1.5.5.9 Assessment of the impact of fisheries on the marine environment of the OSPAR maritime area

This text follows the previous Quality Status Reports (QSRs) (OSPAR Commission, 2000) and presents information by OSPAR Region.

The focus of this report is on changes which have occurred over the last 10 years (1998 to present) that is, since the production of the QSR 2000. During this period there have been a number of initiatives to reduce the environmental impact of fisheries through gear modification; we include case studies of some of these in our text. In most cases the case study covers fisheries in more than one OSPAR region; we have distributed these examples across the regions so that there is at least one case study embedded in the section for each of Regions II–V.

OSPAR requested ICES to prepare an initial scoping report on the content and methods for developing an assessment of the environmental impact of marine fisheries by 2008, as a contribution to the OSPAR QSR 2010. However, the information available was very patchy and as a result the regional reports do not address each of the categories with the same level of detail. OSPAR publishes an overview and separate regional reports. Consequently there is some duplication in order for each of these sections to be read as individual documents.

1.5.5.9.1 NE Atlantic Quality Status Report for 2010

Introduction

Previous Quality Status Reports (QSRs) have reported on the state of fish stocks and fisheries in the region. Though OSPAR does not have competency with respect to fisheries management (Annex V, Article 4) it is, however, required to raise with the competent authorities any issue of concern it may have with respect to fisheries and the ecosystem. As fisheries are probably the most extensive form of human intervention in marine ecosystems and have a long history it is appropriate to consider the past and future effects this activity has had and will have on marine ecosystem dynamics, biodiversity, and the sustainability of marine resource use. This section therefore focuses on the impacts of fisheries on various components of the marine ecosystem and examines how management initiatives are operating to limit the negative impacts while continuing to provide valuable marine food resources and a viable fishing industry.

The most important issues related to fisheries, as identified by the QSR 2000 (OSPAR Commission, 2000), were:

a) excessive fishing effort and overcapacity in the fishing fleet in some regions;
b) lack of precautionary reference points for the biomass and mortality of some commercially exploited stocks;
c) how to address the particular vulnerability of deep-sea species;
d) the risks posed to certain ecosystems and habitats, for example, seamounts, hydrothermal vents, sponge associations, and deep-water coral communities;
e) adverse environmental impacts of certain fishing gear, especially those leading to excessive catches of non-target organisms and habitat disturbance; and
f) the benefits to fisheries and/or the marine environment by the temporary or permanent closure or other protection of certain areas.

Some of these issues relate to fisheries management, while others relate to the impact of fisheries on the environment.

The development of fisheries management and policy since 1998

The need to manage fisheries to prevent over-exploitation and collapse of fish stocks has long been recognized. In more recent times it has also become clear that healthy fish stocks require a healthy supporting ecosystem and that this is at risk from a range of human actions including pollution, development of infrastructure, and the effects of the fisheries themselves. Fisheries not only kill and remove the target species but also cause mortality and injury to other species, alter habitats, and interfere with ecological processes such as nutrient and carbon cycles. With increasing public and political concerns about marine fisheries and environmental issues, fisheries science and management has become increasingly complex. The move to the ecosystem-based approach to fisheries management has gained momentum. The multiple uses of marine resources have been acknowledged to take account of ecosystem considerations and the recommendations from the numerous international agreements, conferences, and summits held on the subject. Some of the most important of these include:

- The 1972 World Conference on Human Environment (http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=97&ArticleID=1503);
- The 1982 United Nations Law of the Sea Convention (http://www.un.org/Depts/los/index.htm);
- The 1992 United Nations Conference on Environment and Development and its Agenda 21 (http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm);
- The 1992 Convention on Biological Diversity (http://www.cbd.int/);
- The 1992 Habitats Directive (http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0043:EN:HTML);
- The 1995 United Nations Fish Stocks Agreement (http://www.intfish.net/treaties/unfsa.htm);
- The 1995 Fisheries and Agriculture Organization (FAO) Code of Conduct for Responsible Fisheries (http://www.fao.org/DOCREP/005/v9878e/v9878e00.htm);
- The 2001 Reykjavik Declaration (http://www.fao.org/docrep/meeting/004/Y2211e.htm);
- The 2002 World Summit on Sustainable Development (http://www.un.org/events/wssd/);
- United Nations 2006 General Assembly to ensure protection of vulnerable marine ecosystems (http://www.un.org/depts/los/general_assembly/general_assembly_resolutions.htm); and
- The 2007 Committee on Fisheries of the United Nations FAO on illegal, unreported and unregulated fishing (IUU) and protecting the marine environment (http://www.europa-eu-un.org/articles/en/article_6838_en.htm).

The fishery policy documents relevant for the OSPAR area express similar objectives. The Common Fisheries Policy (CFP) Council Regulation 2371/2002 on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy includes:

"Precautionary approach shall be applied in taking measures designed to protect and conserve living aquatic resources, to provide for their sustainable exploitation and to minimise the impact of fishing activities on marine ecosystems. It shall aim at a progressive implementation of an ecosystem based approach to fisheries management."

The Marine Strategy Framework Directive 9388/2/2007 establishing a Framework for Community Action in the field of Marine Environmental Policy features the statement that:

"This Directive establishes a framework within which Member States shall take the necessary measures to achieve or maintain good environmental status in the marine environment by the year 2020 at the latest. "

The Maritime Policy Blue Book (COM, 2007) has:

"Fisheries management must take more into account the welfare of coastal communities, the marine environment and the interaction of fishing with other activities. The recovery of fish stocks will be energetically pursued, requiring sound scientific information and reinforcement of the shift to multi-annual planning. The Commission will take action to ensure that the Common Fisheries Policy reflects the ecosystem-based approach of the Strategy for the Marine Environment, and will work to eliminate Illegal, Unreported and Unregulated fishing in its waters and on the high seas."

