sustainable harvest in relation to fishing mortality. It should be emphasised that the expressions outside safe biological limits and being at risk of reduced reproductive capacity or suffering reduced reproductive capacity are considered entirely equivalent by ICES and that the change in language does not imply any change in judgement of the seriousness of the situation when a stock is outside safe biological limits and thereby outside precautionary limits.

The present ICES classification scheme is equivalent to the terminology used before:

- Biomass:
 - stock with reproductive capacity is equivalent to inside safe biological limits ;
 - stock at risk of reduced reproductive capacity or suffering reduced reproductive capacity is equivalent to outside safe biological limits .
- Fishing mortality:
 - stock harvested sustainably is equivalent to harvested inside safe biological limits ;
 - stock harvested outside precautionary limits is equivalent to harvested outside safe biological limits (Figure 4.1).

The following terminology for the state of the stock is used in this report:
 For the status relative to SSB: Based on the most recent estimates of SSB, ICES classifies the stock as...

- If $SSB > B_{pa}$: having full reproduction capacity.
- If $B_{lim} < SSB < B_{pa}$: being at risk of reduced reproductive capacity.
- If $SSB < B_{lim}$: suffering reduced reproductive capacity. OR at a level where the stock dynamics is unknown and therefore risking reduced reproductive capacity. (in the case where B_{lim} is the lowest observed)

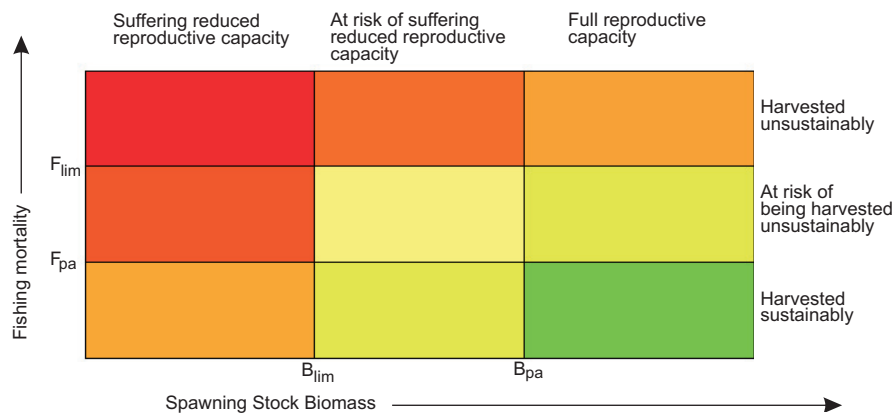


Figure 4.1. Reference points for the status of fish stocks
 (<http://www.ices.dk/committe/acfm/comwork/report/2004/oct/ICES%20Advice.pdf>)

The two last categories were earlier referred to as outside safe biological limits.

For the status relative to fishing mortality: Based on the most recent estimates of fishing mortality ICES classifies the stock to be...

If $F < F_{pa}$: harvested sustainably.

If $F_{lim} > F > F_{pa}$: at risk of being harvested unsustainably.

If $F > F_{lim}$: harvested unsustainably (Figure 4.1).

Also here the two last categories were earlier referred to as outside safe biological limits .

UNCERTAINTY IN THE ASSESSMENT OF THE STATE OF STOCKS

The true abundance of stocks cannot be estimated precisely because it is not possible to count fish directly. Most of the estimates of stock abundance and fishing mortality are derived from age based analytical assessments. These methods use standard statistical approaches to calibrate the catch rate of known commercial or research vessels with historical time series of fish abundance at different ages obtained from landings. It has become increasingly difficult to assure the quality of these data because of under-reporting, discarding at sea and mis-allocation to other areas. If there are biases or errors in the data this will lead to uncertainty in the estimates of spawning stock biomass and mortality. The Precautionary Approach acknowledges that there is uncertainty in the estimates of stock abundance and advice is based on maintaining the spawning biomass well above the level at which the stock could collapse, to allow for this uncertainty. Errors in stock size forecasts are given in ICES Working Group reports but are conditional on correct catch data.

Although ICES advice is largely determined by the status of stocks from single species assessments, increasingly ICES has recognised that advice should include both mixed fisheries issues and wider ecosystems information. Fishing is usually the single largest cause of mortality in commercial fish stocks once they have reached a size large enough to be caught. However, the environment and other forms of predator prey interaction also influence overall survival of the stocks. Juvenile fish can suffer high levels of predation and where these have been estimated,

for instance on cod, whiting and haddock in the North Sea, they are included in the assessments used by ICES.

Impacts of the environment on fish stocks have been considered by ICES and recently included in their review of advice (ICES 2003). ICES note that: "The environment is important in determining the survival of fish eggs and the survival and growth of fish larvae and juvenile fish. A multitude of environmental factors may be involved. For some fish stocks specific hydrographic conditions are known to be important and the composition and density of the plankton, which is the food source of fish larvae and juveniles, is known to be critical for growth and survival. The abundance of predators is also an important factor in juvenile survival. One of the best understood cases is the Baltic Sea where a linkage between the reproductive success of cod and hydrographic conditions has been demonstrated. In North Sea cod, a link has been shown between sea temperature and spawning success (O'Brien *et al.*, 2000) and at low stock levels, the probability of good recruitment even under favourable sea temperatures is reduced.

Fishing leads to a reduction in the spawning stock and to a higher proportion of young spawners in the spawning stock. The high fishing mortalities which have been prevalent for many fish stocks have resulted in reduced spawning stocks which are dominated by first-time spawners. High fishing mortalities have thus lead to low reproductive capacity independently of the environmental conditions. If climate change or other environmental changes have also played a role in the reduced productivity of fish stocks, it therefore becomes even more essential that exploitation rates on these stocks be reduced, to sustain the stocks under conditions of lower productivity (ICES, 2003).

REGIONAL OVERVIEW

In most regions, the level of fishing on demersal stocks remains too high and if maintained, will continue to lead to unsustainable fisheries in the long term. Over the past decade there has been a small improvement in status of some stocks. Of those assessed by ICES 38% are at full reproductive capacity and being harvested sustainably, compared with 21-27% between 1998-2000. Some species such as cod have shown a severe deterioration.

The regional assessments below are based on the advice provided by ICES in 2004 (ICES, 2004b).

4.1 NORTH SEA

“In the past 10 years, the state of the stock for most demersal roundfish and flatfish species in the North Sea has deteriorated”. (ICES ACFM 2004 [www.ices.dk/committe/acfm/comwork/report/2004/oct/alloct.pdf]). In most cases, spawning stock biomass (SSB) has declined over the past 10-20 years to historically low levels while the level of fishing pressure has remained high. One consequence of the high level of exploitation has been a reduction in the number of old fish in the stock. This has severely reduced the proportion of mature fish in the stock as well as making the fishery highly dependent on the success of recruitment of juveniles to the stock. In 2004, out of 8 demersal species assessed by ICES, 4 were considered to be harvested unsustainably or at risk of being harvested unsustainably.

Cod has been particularly severely affected largely as a result of high fishing mortality over a long period. In recent years recruitment has been among the poorest on record and despite some reduction in fishing pressure, the stock has remained at historically low levels and is suffering reduced reproductive capacity (Figure

4.2). Cod is subject to emergency management measures, including mesh regulations and effort controls, and will be under a recovery plan from 2004. Whiting has declined continuously over the time period but its status in 2003 is regarded as uncertain. Strong recruitment has increased the stock of haddock to full reproductive capacity but the fishing mortality remains unsustainable and the stock is expected to decline rapidly. Both plaice and sole stocks have shown steep decreases in abundance since the early 1990s and remain at about a quarter of their peak biomass in the 1960s. Both stocks are harvested outside precautionary limits. In the eastern English Channel sole stocks are considered to be harvested sustainably, but the plaice stock was considered to be at increased risk of suffering reduced reproductive capacity. The status of the herring stock in the North Sea is at full reproductive capacity. SSB has increased following some strong recruitment and is expected to reach over 2 million tonnes, the highest biomass since the 1960s. The North Sea mackerel stock has failed to recover since its collapse in the 1970s. The status of the sandeel stock is uncertain but with poor recruitment in 2002, the SSB is expected to decline and the fishery in 2003 was one of the poorest on record. Similarly, Norway pout has declined since 2002 and is now thought to be at risk of reduced reproductive capacity. The majority of the North Sea *Nephrops* stocks are harvested sustainably.

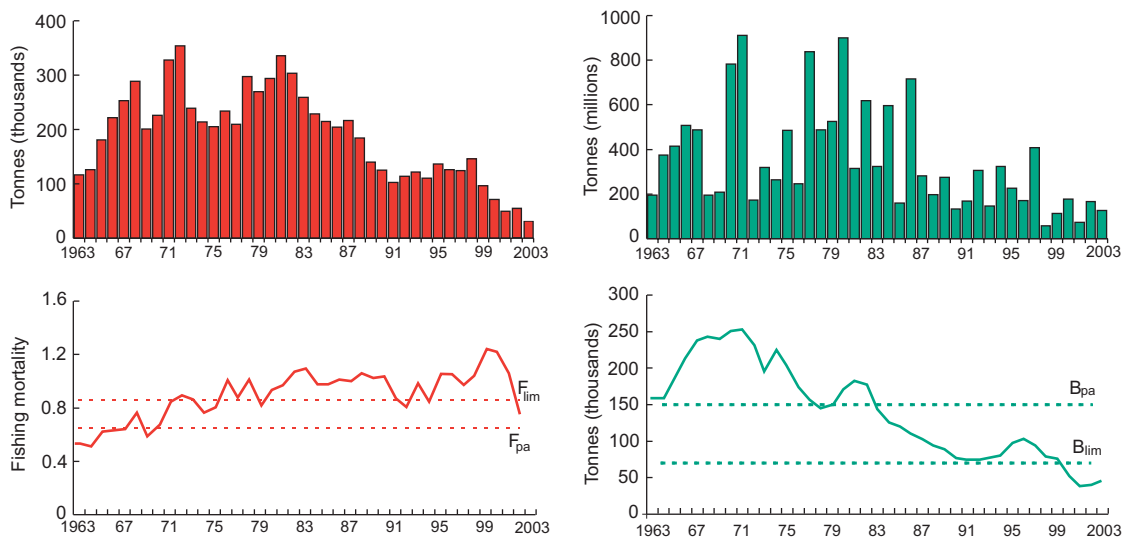


Figure 4.2. Status of North Sea cod in 2003. Left hand: Trends in landings and fishing mortality. Right hand: Trends in recruitment and Spawning Stock Biomass

4.2 IRISH SEA

In the last 10 years, the state of the Irish Sea cod and whiting has deteriorated. Recruitment to both stocks has been severely reduced and there is concern about stock collapse. Cod is under a recovery plan which includes a lower TAC, a closed area, effort regulation and other technical measures. The haddock fishery in the Irish Sea appears to follow occasional periods of strong recruitment and good fisheries were evident in the late 1950s, early 1970s and improvements have occurred again in the 1990s. The stock is currently relatively stable at about 2,500 t compared with a peak of 5,000 t in the period 1996-1999. Plaice stocks are harvested sustainably while sole stocks are harvested outside precautionary limits. Fishing pressure on both stocks has been reduced mainly as a result of a switch in activity away from the Irish Sea by large beam trawlers. The herring stock has increased in recent years from low levels in the early 1990s. *Nephrops* stocks are considered to be fully exploited but there is concern about the high level of whiting discards in the fishery. About 60% of whiting caught by the *Nephrops* otter trawlers are discarded.

4.3 SOUTHWEST APPROACHES

The majority of stocks which are assessed by ICES in this area are harvested outside precautionary limits. The northern hake stock remains at a low level and is at risk of reduced reproductive capacity. It is subject to a management recovery plan which came into force in 2004 because of the low stock size, high fishing pressure and poor recruitment. Celtic Sea cod is also considered to be at risk of reduced reproductive capacity and is under consideration for a recovery plan. Of the remaining demersal finfish stocks, only Celtic Sea whiting has an acceptable level of spawning biomass. In the southwest approaches stocks of anglerfish, megrim, sole and whiting were considered to be at full reproductive capacity. The western mackerel makes up around 85% of the North East Atlantic mackerel stock which extends from ICES division IXa in the south to IIa in the North. The spawning stock is thought to have declined in recent years and fishing mortality on the stock is unsustainable in the long run and needs to be reduced. The status of the horse mackerel stock is uncertain and

is expected to decline at all levels of fishing pressure. *Nephrops* stocks are all thought to be exploited at sustainable levels, although landings from stocks on the Porcupine Bank have declined significantly in recent years.

4.4 WEST OF SCOTLAND AND ROCKALL

A number of stocks are closely related to those in the North Sea and show similar trends including, haddock (VIa), saithe (VI), anglerfish (IIIa, IV & VI) and megrim (VI). Stocks of cod in VIa (west of Scotland) and haddock in VIb (Rockall) are thought to be at or close to historically low levels in 2000-2003 and below the precautionary reference limit point (B_{lim}). Cod stocks are subject to recovery plans (see Section 5.4). Haddock in VIa have shown a temporary recovery following the recruitment of a single strong year class. Whiting in VIa has declined steadily since 1981, and although the stock is uncertain in 2003, it is considered to be close to historically low levels. The northern hake stock is caught by most demersal fleets fishing in the west of Scotland. The status of this stock has already been described (see Section 3.4) and is at risk of reduced reproductive capacity and subject to a recovery programme. Anglerfish and megrim were previously taken as a by-catch in the mixed demersal fisheries in west of Scotland and were often heavily discarded. As fleets have moved offshore, these species have been increasingly targeted. Anglerfish are considered to be at risk of reduced reproductive capacity, and the state of megrim is uncertain. The status of the pelagic stocks (herring, mackerel and horse mackerel) are less certain mainly due to unreliability of the landings and effort data. Fishing pressure on the VIa north herring stock appears to be low and the stock has shown signs of increasing while both the Clyde and VIa south herring stocks are above the precautionary reference point, B_{pa} . The mackerel and horse mackerel exploited in the west of Scotland are part of the larger westerly stocks which have been described in Section 3.4. The status of the west of Scotland sandeel stock is uncertain but the fishery is closed after 31 July each year to protect the sandeels as a food source for breeding seabirds. *Nephrops* are exploited at sustainable levels and landings have remained stable since the mid-1980s.

5. Management initiatives

5.1 INTRODUCTION

Responsibility for the management of fisheries in the seas around the UK rests with a number of competent authorities. Within European member state waters management decisions affecting most of the major commercial stocks of fish and Nephrops are taken by the Council of Ministers operating within the framework of the recently reformed Common Fisheries Policy (CFP) http://europa.eu.int/comm/fisheries/reform/index_en.htm. Management of a number of the major stocks in the North Sea also fished by Norway (a non-EU member) is achieved through bilateral agreements. Individual states may also apply unilateral measures affecting their own vessels operating throughout EU waters. In international waters to the north and west of the UK, North East Atlantic Fisheries Commission (NEAFC) is the responsible management body and representation of EU member states in the process is undertaken by the European Commission within the framework of the CFP agreement.

Inshore areas (under 12 miles) are the responsibility of the UK and some aspects of fisheries management are further devolved to national administrations or local organisations.

The principal tool of fisheries management employed by the EU for a range of species over a number of years has been the Total Allowable Catch (TAC). Utilising a set of relative stability keys, this tool has provided a starting point for dividing up the available resource amongst member states. TACs have not, however, been successful in regulating fishing mortality rate on a number of stocks, and management increasingly includes more direct control of effort. The EU has also employed a suite of Technical Measures including fishing gear regulations and minimum landing sizes and has established 'boxes' in

various areas, within limit certain types of fishing activity are limited.

5.2 MORE RECENT EU MEASURES

The ever-increasing stringency of ICES advice regarding the poor state of a number of cod stocks throughout the 1990s eventually led to formal advice to reduce catches or fishing mortality on them to as near to zero as possible, or to implement stock recovery plans for them. This ultimately led to advice for zero catches of cod in the North Sea, to the west of Scotland and in the Irish Sea. Stringent advice has been propounded for other species too, and measures for the recovery of the northern hake stock were introduced in 2004.