The Bergen Declaration (2002) set out that:

"…fisheries policies and management should move towards the incorporation of ecosystem considerations in a holistic, multiannual and strategic context. While the transition towards a full ecosystem approach to fisheries management should be progressive and concomitant with the enhancement of scientific knowledge…",

"…the current state of scientific knowledge, coupled with a sound application of the precautionary principle, allows the immediate setting of certain environmental protection measures."

"…encourage the appropriate authorities to promote those fishing activities having less impact on the ecosystem…"

Broad trends in fisheries policy since 1998 have included strengthening governance by creating more transparent scientific advice provision, a precautionary approach, and a shift towards inclusion of ecosystem elements in management. The complex process of translating international agreements into operational and sustainable regional management continues to evolve. In the 2006 State of the World Fisheries and Aquaculture Report (FAO, 2007) the FAO called for strengthening of Regional Fisheries Management Organisations (RFMOs) in order to prevent further erosion and mismanagement of fish stocks. In response to this request the Northeast Atlantic Fisheries Commission (NEAFC) was the first RFMO to initiate such a review process.

In response to an external review NEAFC has implemented the following changes:

- Adoption of conservation and management measures for all major fisheries in the NEAFC regulatory area;
- Ensuring complementary management of straddling stocks between coastal states and NEAFC;
- New Port State Control measures entered into force May 1, 2007 and limits uncertified landings of frozen fish;
- Information sharing between NEAFC and the Northwest Atlantic Fisheries Organization (NAFO) on the IUU vessels list in the respective areas; and
- Prohibition of bottom trawling and use of static gear in a further three NEAFC areas to conserve vulnerable ecosystems.

(Source: http://www.neafc.org/news/docs/neafc_review_final_march07.pdf)

The European Union's (EU) instrument for managing marine resources is the Common Fisheries Policy (CFP). Reforms to the CFP took place in 2002 and can be summarized broadly as:

- Implementing a long-term approach with the aim of improving ecosystem and economic outcomes;
- New fleet policy with the aim of capacity reduction;
- Streamlining and harmonizing enforcement rules across the EU; and
- Stakeholder involvement.

(Source: http://ec.europa.eu/fisheries/cfp/2002_reform_en.htm)

The Cod Recovery Plan was the first long-term management plan to be adopted by the EU in the wake of the 2002 Reform of the Common Fisheries Policy. The overall objective of the plan was to ensure the recovery of the cod stocks concerned to the precautionary stock sizes within a time frame of five to ten years. The plan has recently (April 2008) been amended in order to hasten the recovery of cod in Community waters (amending Regulation (EC) No. 423/2004 as regards the recovery of cod stocks and amending Regulation (EEC) No. 2847/93).

The EU has recently begun a review process of the Data Collection Regulations (DCR) to consolidate the existing data collection activities of member states, and to provide indicators of the integration of ecosystem considerations into fisheries management. Recent progress by the Scientific and Technical and Economic Committee (STECF, 2006) will generate proposals for indicators to be adopted as a formal part of the DCR.

In 2006 the European Commission (EC) and Greenland renewed their 1985 Fisheries Policy agreement (http://ec.europa.eu/fisheries/cfp/external_relations/bilateral_agreements/greenland_en.htm). The agreement sets out arrangements for EC fishing within the Greenlandic exclusive economic zone (EEZ) in exchange for capacity building (including financial support) of a sustainable Greenlandic fisheries sector. In 2006 the EC and Norway (http://ec.europa.eu/fisheries/cfp/external_relations/bilateral_agreements/norway_en.htm) adopted an Agreed Record of Conclusions which formalizes fisheries agreements between the two parties on a variety of governance issues. (Source: http://www.oceanlaw.net/projects/current/pdf/cdiflp2007.pdf)

International commissions such as the International Commission for the Conservation of Atlantic Tunas (ICCAT), the International Whaling Commission (IWC), and the North Atlantic Marine Mammal Commission (NAMMCO) have continued to work towards sustainable management and conservation goals through scientific investigation, monitoring, and management plans (with varying levels of success).

Drivers on fishing activities in the OSPAR maritime area

Fishing has great economic and social importance for most OSPAR countries, and technical developments have led to more efficient exploitation of commercial fish stocks.

The principal drivers of fisheries activities include the availability of targeted species, the market price paid for fish on landing, the cost of fuel, and the need to operate within the regulatory regime. There is evidence that in some nations (UK, Netherlands) consumers are becoming concerned about the source and ecological impact of the fisheries that supply their fish. This has contributed to some changes in the wholesale and landed prices of some fish. Changes in the distribution of seafood prices can also provide useful insights into the availability of different species to fishers and to fish markets (Pinnegar *et al*., 2006). A new inflation-adjusted indicator has recently been applied to prices of fish from the Celtic Sea fisheries (Pinnegar *et al*., 2006). It suggests that a decline in the availability of higher trophic level target species such as cod and hake as well as an increase in the availability of lower trophic level pelagic species has driven the changes in price (Figure 1.5.5.9.1.1).

Global fuel prices (Figure 1.5.5.9.1.2), and hence fuel costs for the fishing industry, have increased dramatically in recent years and this is effecting both the grounds fishers exploit (reducing the time spent travelling between fishing opportunities), but also more fundamental shifts to using fishing gears that are less energy demanding.

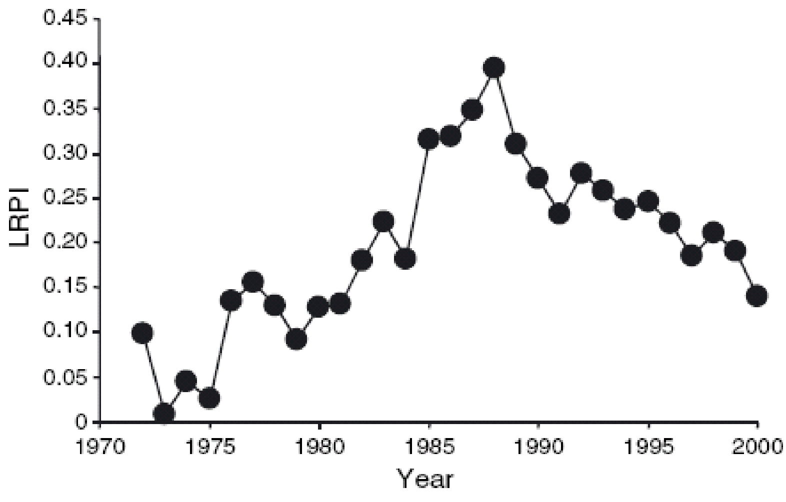


Figure 1.5.5.9.1.1 Pattern of change in the price of 26 species of fish captured by UK vessels in the Celtic Sea (ICES area VIIe–k) over a 30-year time-series, expressed as a 'log-relative-price-index' (LRPI). Prices are expressed in £ kg^{-1}. The LRPI index takes account of annual inflationary price rises and provides information on changes in mean trophic level of the fish or shellfish species sold. A declining log-relative-price-index (LRPI) can indicate that either the relative price of high trophic level species has declined or low trophic level species are becoming relatively more valuable, while the reverse holds for increasing index values (from Pinnegar *et al*., 2006).

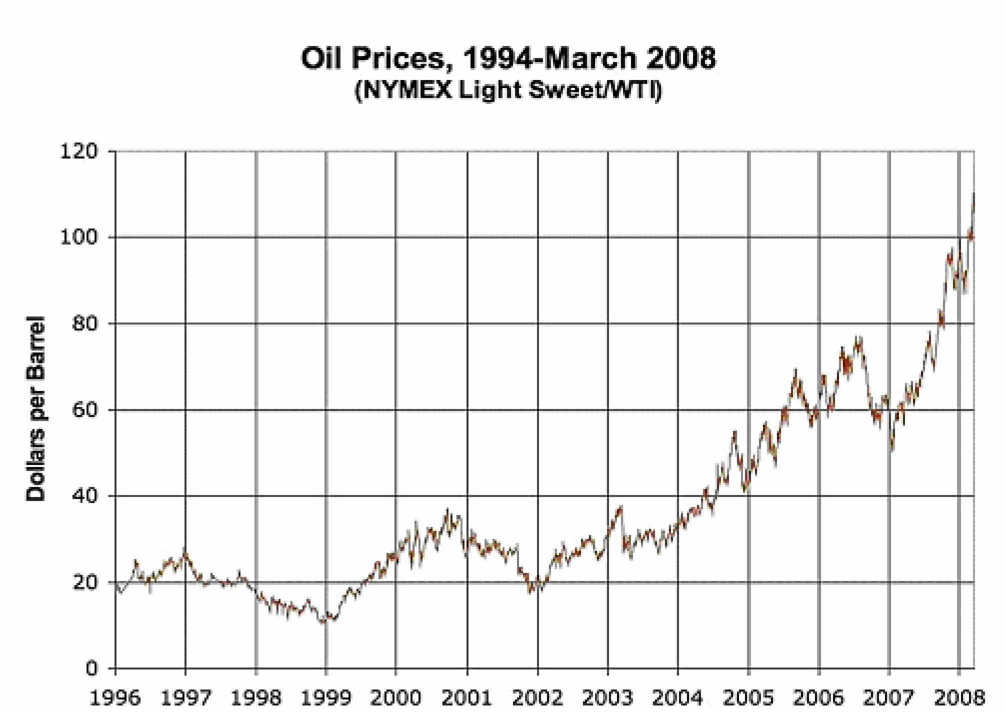


Figure 1.5.5.9.1.2 Global price of crude oil 1996–2008 (from http://octance.nmt.edu/gotech/Marketplace/prices.aspx).

Fisheries are constantly changing. New fisheries are developed to meet market demand. Fishing grounds move as fish stocks respond to changing environmental conditions. Technical development of gears leads to increased efficiency or allows exploitation of new areas. Fishing practices change to respond to external economic factors such as the cost of capital and fuel.

In the OSPAR region the fisheries in the last decade have continued to decline in terms of number of vessels and people employed in the catching sector but through technical advance there has been only a small decrease in total effort and exploitation has increased in deep-water areas (Salz *et al*., 2004).

Fishing also results in the mortality of non-target species and towed fishing gears can impact on benthic communities and cause physical disturbance of the seabed. The growing concern about impacts of fisheries on marine ecosystems has stimulated the integration of fishing gear technology research into the framework for fisheries management. Fishing gear technologists have tended to focus on the interaction of the gear with a single or multiple commercial fish species. With the exception of charismatic species, very little fishing gear research has focused on non-target fish species and benthic invertebrates. Most of the fishing gear research is driven by the fisheries management objectives, which is in its turn mainly driven by the health of commercial fish stocks. Much of current fisheries gear research is focused on the reduction of physical habitat impacts but none of these efforts have been implemented in the actual fisheries. Gear modifications to improve selectivity of commercial fish species through a variety of sorting devices reduces the bycatch and discards rates, mainly of fish species (Valdemarsen and Suuronen, 2003; Suuronen and Sarda, 2008). A number of such initiatives have been applied in European fisheries in the past 10 years and some case studies are described in the Regional accounts below.

Impacts of fisheries on the ecosystem

Commercial fishing has direct and indirect effects on the marine ecosystem; these can be summarized as effects on:

1. commercial fish stocks;
2. non-target species, including birds, marine mammals and discarded fish;
3. the sea bed and associated benthic communities and habitats;
4. community structure and food webs; and
5. genetic structure (OSPAR Commission, 2000).

Effects on commercial fish stocks

Sparholt *et al*. (2007) completed a meta-analysis of stock size, recruitment, and fishing mortality over time, in order to evaluate the general status of fish stocks within the ICES Area (i.e. the Northeast Atlantic). Their analysis was based on data for 34 (7 pelagic, 27 demersal) commercial stocks and indicates that most of those pelagic stocks recovered to sustainable levels after several had collapsed in the 1960s and 1970s. In contrast, most demersal stocks have continued to decline over the past half century and are now recruitment-overfished (Sparholt *et al*., 2007).