5.3 EMERGENCY MEASURES

First in a series of stock recovery measures was put forward by the European Council for cod in the Irish Sea in 2000. As well as a reduced TAC, the Council proposed a temporary closed area in the Irish Sea to avoid fishing on spawning aggregations of cod, and for the adoption of technical measures to improve the selectivity of fishing gears and reduce the capture of young fish (http://europa.eu.int/comm/fisheries/pcp/faq1_en.htm). Commission Regulation 304/2000 of February 2000 (http://europa.eu.int/eur-lex/pri/en/oj/dat/2001/l_044/l_04420010215en00120014.pdf) addressed the closed area for protecting spawning fish in 2000, including certain derogations for non-cod fishing activities, and the enhanced control of fishing gears was enacted in November 2000 through Council Regulation 2549/2000 (http://europa.eu.int/eur-lex/pri/en/oj/dat/2000/l_292/l_29220001121en00050006.pdf). Subsequent Council Regulations have continued to maintain

the spawning closures with some modification to the conditions under which derogations apply.

For cod in the North Sea and to the west of Scotland, the Commission introduced emergency measures in the Spring of 2001, enacting temporarily closed areas to protect spawning fish (http://europa.eu.int/comm/fisheries/pcp/faq4_en.htm). This was followed in October 2001 by a Commission Regulation, 2056/2001 (http://europa.eu.int/eur-lex/pri/en/oj/dat/2001/l_277/l_27720011020en00130016.pdf), that introduced additional technical measures to enhance the selectivity of fishing gears in targeted cod fisheries and in those mixed demersal fisheries in which cod comprised an important part of the catch. These measures served to increase the minimum mesh size in codends from 100 mm to 120 mm in 2002, although in certain cases the change could be phased in by using a 110 mm minimum mesh size in 2002. In contrast to regulation in the Irish Sea, the seasonal spawning closures in the North Sea and to the west of Scotland were not replicated by European legislation in 2002 and 2003, although Scottish legislation was used to continue the seasonal closures within the Clyde sea area in those years.

In 2001 the Commission used its powers to enact emergency regulations for the northern stock of hake (http://europa.eu.int/comm/fisheries/pcp/faq4_en.htm) to run alongside reduced TACs. Commission Regulation 1162/2001 of June 2001 (http://europa.eu.int/eur-lex/pri/en/oj/dat/2001/l_159/l_15920010615en00040009.pdf) identified two areas off the western seaboard of Europe in which minimum mesh sizes were increased from 70/80 mm to 100 mm in targeted hake fisheries. The aim of this regulation was to reduce the catches of juvenile hake. These measures were continued through Commission Regulations 2602/2001 (December 2001, http://europa.eu.int/eur-lex/pri/en/oj/dat/2001/l_345/l_34520011229en00490051.pdf) and 494/2002 (March 2002, http://europa.eu.int/eur-lex/pri/en/oj/dat/2002/l_077/l_07720020320en00080010.pdf).

5.4 RECOVERY PLANS

Although the above measures provide increasingly stringent regulations to protect cod in a number of areas and a series of measures to promote the conservation of northern hake throughout its widespread distribution, they do

not comprise formal stock recovery plans for the species concerned. Unfortunately, the European Commission has been unable successfully to steer a formal cod recovery plan through the Fisheries Council. The European Commission had proposed recovery plans for both cod and hake to the Fisheries Councils of 2001 (COM (2001) 724 Final) and 2002 (COM (2002) 773 Final). Further development of the proposals continued in 2003, and a separate proposal was drawn up for each species. These are currently maintained as proposed legislation for cod (COM (2003) 237 Final, http://europa.eu.int/eur-lex/en/com/pdf/2003/com2003_0237en01.pdf) and hake (COM (2003) 374 Final, http://europa.eu.int/eur-lex/en/com/pdf/2003/com2003_0374en01.pdf).

Both sets of plans encompass similar features. Recovery Plans aim to ensure the safe recovery of stocks to their precautionary levels within a period of five to ten years. It is their intent to establish rules for the setting of TACs that are prescribed according to a desired annual increment in stock size that depends: (i) upon the state of the stock with reference to precautionary limits, and (ii) upon a maximum inter-annual change in TAC. In addition, fishing effort will be directly regulated by the allocation of kilowatt-days effort to national fleets in each fishery. Improved monitoring, enforcement and control of fishing will be required to ensure effort is not exceeded. For hake, the requirements of the recovery plan will encompass its entire distribution except for the direct control of effort that will be restricted to those areas in which the bulk of the stock resides. For cod, the measures will apply to stocks in the North Sea, to the west of Scotland, the Irish Sea and the eastern Channel. Several recovery plan proposals for other species and stocks are waiting to be discussed, or are likely, including sole in the western Channel and the Bay of Biscay, southern hake and possibly western cod.

5.5 EFFORT LIMITATION – DAYS AT SEA

By the time of the 2002 Fisheries Council, the Commission brought forward additional proposals that sought to limit directly the activity of fishing vessels by regulating the number of fishing days at sea that were permitted for individual vessels. This was done in an attempt to reduce fishing effort in a manner commensurate with the reduction in fishing mortality implied

by the Commission's TAC proposals for 2003. The days at sea regulations were presented in Annex XVII of that year's TACs and quotas regulation, Council Regulation 2341/2002 (http://europa.eu.int/eur-lex/pri/en/oj/dat/2002/l_356/l_35620021231en00120120.pdf). The permissible number of days at sea varied according to broad categorisations of fisheries and fishing gears. For towed demersal gears in North Sea and west of Scotland fisheries targeting cod or in which cod comprised a significant catch in a mixed demersal round fish fishery, the basic allowance of days was nine, with additional days permitted to compensate for steaming time between fishing grounds and the effects of national fishing vessel decommissioning schemes. Implementation of Annex XVII proved difficult, and it was amended in April 2003 to clarify its provisions and to add the degree of flexibility that was considered necessary to make the legislation workable. Days at sea regulations were continued for the North Sea and waters to the west of Scotland in 2004 as listed under Annex V of the 2004 TACs and quotas regulation, Council Regulation 2287/2003 (http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_344/l_34420031231en00010119.pdf). This regulation also marked for the first time the introduction of direct effort limitation through the days at sea legislation, for vessels fishing within the Irish Sea. For waters to the west of Scotland, this regulation also marked the return of a seasonal closed area off the northwest coast of Scotland to protect spawning cod, but without any corresponding area closures within the North Sea.

5.6 COD PROTECTION AREA AND TARGETING OTHER SPECIES

The ICES advice in 2003 provided avenues for the fishing of stocks of species at less risk than cod. This included the suggestion that gear, spatial or temporal means might be found to minimise the bycatch of cod while allowing fishing for other target species. The Council involved considerable discussion and negotiation on this subject and one outcome was the definition of a cod protection area where relatively small quantities of other species could be taken and provision for increased access to other species, such as haddock, in areas outside the cod zone http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_344/l_34420031231en00010119.pdf.

pdf. Fine tuning of the details of this proposal continued for several months after the agreement and implementation of the principles.

5.7 MEASURES PROMOTED BY UK

5.7.1 DECOMMISSIONING

Alongside the EU's management measures, the UK has been active in implementing unilateral measures to conserve whitefish stocks. A significant amount of decommissioning of the UK fleet has taken place over the last two to three years, particularly in Scotland. The net effect of this in terms of mortality reductions has yet to be evaluated, although ICES did not discount the possibility that this process had contributed to some of the observed reductions in mortality observed for cod and haddock.

5.7.2 TECHNICAL MEASURES SUCH AS SQUARE MESH PANELS

Research in Scotland pointed to the potential benefits for the release of undersized fish in the fitting of square meshed panels just in front of the codend of trawl nets. The UK has legislated for the use of square meshed panels (for example in *Nephrops* nets <http://www.scotland-legislation.hms.gov.uk/legislation/scotland/ssi2000/20000227.htm>) and is actively pursuing research into other means of separating unwanted or at risk species from target species.

5.7.3 INSHORE MEASURES

Within the UK's inshore areas a wide range of measures are in place to manage stocks of fish and especially shellfish. In Scotland this is largely achieved at present through the Inshore Fishing (Scotland) Act and the development of Regulating Orders offering local management opportunities. The Inshore Act mainly works through a schedule of closed areas and through specific restrictions on the use of certain gears at certain times and places. There is currently a review of inshore management taking place (<http://www.scotland.gov.uk/consultations/fisheries/srif-00.asp>).