Total landings in the OSPAR area have remained at approximately ten million tonnes per year since the 1980s (Figure 1.5.5.9.1.3). Demersal stock landings have shown a decrease from a peak of six million tonnes in the 1970s to currently around three million tonnes. Total pelagic stock landings peaked in the 1970s and have remained consistent at around seven million tonnes since then.

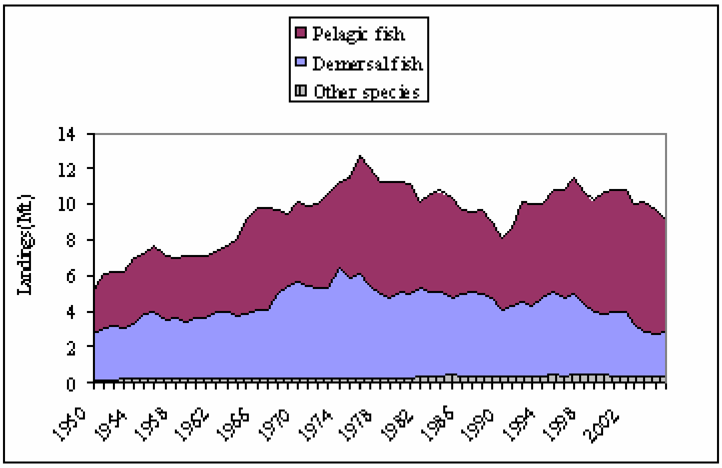


Figure 1.5.5.9.1.3 Landings in the Northeast Atlantic (ICES Area) of demersal stocks (D), pelagic stocks (P), and other species (crustaceans, squids, tunas, and tuna-like species). Data from the ICES Statlant database (http://www.ices.dk/fish/statlant.htm) which includes stocks from the Baltic Sea (Subdivisions 22–32) that are not in the OSPAR region.

The regional breakdown of landings is given in Figures 1.5.5.9.1.4 to 1.5.5.9.1.8 by pelagic, demersal, and shellfish species. In Region I, shellfish and pelagic catches have declined while demersal catches have remained stable. In Region II, all categories of catches have declined, while in Region III they have all increased. In Region IV, shellfish and pelagic catches have increased while demersal catches have remained stable. In Region V catches of pelagic and demersal species have increased from 0.1 Mt in 1998 to over 0.6 Mt in recent years.

Region I

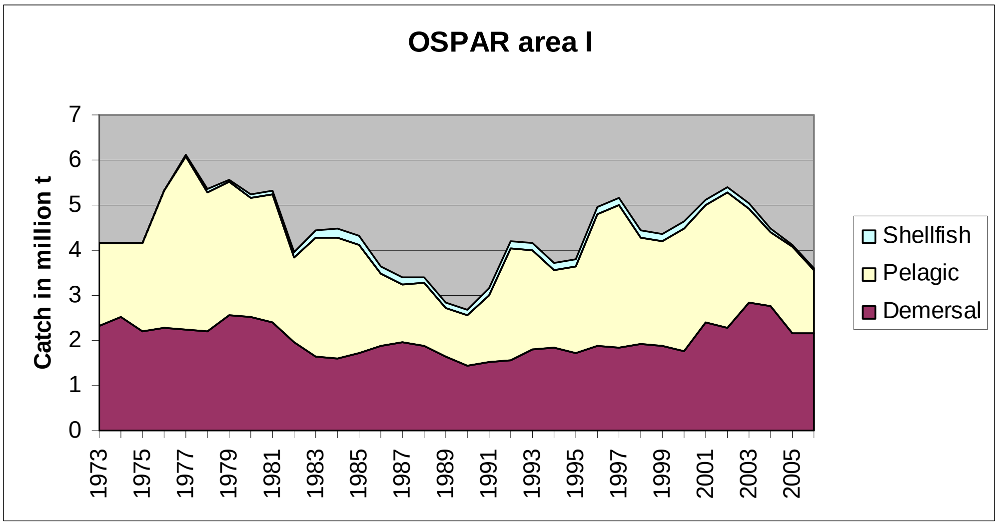


Figure 1.5.5.9.1.4 Total landings for shellfish, pelagic, and demersal species in OSPAR Area I. Data from the ICES Statlant database (http://www.ices.dk/fish/statlant.htm).

Region II

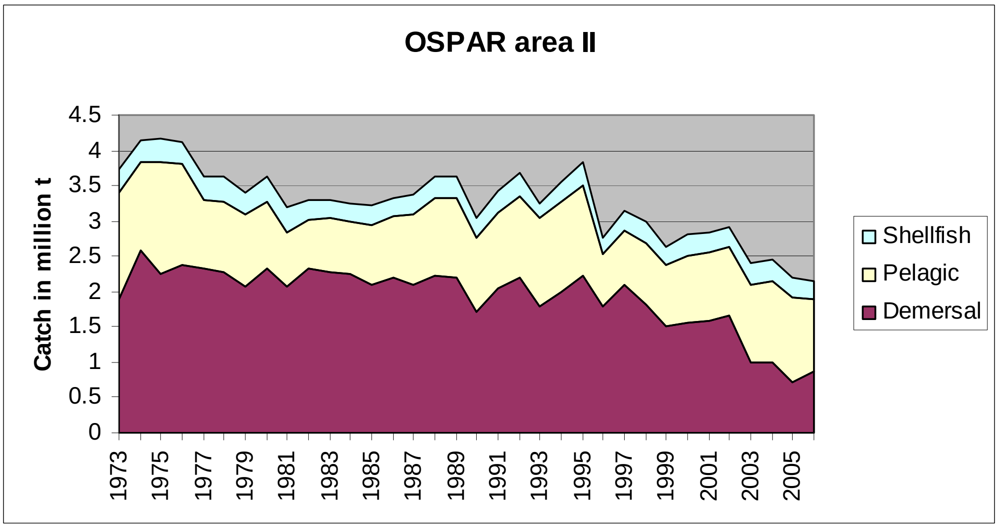


Figure 1.5.5.9.1.5 Total landings for shellfish, pelagic, and demersal species in OSPAR Area II. Data from the ICES Statlant database (http://www.ices.dk/fish/statlant.htm).