In England and Wales, a large part of inshore management is handled through Sea Fisheries Committees who use byelaws to operate a series of technical and access arrangements.

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6. Fisheries impacts

6.1. IMPACT OF FISHING

Consistent with UK commitments to the ecosystem approach, the environmental impacts of fisheries are a growing focus of monitoring, management and research. The environmental impacts of fisheries include those on the abundance, size and genetic diversity of target species, on non-target animals such as marine mammals, fish and benthic fauna that are also caught during fishing operations, on seabed habitats, on genetic, species and population diversity and on the food web (Gislason and Sinclair, 2000; Jennings and Kaiser, 1998; Kaiser and de Groot, 2000; Sinclair *et al.*, 2002).

6.1.1 TARGET SPECIES

Target species are actively pursued by fishermen, and catch rates and landings are controlled by managers (Section 6). Since fishermen use fishing gears to target the larger and more valuable individuals, the fastest growing fishes tend to be caught first and thus fishing can also have selective genetic effects on target populations. Thus fishing can select for slower growth and earlier maturity (Law, 2000). There is growing evidence that plaice and cod stocks have been affected in this way, and other species are also thought to be affected (Heino and Godo, 2002). Fishing also has genetic effects because fish in a managed stock may not breed randomly and the stock may actually be composed of genetically distinct sub-populations (Carvahlo and Hauser, 1994; Hutchinson *et al.*, 2003). Overfishing of individual sub-populations can thus reduce the genetic diversity of the stock (Kenchington *et al.*, 2003). Given UK commitments to minimising effects on genetic structure of fish stocks, the UK is working through ICES to develop ways of managing fishing impacts on genetic diversity.

6.1.2 BYCATCHES

Fisheries take by-catches of non-target species, such as marine mammals, fish, seabirds and benthic animals and can affect the viability of their populations. Some fish bycatches are retained to be sold, but much more bycatch is discarded at sea. Reduced rates of bycatch and discarding generally have desirable impacts on the ecosystem, although seabird populations in areas such as the North Sea are increasingly reliant on discards as a food supply (Camphuysen *et al.*, 1993).

Fish populations vary in their response to bycatch mortality. Small, fast growing short-lived, productive species such as dabs and gurnard are largely unaffected, while long lived slow growing and unproductive species such as spurdog, common skate and thornback ray have been reduced to a fraction of their former abundance (Brander, 1981; Jennings *et al.*, 1999; Walker and Hislop, 1998). Many larger target and bycatch species in the North and Irish Seas are now reduced to less than 10% of their expected abundance without fishing, and mean weight of fish has declined (Figure 6.1). The loss of species such as common skate and angel shark has led to reduced biodiversity in the North Sea, English Channel and Irish Sea (Brander, 1981; Rogers and Ellis, 2000). One recent estimate suggests that the biomass of all North Sea fishes weighing 4-16 kg and 16-66 kg respectively is 97.4% and 99.2% lower today than if there were no fishing (CEFAS, unpublished).

Monitoring programmes to determine the quantity and composition of discarded catches are now in place in many of the UK fisheries, and major discarding problems have been revealed in a few fisheries. Since the EC Data Collection

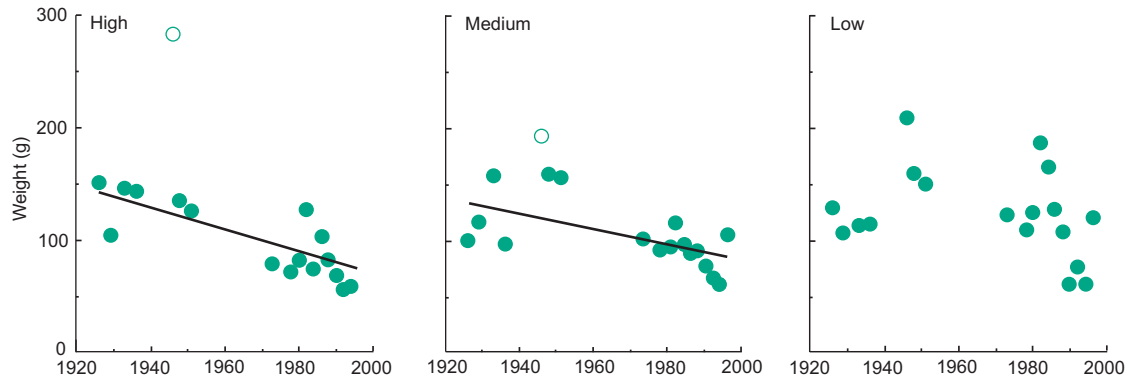


Figure 6.1. Trends in the mean weight of North Sea bottom dwelling (demersal) fish in areas subject to high, medium and low levels of otter trawl effort, as estimated from catches on the FRS funded Scottish August Groundfish Survey. Lines indicate a general decline in the mean weight of fish in areas subject to high and medium levels of fishing effort.. Unfilled circles are statistically significant outliers

Regulation (EC 1639/2001), England and Wales have used observers on most important types of fishing vessels to prepare annual estimates of discarding by weight and length for the main commercial species. Scotland has been monitoring discards since the 1970s and their programme has not been greatly altered by the EC regulations. Northern Ireland have conducted extensive short-term discard studies through EU funded research projects along with a fisher 'self sampling' scheme which has been running since the early 1980s. A discard programme supported by the EC Data Collection Regulation (EC1639/2001) similar to that running in England and Wales is about to commence. These data are important because they indicate the total catch, in contrast to landings, which omit information about quantities discarded. Discard data have uses in the assessment process and the management of regional fisheries (Cotter, 2003).

Controls to limit fishing activity on target stocks are expected to lead to reductions in the rates of bycatch mortality, and some bycatch species may start to recover if fishing rates on target stocks can be kept within sustainable limits.

6.1.3 MARINE MAMMALS

It is appropriate under this section on fishing impacts to refer to the effects of fishing on marine mammals, however, a full discussion of the effects on population dynamics of marine

mammals is available in the sectoral report on habitats and species.

Marine mammals are caught accidentally during fishing operations and bycatches of common dolphins in the pelagic bass pair trawl fishery and harbour porpoises in the North Sea gill and tangle net fisheries were identified as a concern, since mortality rates were thought to exceed the ASCOBANS-IWC limit of 1.7% of the population per year. For harbour porpoises, this limit was adopted as an EcoQO at the 5th North Sea Conference and the EcoQO is being piloted by the UK.

In 2001, 53 common dolphins were recorded from 116 observed tows in the English Channel and in 2002 eight common dolphins were recorded in 66 observed tows. Bycatches were very variable and no clear patterns identified. Defra are continuing to fund work on the development of a dolphin exclusion grid to stop dolphins being caught in this fishery. Trials were completed in 2002 and 2003.

In the mid 1990s bycatch rates of harbour porpoises in the central North Sea gill and tangle net fisheries were thought to exceed 1.7% of the population size. Recent reductions in fishing effort in these fisheries have reduced bycatch rates and, as part of the EcoQO pilot, work is in progress to assess whether bycatches are within the limit (see sectoral report Marine Habitats and Species).

The UK Small Cetaceans Bycatch Response Strategy works towards the reduction of bycatch – mainly of dolphins and porpoises – to the lowest possible level. An EU Council Regulation was agreed in April 2004 to reduce the incidental bycatch of cetaceans.

6.1.4 SEABED AND HABITATS

Towed bottom fishing gears such as beam trawls and scallop dredges directly impact seabed habitat. This leads to loss of sensitive habitat and fragile species, modification of habitat, the disturbance of sediments and the potential release of nutrients (Kaiser *et al.*, 2002). The gears can also leave a trail of dead and dying carrion on

the seafloor that is eaten by scavenging species (Ramsay *et al.*, 1997, 1998).