Region III

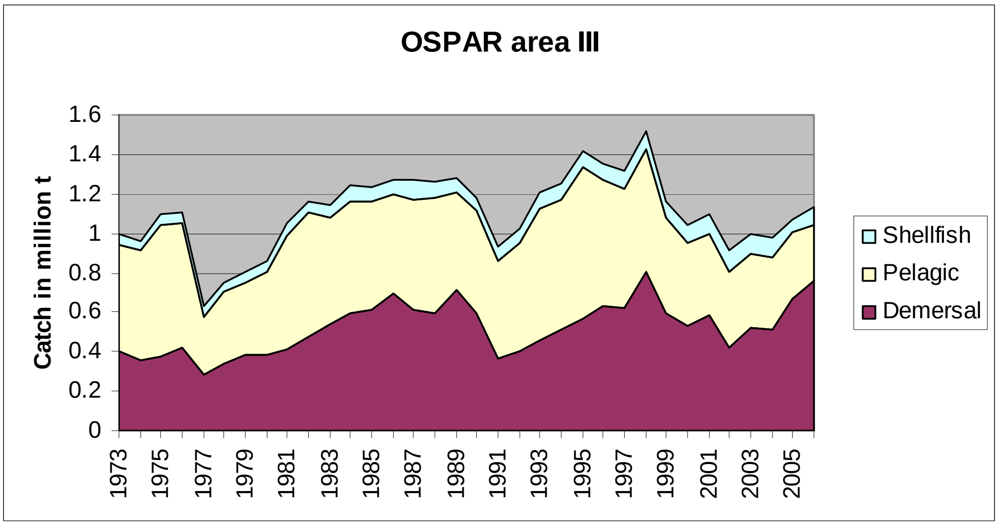


Figure 1.5.5.9.1.6 Total landings for shellfish, pelagic, and demersal species in OSPAR Area III. Data from the ICES Statlant database (http://www.ices.dk/fish/statlant.htm).

Region IV

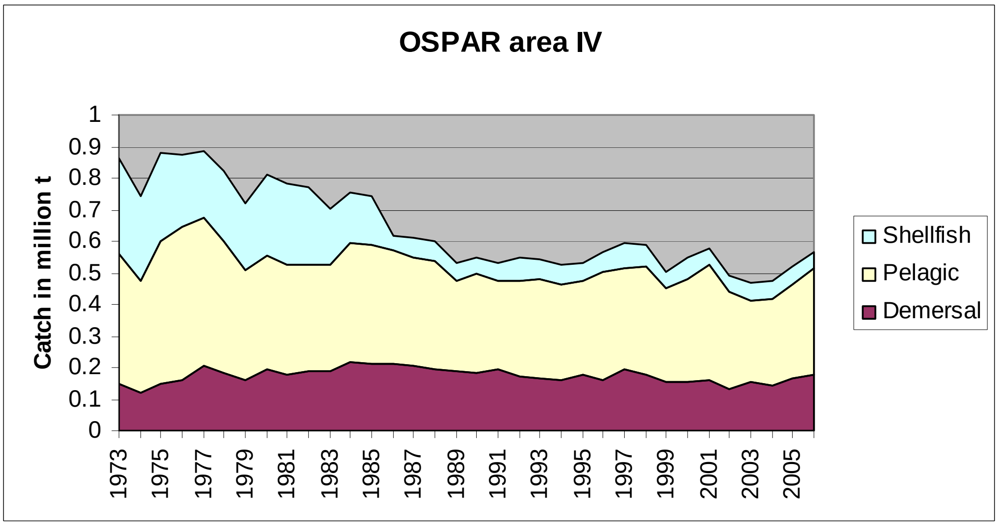


Figure 1.5.5.9.1.7 Total landings for shellfish, pelagic, and demersal species in OSPAR Area IV. Data from the ICES Statlant database (http://www.ices.dk/fish/statlant.htm).

Region V

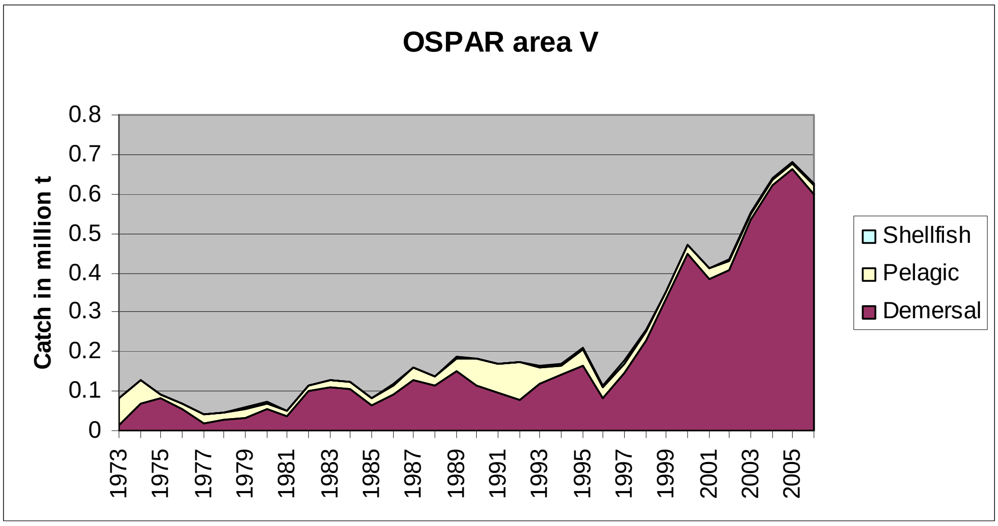


Figure 1.5.5.9.1.8 Total landings for shellfish, pelagic, and demersal species in OSPAR Area V. Data from the ICES Statlant database (http://www.ices.dk/fish/statlant.htm).

The standardized Spawning-Stock Biomass (SSB) of demersal stocks from the ICES area (Sparholt *et al.*, 2007) shows a negative linear trend throughout the time-series, with mean values showing a decrease from a plateau in the 1970s. This is even more evident following the standardization of SSB using B_{lim} (Figure 1.5.5.9.1.12). A stock with a SSB < B_{lim} is suffering reduced reproductive capacity. The standardized SSB of pelagic stocks show a sharp decline in the 1970s associated with a number of stock collapses and subsequent rebuilding (Figure 1.5.5.9.1.13). This is visible in the long-term means trajectory and results in a non-significant time trend. SSB showed a steep decline (15% per annum) to a trough in the 1970s, after which there was a rapid rise (5% per annum) in SSB during the 1970s and 1980s back to levels nearing those observed in the 1950s.

The fishing mortality F on a stock provides a measure of the degree of exploitation by the fishery. For some stocks a reference point F_{lim} is provided by the ICES assessments, providing an indication of whether the stock is harvested unsustainably ($F > F_{lim}$) or not. For those stocks where the reference points for both SSB and fishing mortality are present it is possible to provide an indication of the status of the stock (Figure 1.5.5.9.1.9). Note, however, that if a stock is on the safe side of both limits it may still be at risk of suffering reduced reproductive capacity and/or being harvested unsustainably. This cannot be assessed if a precautionary reference point is not defined.

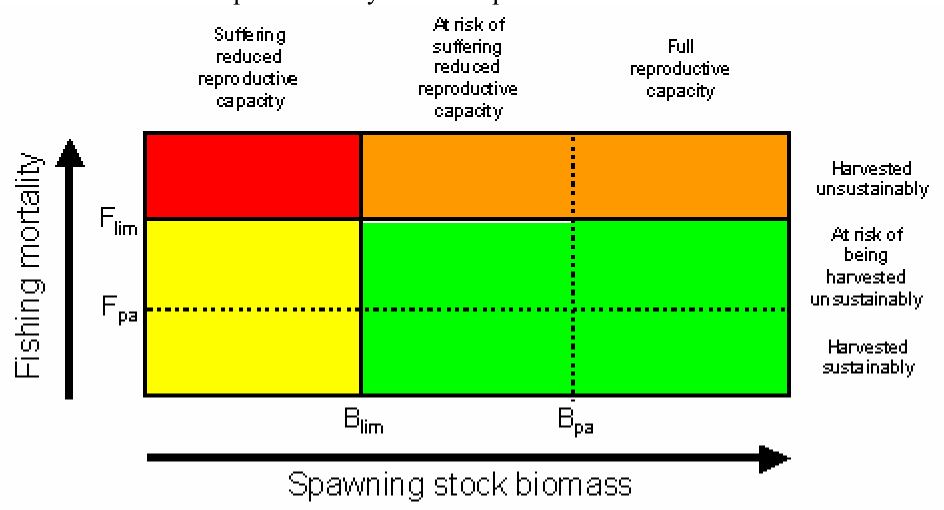


Figure 1.5.5.9.1.9 Colour codes used to describe the status of a stock based on its spawning-stock biomass and fishing mortality relative to the reference points B_{lim} and F_{lim}. Note in particular that the "precautionary" reference points B_{pa} and F_{pa} are not taken into account. This means that a stock coloured green can still be at risk of suffering reduced reproductive capacity and/or at risk of being harvested unsustainably.

The development of the status of the stocks indicates that a growing proportion of the stocks are moving away from being harvested unsustainably, but at the same time a decreasing proportion of stocks have full reproduction capacity

(Figure 1.5.5.9.1.10). This result has to be treated with caution, as the cases where the stock assessments have been able to provide both reference points on SSB and fishing mortality were rather few, in particular for Regions III, IV, and V (Figure 1.5.5.9.1.11). Stocks with both reference points are roughly equally divided between demersal and pelagic stocks. No benthic stocks (e.g. *Nephrops*, *Pandalus*) have reference points.