Fishing with towed gears takes place in all sea areas, but when viewed on a local scale the distribution of fishing effort is remarkably patchy. For example, in the case of the North Sea beam trawl fishery, much of the North Sea is fished less than once in 7 years while smaller areas may be fished repeatedly, up to 10 times each year or more (Rijnsdorp *et al.*, 1998) (Figure 6.2). The effects of beam trawling on the seabed would be much greater if trawling effort were more evenly distributed (Dinmore *et al.*, 2003). Of course, the areas not impacted by the beam trawl fishery may be fished in other ways, but even when the

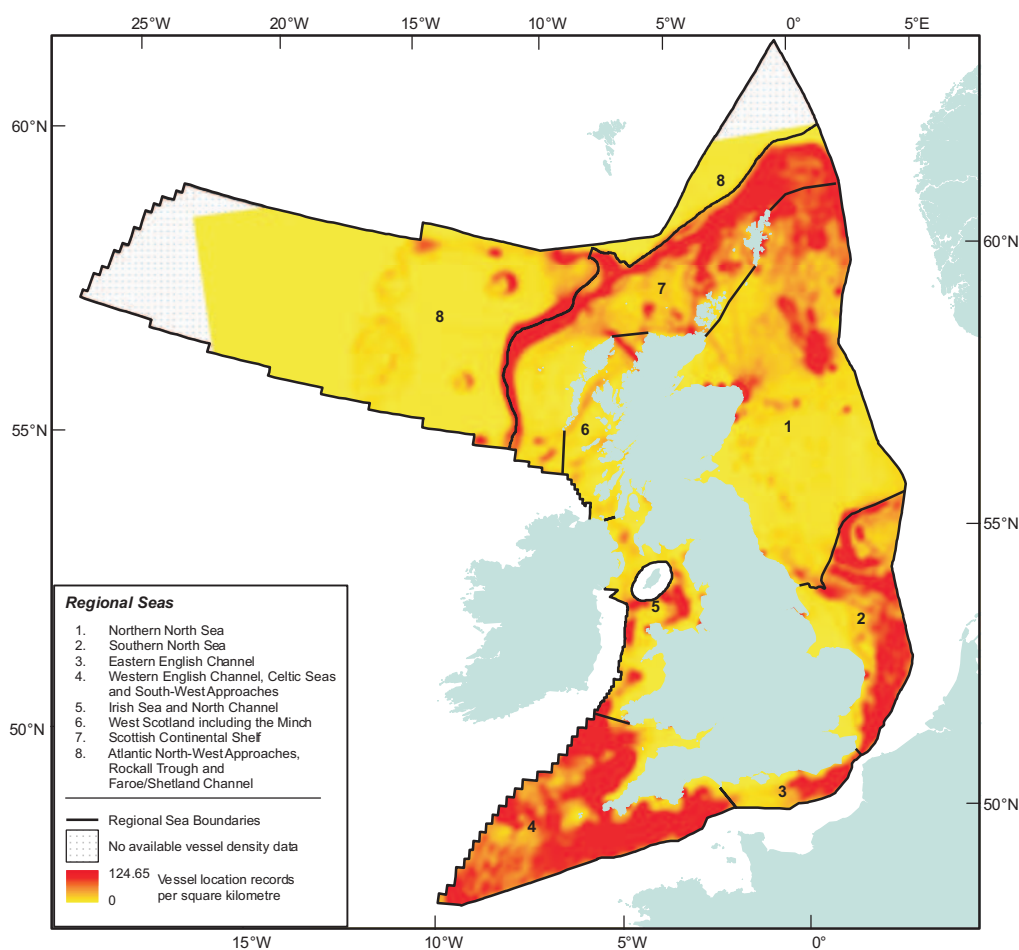


Figure 6.2. Observed density of all European fishing vessels >24m length in 2002 using Vessel Monitoring System satellite data. No speed filter has been applied so data reflects both fishing activity and steaming

aggregate effort of all North Sea bottom trawl fisheries is considered, much of the North Sea is only impacted infrequently by bottom trawl gears (Callaway *et al.*, 2002). Infrequent impacts can, however, be ecologically significant since the first impact of trawling on a previously untrawled area has the greatest effect on production and biomass of the benthic community and some infrequently impacted areas may have slow recovery times and thus be particularly vulnerable to impacts. Bottom trawling disturbance reduces the production and diversity of larger bottom dwelling invertebrates, but has a smaller effect on many of the smaller bottom dwelling animals that provide food for flatfish (Jennings *et al.*, 2002b). Scavenging animals also benefit from the carrion left on the seabed after gears have disturbed the seabed.

The initial effects of bottom fishing in previously unfished areas have greater impacts on benthic habitats and species than repeated fishing in fished areas. In unfished areas with low levels of natural disturbance, such as wave or tidal action, benthic communities are often dominated by large slow-growing and habitat forming species that are more vulnerable to fishing disturbance than the smaller fast-growing species that dominate biomass in fished areas (Kaiser and Spencer, 1996). For benthic animals, the densities of sensitive (e.g. fragile) species and opportunistic species have been proposed as EcoQ elements (Bergen Declaration Issue 6). These indicators are now being assessed by ICES.

Burrowing seabed animals play an important role in controlling sediment structure and biochemical processes. Trawling disturbance rapidly depletes populations of the most active bioturbators, and thus the mechanical effects of trawling may replace animals as bioturbators (Duplisea *et al.*, 2001). Trawling also suspends seabed sediments. The effects of these changes are not well understood, and Defra are now funding research to assess them.

Cold-water coral reefs are slow growing fragile habitats that are easily damaged by towed fishing gears (Hall-Spencer *et al.*, 2002). In response to this threat, the Darwin Mounds coral reef off northwest Scotland was protected by an EC Emergency Regulation in 2003, and a Council Regulation providing permanent protection was agreed in March 2004. An area of 1300 km²

was closed to towed gears. This site will now be designated as an SAC. Such closures are the only effective way to protect the most sensitive habitats from bottom fishing impacts.

Additional monitoring of invertebrate species on fisheries stock assessment surveys has provided a good picture of the distribution and diversity of animals that can be impacted by towed fishing gears (Callaway *et al.*, 2002; Ellis *et al.*, 2000). Broad patterns in benthic community structure around the British Isles are strongly influenced by the biogeography of the area, which is at the boundary between two contrasting faunal types. The water depth and substrate type also influences species diversity and structural complexity of seabed habitats. These factors are responsible for a natural decreasing trend in species richness and taxonomic range between the southern North Sea and the northern and western waters of the British Isles (Rogers *et al.*, 1999).

Commercial exploitation of fish not only affects the abundance and size structure of some populations, but has been associated with changes in species diversity, and other aspects of assemblage structure. Unfortunately the direction of change in these measures has not been consistent or predictable, and it is not yet possible to predict how fishing disturbance affects species richness or species diversity (Greenstreet and Hall, 1996). An EU/Defra research programme (MAFCONS) is currently aimed at quantifying the consequences to benthic species diversity of achieving particular fisheries management objectives.

In stable habitats, fragile emergent species such as corals, sponges and bryozoans increase the structural complexity of the habitat and can provide important refuges and feeding sites for fish. After impact by fishing gears, the recovery rate of these habitats can have important consequences of fish species at various life-history stages. The detailed mapping of benthic habitats is an important stage in the identification and protection of some fish species (Kaiser *et al.*, 2002).

6.1.5 FOOD WEB

Fisheries can modify the marine food web, by removing both predator and prey species.

Since larger species and individuals are more vulnerable to fishing, many of the top fish predators have been lost from UK seas (Greenstreet and Rogers, 2000; Greenstreet *et al.*, 1999a). The combined effects of predator depletion and the capture of large fishes have led to reduction in the mean height of the food web in the North and Celtic Seas and a proliferation of smaller fishes (Jennings *et al.*, 2002a; Pinnegar *et al.*, 2002). A community dominated by smaller fish has a faster turnover time, and this will lead to greater fluctuations in the abundance of fishes as the environment changes. These fishing effects take place against a background of climate change; recent warming of the North Sea has led to a change in the composition of the fish community.

Fishing for small but important 'forage' species, such as sandeels, can disrupt the local food supply for predatory fishes and seabirds. In an attempt to mitigate against this, fishing for sandeels has been restricted in the vicinity of seabird colonies. Along the north-east coast of Britain a 20 000 km² 'sandeel box' is now closed to sandeel fishing to protect seabird food supply. FRS has been monitoring the effects of this sandeel closure on seabird and gadoid fish predators in the vicinity of the Wee Bankie, Marr Bank and Berwick's Bank, off the Firth of Forth, over the period 1997 to 2003. Results of this study will be published shortly. Defra are also currently funding research on the effects of sandeel fishing on the fish predators, such as cod, that may rely on them in some areas.