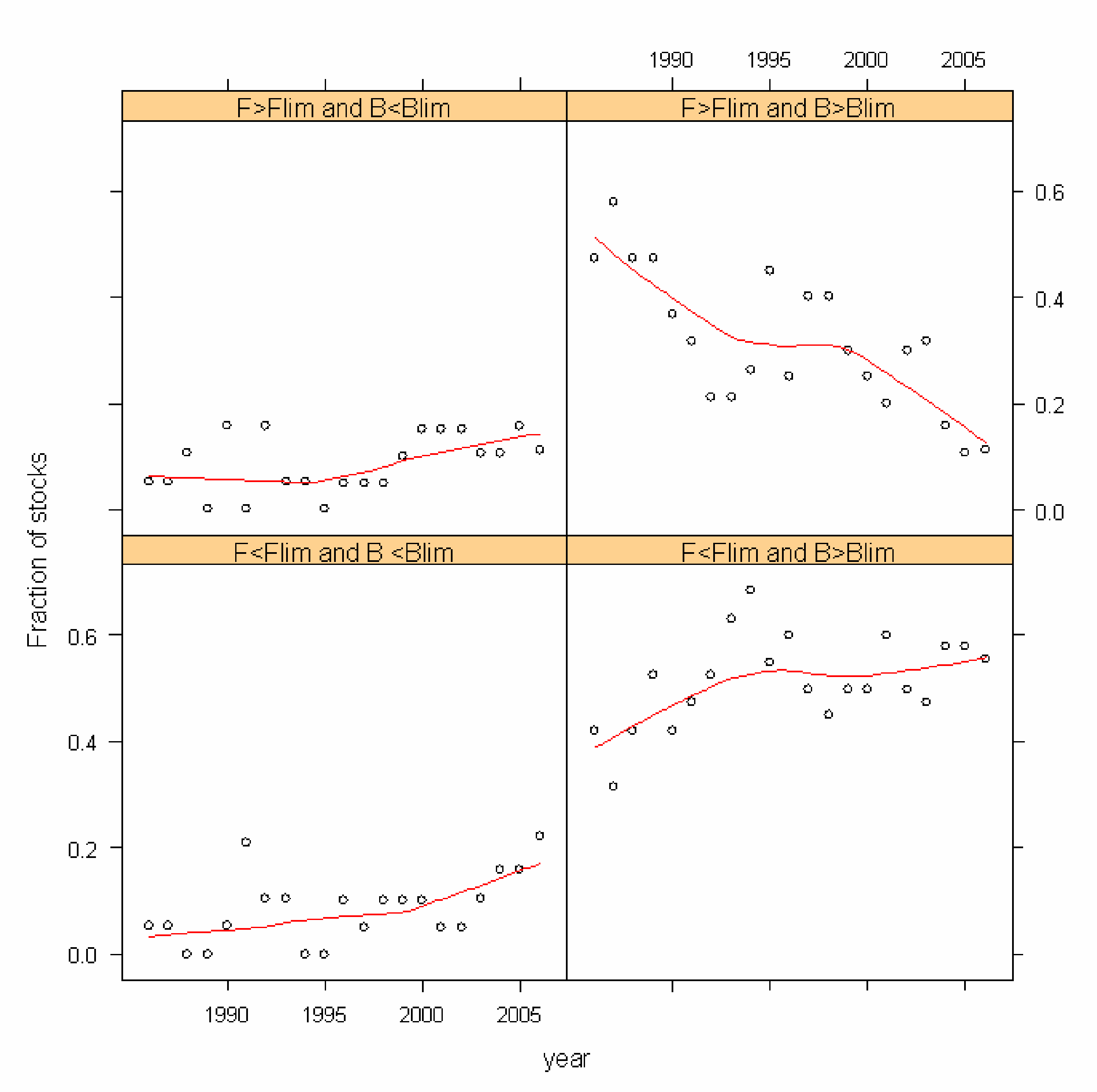


Figure 1.5.5.9.1.10 Development of the status of those assessed stocks where limit reference points were provided for both fishing mortality and spawning-stock biomass from 1986–2006. The estimates from the last two data years have to be treated with caution as these are more uncertain than the rest, due to the convergence feature of fish stock assessment models. Loess smoother (span=0.75 see, e.g. **www.r-project.org**) has been used.

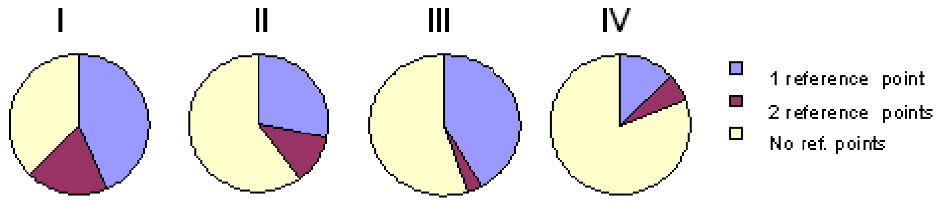


Figure 1.5.5.9.1.11 Fraction of the total landings in 2001 which are taken from stocks where 1 or 2 of the reference points F_{lim} and B_{lim} are available; per OSPAR Region I–IV. No reference points are available for Region V.

In those cases where the hard limits were not provided, "soft" criteria for determining the status of a stock can be used (ICES, 2007b) (Table 1.5.5.9.1.1). The soft criteria are mainly based on the whether SSB is below B_{lim}. In cases where not even the B_{lim} is available other, in some cases subjective, criteria are invoked. With many of the stocks for which hard criteria are not available the use of soft criteria leads to these stocks being perceived as being outside safe biological limits. For all regions more than half of the stocks are perceived as being outside safe biological limits. In Region IV this goes for all assessed stocks.

Table 1.5.5.9.1.1 Total catch and number of stocks perceived to be inside or outside safe biological limits per OSPAR region. In cases where hard limits on spawning-stock biomass and fishing mortality are not available the assessment of whether a stock is inside or outside safe biological limits is based on "soft" criteria (based on data from ICES, 2007b).

Ospar Region	Total Catch In Tonnes In 2006	Catch Of Assessed Stocks In Tonnes In 2006	Number Of Assessed Stocks Outside 'Safe' Limits, Pr 1 Jan 2007	Number Of Assessed Stocks Inside 'Safe' Limits, Pr 1 Jan 2007
I	3774783	3712330	15	22
II	1817719	1759228	11	14
III	1225211	1109228	18	26
IV	599649	451204	14	14
V	542866	535199	2	7

French fishing effort of both towed and fixed gears for demersal species has increased since 1999, and indicators for 51 fish populations and the whole fish community document a steady decline attributed to overfishing (Rochet *et al.*, 2005). Despite a decrease in the number of fishing vessels in the French fleet, fishing effort has increased and, under this continuing pressure, the impact of fishing cannot be said to have decreased over the past ten years. Although some management measures have proven efficient like the Northern hake recovery plan, in general there has been low or no improvement in the status of target species and in the impact of fishing on the community, and the anchovy fishery had to be closed in 2005. Moreover, undersized individuals and bycatch species continue to be caught and discarded in large amounts. Recent changes in fishing gears for example, in the *Nephrops* fishery, have not yet proven efficient.

Recent Scottish and Irish groundfish surveys (1997–2000 and 1993–2000, respectively) in Region III show declines in the biomass and abundance of cod, whiting, and hake, amongst others, which were more pronounced in the latter part of the time-series (Mahé, 2001; ICES, 2008a). In the North Sea (Region II) declining trends in indicators for 13 fish populations have been reported (Rochet *et al.*, 2005). The strong year classes of cod, haddock, whiting, and saithe of the 1980s have continued to decrease and cod is at the lowest level observed for over 100 years (ICES, 2008d). Spawning biomass of sandeel in the North Sea was at the lowest level observed in 2004 as a result of a targeted industrial fishery (ICES, 2008a).