The effects of fishing on biomass and production are well understood conceptually, even though the practical demonstration of effect is not always easy to demonstrate (Jennings *et al.*, 2002). There are no current estimates of the total fish production per unit area for UK shelf seas, or of the trend in production as a result of fishing effects. However, it is estimated that, for the southern North Sea, the international beam trawl fleet has reduced benthic production by 15% compared to an unfished situation (Hiddink, pers. comm.). The continental shelf waters around the UK are productive, and estimates of net primary production from phytoplankton are equivalent to published estimates for land plants (Longhurst *et al.*, 1995). Although causes of the recent increase in chlorophyll are unclear, it is thought that natural atmospheric and hydrographic variability is the major contributor to ecosystem change.

6.1.5 GENETIC DIVERSITY

There are three general classes of threat to genetic diversity; 1) extinction (population or species) which results in the complete and irreversible loss of genes, 2) hybridisation, which causes loss of adaptability to local conditions, and 3) reduction in genetic variability within populations, from selective fishing or inbreeding.

Normally, marine fish have very large population sizes and fisheries become non-viable long before there is serious risk of biological extinction. Apart from cases of severe overfishing, the predominant potential for loss of genetic diversity is through loss of genetic variation in populations from gear selection. Fishing mortality could be incidental or directed, and fisheries can also have genetic effects on non-target species.

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7. Long-term changes in the abundance and demography of fish

7.1 INTRODUCTION

There are many factors that can cause changes in the abundance and distribution of fishes, including natural variation, biological interactions and anthropogenic activities. Anthropogenic activities that are known to affect the structure and diversity of fish communities include fishing, changing habitat quality (e.g. pollution, eutrophication and habitat destruction) and the introduction of non-native species (e.g. Hobday *et al.* 1999). Determining the relative impacts of these various factors is, however, difficult and whereas many studies have demonstrated a correlation between environmental variables and biological indices, there are few cases that prove causal relationships (de Vooy and van der Meer, 1998). The use of long-term data sets to monitor changes, natural variation and cycles in marine ecosystems has attracted increased attention since the 1980's (Southward, 1983, 1995; Southward *et al.*, 1995), with several long-term studies of fisheries data undertaken in recent years. Such data are useful for determining the effects of anthropogenic activities (e.g. fishing) and/or environmental characteristics (e.g. climate change) on fish demography.

There have been several studies examining 'long-term' changes in the offshore fishes of European waters, and these studies have covered the North Sea (Greenstreet and Hall, 1996; Heessen, 1996; Heessen and Dann, 1996; Rijnsdorp *et al.*, 1996; Rogers and Ellis 2000), English Channel and Irish Sea (Rogers and Millner 1996; Rogers and Ellis, 2000) and Bay of Biscay and Iberian waters (Quero and Cendrero, 1996; Fariña *et al.*, 1997). Such studies have invariably used fishery-independent trawl surveys, although some studies have also

included supporting information from market surveys (e.g. Quero and Cendrero, 1996). Most studies on long-term change have examined annual data collected since the 1970s (e.g. Heessen, 1996; Rogers and Millner, 1996), although there are a few studies that have compared historical and contemporary data sets (e.g. Rijnsdorp *et al.*, 1996; Rogers and Ellis, 2000).

In general, studies on the long-term changes of fish populations have provided evidence of a gradual decline in large-bodied species that mature late in life, such as skates and sharks, and increases in some small-bodied, non-target teleost species. Despite increasing international concern over the effects of fishing (OSPAR Commission, 2000a, b) there is little evidence that links all these changes exclusively to the effects of bottom trawling, and there are several reasons for this. Firstly, concurrent time-series of fishing effort trends and samples of the fish community (e.g. Greenstreet *et al.*, 1999b) are rare, and this restricts our ability to correlate fluctuations in these variables over a long time period. Secondly there have been changes in the natural environment over the same period, which have confounded any simple interpretation of the data.

7.2 IMPACTS OF FISHING AND CLIMATE

Continental shelf ecosystems of NW Europe are some of the most disturbed habitats within European waters and have been subject to exploitation from demersal fishing since the advent of sail trawling during the late 18th Century. The subsequent development of steam trawling, motor trawling, the development of large-scale beam trawl and dredge fisheries, and continuous

increases in fishing efficiency has increased pressure on demersal ecosystems during the 20th Century (Rijnsdorp *et al.*, 1996; Jennings and Kaiser, 1998; Rogers and Ellis, 2000). As a response to increases in fishing effort, major changes have taken place in the structure and composition of demersal fish assemblages (e.g. Greenstreet and Hall, 1996; Jennings and Kaiser, 1998). The most reliable evidence comes from recent re-surveys of sites for which historical data sets are available, and our understanding of the response of different life-history characteristics to increased and sustained fishing mortality. Such studies have often shown the loss or decline of long-lived, slow-growing and late-maturing fishes (i.e. *k*-strategists), which include various sharks and skates (e.g. Quero and Cendrero, 1996; Walker and Heessen, 1996). These life-history characteristics make these species more vulnerable to over-exploitation and the declines in these species, which are widely reported in the scientific literature, are due primarily to the effects of commercial fishing activity. Within UK waters, there have been either significant declines in the distribution and abundance or local extirpation of common skate *Dipturus batis*, white skate *Rostroraja alba* and angel shark *Squatina squatina* (Brander, 1981; Dulvy *et al.*, 2000; Rogers and Ellis, 2000).

Changes in marine communities also occur naturally, and may be driven by variable and changing environmental conditions. For example, stocks of marine fish and shellfish, their reproductive success and recruitment are known to fluctuate in response to environmental conditions (Attrill and Power, 2002). Indeed, there is much evidence that natural climatic and hydrographic factors may cause dramatic changes in the abundance and distribution of pelagic fishes (Southward, 1980; Cushing, 1982; Southward *et al.*, 1988). There are, however, fewer studies examining the effects of such underlying variability on demersal fish assemblages.

Many natural and anthropogenic factors will affect the distribution and abundance of fishes. The majority of teleost fishes are broadcast spawners, which have a high fecundity (e.g. cod), although some taxa have a lower fecundity and either lay eggs on the sea floor (e.g. wolf-fish) or brood the eggs (e.g. seahorses). Hence, the successful survivorship of the eggs and larvae of the dominant fish species can be highly variable and dependent on environmental conditions. Given the potential variation in recruitment, explaining long-term trends

in the relative abundance of fish is problematic. Elasmobranch fishes tend to have a low fecundity and it is generally assumed that there is a closer relationship between recruitment and the size of the mature female stock in these taxa.

7.3 LANDINGS DATA

Defra collate national landings statistics, and these data are submitted to ICES, who collate international landings for European seas. These data cover an extensive period (early 1900s onwards), and large geographical area. Nevertheless, their utility for describing trends in abundance is limited. The data refer to fishes landed, not captured (i.e. there are fewer data for discards), tend to focus on commercial species, with species of lesser commercial importance (e.g. gurnards) aggregated in species groups, while non-commercial species are not recorded. Additionally landings data, which do not directly consider effort and management measures, will be influenced by changes in fisher behaviour. Despite the limitations, landings data provide valuable data for assessing the status of species and stocks. Examples of landings are given in Figures 7.1 and 7.2.

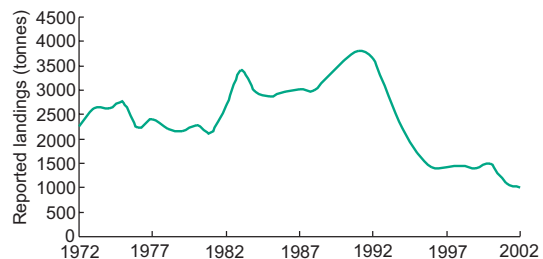


Figure 7.1. Landings of wolf-fish in the North Sea and Skagerrak (1972–2002)

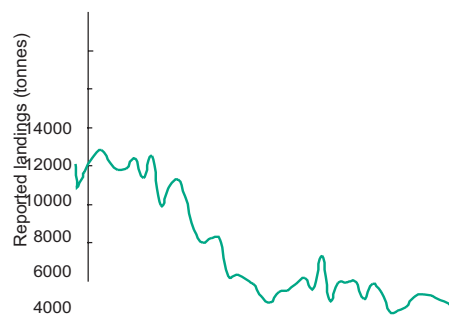


Figure 7.2. Landings of skates and rays (Rajidae) in the North Sea and Skagerrak (1952–2002)

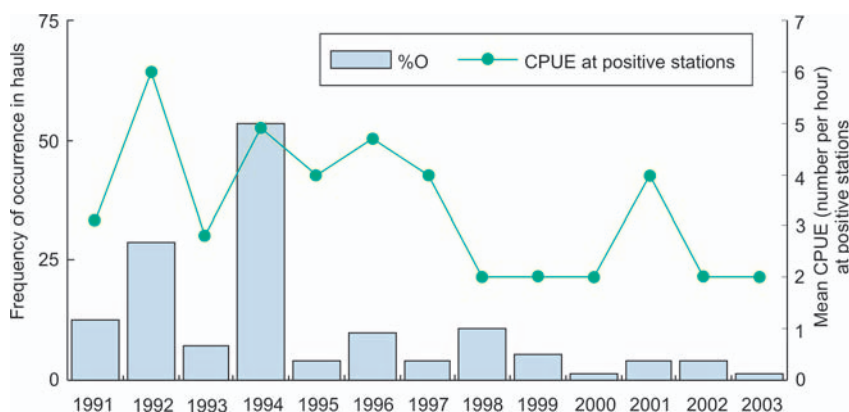


Figure 7.3: Change in the frequency of occurrence and the relative abundance of spurdog *Squalus acanthias* in the North Sea (1991-2003)

7.4 SURVEY DATA

Fishery-independent survey data are the best way of assessing trends in the relative abundance of marine fishes, although most contemporary surveys are less than 20 years old, and the survey gear and grid may not be optimal for all species of fish. Nevertheless, long-term groundfish surveys undertaken by CEFAS, FRS and DARDNI provide valuable information on temporal trends in the distribution and relative abundance of many demersal and pelagic fish species.

Although long-term data sets are available for the North Sea, comparable long-term data sets are rarely available for other areas. It should also be noted that even where historical data are available, such data were generally collected after the expansion of commercial fishing activities at the end of the 19th century. Hence, most studies on long-term change have either focused on examining gross changes between historical and contemporary surveys (e.g. Rogers and Ellis, 1999) or trends in relative abundance from long-term data sets collected from standardised surveys.

Trends in abundance of fishes from surveys generally show much variation, and the majority of species do not show clear increases or decreases in abundance. The variation in catch data is due in part to the natural variation in abundance and, for those species that aggregate, catches can be highly variable. Whereas most species show no

clear pattern, some species show a consistent decline in abundance. Spurdog *Squalus acanthias* are known to have declined (Hammond and Ellis, 2002), and this is pronounced in survey data (Figure 7.3).

Whereas the decline in long-lived, slow-growing *k*-strategists is well documented, and most likely related to the impacts of overfishing, increases or decreases in the abundance of *r*-strategists are more difficult to explain, as natural variability, anthropogenic activity and biological interactions (e.g. predator-prey relationships, and competition) are all likely to exert some degree of influence. Blue whiting *Micromesistius poutassou*, for example, have shown a general increase in abundance in the North Sea in recent years (Figure 7.4), although the reasons for this are unclear.

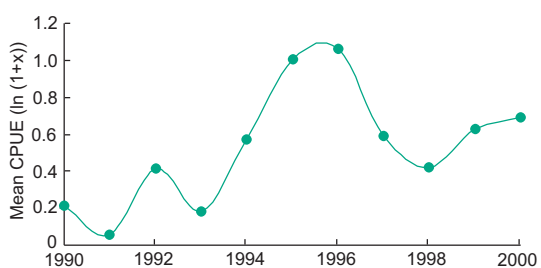


Figure 7.4. Change in the relative abundance of blue whiting *Micromesistius poutassou* in the North Sea (1990-2000, 56 stations fished each year)

8. Threatened and declining fish species

In contrast to the major commercial fish species, for which data are generally sufficient to allow for a rigorous stock assessment, data for non-target and rarer fish species are usually insufficient to allow comparable assessments and other processes are required.

Most fish species that have become regionally extinct were by-catch species of little economic importance. In 1996 a number of commercially important species including cod *Gadus morhua*, southern bluefin tuna *Thunnus maccoyii* and Atlantic halibut *Hippoglossus hippoglossus* were included in the IUCN Red List of threatened animals. They had undergone declines in abundance at the qualifying rate over a period of time equivalent to at least the length of three generations. This brought into focus the negative impact of exploitation on biodiversity, and has begun a debate on the most appropriate protocols that should be used for threat listing of marine species. Discussion has focused on whether it is valid to apply decline criteria to species where the degree of decline is within management targets, whether decline thresholds for terrestrial taxa are appropriate for marine species, and whether threat categories accurately reflect the perceived lower extinction risk of widely distributed, fecund broadcast spawning species (Punt, 2000; Hutchings, 2001). It is likely that using population decline criteria to assess threat may be more precautionary than using detailed population projection and time-series approaches.

In 1979, the Council of Europe adopted the Convention on the conservation of European wildlife and natural habitats (The Bern Convention). Amongst other things, the Convention requires each Contracting Party to

take appropriate legislative and administrative measures to ensure the protection of wild fauna.

Groups of Experts submit guidelines, recommendations and action plans to the Standing Committee, which meets annually. The species of marine, estuarine and diadromous fishes currently listed in Appendices II and III of the Bern convention are summarised in Table 8.1.

In 1992, the European Commission passed Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora. The EC Habitats Directive lists “animal and plant species of community interest whose conservation requires the designation of special areas of conservation” (ANNEX II), “animal and plant species of community interest in need of strict protection” (ANNEX IV) and “animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures” (ANNEX V). Although no fully marine species were listed under the EC Habitats Directive, several diadromous and brackish water species are listed (Table 8.2).

The OSPAR Commission is actively involved with assessing threatened and declining species, using criteria including global importance, local importance, decline, sensitivity and rarity. The UK has worked closely with the OSPAR Commission to develop and apply the Texel/Faial Criteria for the identification of species and habitats in need of protection, and generate an initial list of threatened and/or declining fish species (Table 8.3). The list will guide the OSPAR Commission in setting priorities for its further work on the conservation and protection of these species, in collaboration with existing international agreements.

Table 8.1. Marine and diadromous fishes listed under the Bern Convention. Those freshwater fishes that are occasionally recorded from brackish waters are excluded

Family	Species	Appendix	
		II	III
Petromyzonidae	Lampern <i>Lampetra fluviatilis</i>	-	Yes
	Sea lamprey <i>Petromyzon marinus</i>	-	Yes
Squatinae	Angel shark <i>Squatina squatina</i> (Med.)	-	Yes
Cetorhinidae	Basking shark <i>Cetorhinus maximus</i> (Med.)	Yes	-
Lamnidae	White shark <i>Carcharodon carcharias</i> (Med.)	Yes	-
	Mako <i>Isurus oxyrinchus</i> (Med.)	-	Yes
	Porbeagle <i>Lamna nasus</i> (Med.)	-	Yes
Carcharhinidae	Blue shark <i>Prionace glauca</i> (Med.)	-	Yes
Rajidae	White skate <i>Rostroraja (Raja) alba</i> (Med.)	-	Yes
Mobulidae	Devil fish <i>Mobula mobular</i> (Med.)	Yes	-
Acipenseridae	Adriatic sturgeon <i>Acipenser naccarii</i>	Yes	-
	Starry sturgeon <i>Acipenser stellatus</i>	-	Yes
	Sturgeon <i>Acipenser sturio</i> (Med.)	Yes	-
	Beluga <i>Huso huso</i> (Med.)	Yes	-
Clupeidae	Beluga <i>Huso huso</i>	-	Yes
	Allis shad <i>Alosa alosa</i>	-	Yes
	Twaite shad <i>Alosa fallox</i>	-	Yes
	Pontic shad <i>Alosa pontica</i>	-	Yes
Salmonidae	Whitefish <i>Coregonus</i> spp.	-	Yes
	Salmon <i>Salmo salar</i>	-	Yes
Gasterosteidae	Southern ninespine stickleback <i>Pungitius (Tuntitius) platygaster</i>	-	Yes
Syngnathidae	Short-snouted seahorse <i>Hippocampus hippocampus</i> (Med.)	Yes	-
	Seahorse <i>Hippocampus ramulosus</i> (Med.)	Yes	-
	Black-striped pipefish <i>Syngnathus abaster</i>	-	Yes
Cottidae	Fourhorn sculpin <i>Myoxocephalus quadricornis</i>	-	Yes
Serranidae	Dusky grouper <i>Epinephelus marginatus</i> (Med.)	-	Yes
Sciaenidae	Brown meagre <i>Sciaena umbra</i> (Med.)	-	Yes
	Shi drum <i>Umbrina cirrosa</i> (Med.)	-	Yes
Gobiidae	<i>Knipowitschia (Padogobius) panizzae</i>	-	Yes
	Bighead goby <i>Neogobius (Gobius) kessleri</i>	-	Yes
	Syrman goby <i>Neogobius (Gobius) syrman</i>	-	Yes
	<i>Pomatoschistus canestrinii</i> (Med.)	yes	-
	<i>Pomatoschistus canestrinii</i> (Med.)	-	Yes
	<i>Pomatoschistus microps</i>	-	Yes
	Sand goby <i>Pomatoschistus minutus</i>	-	Yes
	<i>Pomatoschistus tortonesei</i> (Med.)	yes	-
	Tube-nose goby <i>Proterorhinus marmoratus</i>	-	Yes
Grass goby <i>Zosterisessor (Gobius) ophiocephalus</i>	-	Yes	

Table 8.2. Diadromous and brackish water fish species listed under the EC Habitats Directive

Family	Species	Annex II	Annex IV	Annex V
Petromyzonidae	<i>Lampetra fluviatilis</i> ¹	Yes		
	<i>Lampetra fluviatilis</i>			Yes
	<i>Petromyzon marinus</i> ²	Yes		
Acipenseridae ³	<i>Acipenser naccarii</i>	Yes	Yes	
	<i>Acipenser sturio</i>	Yes	Yes	
Salmonidae	<i>Coregonus oxyrinchus</i> ⁴	Yes	Yes	
	<i>Coregonus</i> spp. ⁵			Yes
Clupeidae	<i>Alosa</i> spp.	Yes		Yes
Gobiidae	<i>Pomatoschistus canestrini</i>	Yes		
	<i>Knipowitschia (Padogobius) panizzae</i>	Yes		

¹ Except Finnish and Swedish populations

² Except Swedish populations

³ All sturgeons not listed in Annex IV are included in Annex V

⁴ Anadromous populations in certain sectors of the North Sea

⁵ Except *Coregonus oxyrinchus* - anadromous populations in certain sectors of the North Sea

Table 8.3. The OSPAR Commission provisional list of threatened and/or declining fish species

Scientific name	Common name	OSPAR Regions where the species occurs	OSPAR Regions where the species is under threat and/or in decline
<i>Acipenser sturio</i> (Linnæus, 1758)	Sturgeon	II, IV	
<i>Alosa alosa</i> (Linnæus, 1758)	Allis shad	II, III, IV	Wherever it occurs
<i>Cetorhinus maximus</i> (Gunnerus, 1763)	Basking shark	All	Wherever it occurs
<i>Coregonus lavaretus oxyrinchus</i> (Linnæus, 1758)	Houting	II	Wherever it occurs
<i>Dipturus batis</i> (Linnæus, 1758) (synonym: <i>Raja batis</i>)	Common Skate	All	Wherever it occurs
<i>Raja montagui</i> (Fowler, 1910)	Spotted Ray	II, III, IV, V	Wherever it occurs
<i>Gadus morhua</i> (Linnæus, 1758) – populations in the OSPAR regions II and III ¹	Cod	All	II, III
<i>Hoplostethus atlanticus</i> (Collett, 1889)	Orange roughy	I, V	Wherever it occurs
<i>Petromyzon marinus</i> (Linnæus, 1758)	Sea lamprey	I, II, III, IV	Wherever it occurs
<i>Salmo salar</i> (Linnæus, 1758)	Salmon	I, II, III, IV	Wherever it occurs ²
<i>Thunnus thynnus</i> (Linnæus, 1758)	Bluefin tuna	V	Wherever it occurs ³

¹ That is, the populations/stocks referred to in ICES advice as the North Sea and Skagerrak cod stock, Kattegat cod stock, Cod west of Scotland, Cod in the Irish Sea, Cod in the Irish Channel and Celtic Sea.

² In accordance with the comments of ICES in its review, the varying states of the numerous different stocks have to be taken into account.

³ The main threat is the high rate of catch of juvenile fish of the species (SCRS Report, page 59).

Species under threat that ICES supported included various elasmobranchs (e.g. common skate *Dipturus batis* and angel shark *Squatina squatina*), diadromous fish species (e.g. Atlantic sturgeon *Acipenser sturio*) and selected non-target species, such as sea horses *Hippocampus* spp. Sea horses tend to occur in complex habitats that may be susceptible to disturbance (e.g. seagrass beds, areas with coverage of hydroids), and they also have several biological characteristics that would make them prone to over-exploitation. Many species of diadromous fish (i.e. those species of fish that utilise freshwater habitats and seas during various stages of their life-cycle) have declined, although the most significant threats affecting these species, such as water quality and physical obstructions, tend to occur in rivers and estuaries.

An EcoQO for threatened and declining species (Issue 2) 'presence and extent of threatened and declining species in the North Sea' was also suggested at the 5th North Sea Conference and may include many of the species, such as common skate, that have been depleted. This EcoQO is currently at an early stage of the testing process in ICES.

The criterion 'rarity' is difficult to quantify. It is important to note that rarity is a natural phenomenon, and that our perception of rarity is normally based on abundance data collected by selective sampling gears. Most fish species occur infrequently in samples, and catches are often dominated by a few abundant species. For example, although more than 70 species of fish have been recorded in beam trawl surveys in the Bristol Channel (1991-2002), only 10 species were recorded in more than half of the trawl samples (Figure 8.1), and only 13 species had a maximum catch per unit effort of >100 ind.per hour.

Most species were infrequent in catches, either due to their natural low abundance (rarity) or the inappropriateness of the sampling gear. Hence,

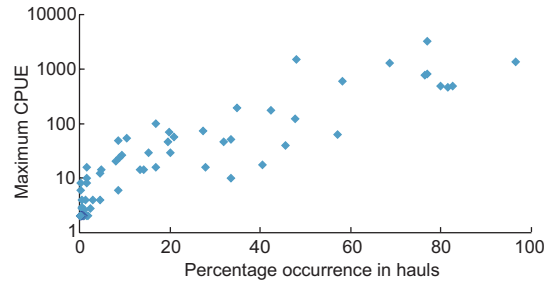


Figure 8.1. Maximum catch-per-unit-effort (CPUE) of fish species (ind./h, log scale) against their frequency of occurrence in trawl samples from beam trawl surveys in the Bristol Channel

the use of rarity as a criterion for selecting species of fish that may be threatened could be problematic.

Another useful criterion is decline, and determining the accuracy, extent, and magnitude of declines in relative abundance from survey data can be difficult, especially as there is generally a high variability in recruitment for many species. Also, for many species of fish, especially non-target species, there is a paucity of quantified historical data. In the absence of baseline information, long-term trends in the relative abundance and distribution of fish can indicate broad population trends, although these features can be highly variable and should be viewed over an appropriate time period for the species in question. For many species the cause of any observed trend will not be easy to identify.

Red mullet, for example, have increased in recent years, with both the frequency of occurrence and maximum catch-per-unit-effort increasing in surveys in the Bristol Channel. In contrast, catches of hake have declined in the same survey, although the reasons for this are unclear, as hake is an offshore species and the Bristol Channel is at the edge of their distribution.

Appendix 1.

Key documents which provide further information on fish assemblages and the effects of fishing.

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