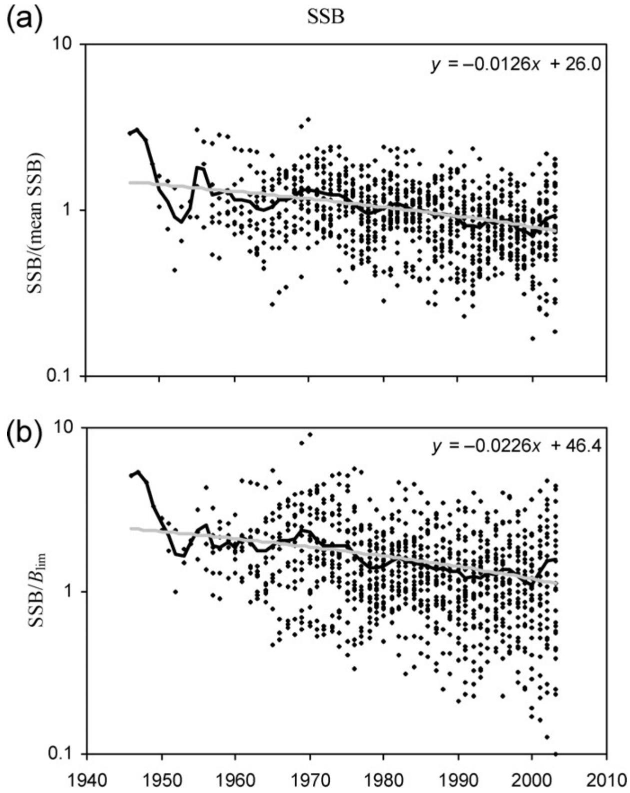


Figure 1.5.5.9.1.12 Standardized Spawning-Stock Biomass (SSB) for demersal stocks by year by (a) annual mean SSB; (b) ratio of SSB to the biomass limit value (B_{lim}). The black line reflects the mean values by year, and the grey line is the linear regression (parameters are given in each panel) (Sparholt *et al.*, 2007).

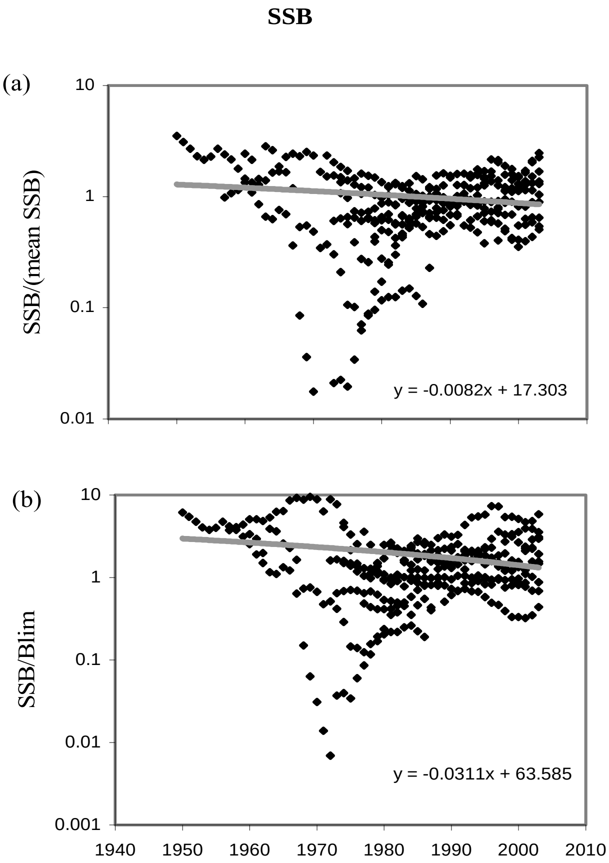


Figure 1.5.5.9.1.13 Standardized Spawning-Stock Biomass (SSB) for pelagic stocks by year by (a) mean SSB; (b) SSB/B_{lim}. The grey line is the linear regression (parameters are given in each panel) (Sparholt *et al.*, 2007).

Modern fishing fleets are capable of causing a very significant reduction in demersal deep-water fish biomass in just a few years; a consequence of this has been the collapse of several fisheries. There is strong evidence that some deep-water fish (500–1800 m) have been severely depleted in the Celtic Sea (Region V) by the deep-water fisheries carried out in this area (ICES, 2008b). Unlike the commercial groundfish these fish all have attributes which make them particularly vulnerable to overfishing such as slow growth rates, late age of maturity, low or unpredictable recruitment, and long lifespans. Examples include the roundnose grenadier *Coryphaenoides rupestris*, black scabbard fish *Aphanopus carbo*, blue ling *Molva macrophthalma*, and orange roughy *Hoplostethus atlanticus* as well as deep-sea squalids (sharks) and Macrouridae (ICES, 2008b). Populations of large fish that aggregate on oceanic bathymetric features such as seamounts are particularly sensitive to overfishing, due to low productivity and high catchability. On the southern part of the mid-Atlantic Ridge and adjacent seamounts, populations of alphonsinos were depleted also in the 1970s. More recently, longline fisheries appear to have depleted seamount populations of "giant" redfish on seamounts of the northern mid-Atlantic Ridge (ICES, 2008b).

However, some stocks show some positive trends most likely due to natural variation. For example, haddock recruitment has been particularly strong in recent years in Region I. Except for that of 2001, all year classes between 1998 and 2003 have been strong. In fact, the 2003 year class is estimated to be the strongest in 45 years (ICES, 2008a). Also, the spawning stock of Greenland halibut in Region I is low from a historical perspective, but has increased slowly since 1996 (ICES, 2008a).

Effects on non-target species, including birds, marine mammals, and discarded fish

In all five OSPAR regions some fisheries generate a large amount of discards, representing up to 50% of the total catch or even more. The discarded material contains both non-target species and target species which are undersized or exceed quota. In many regions, the *Nephrops* and *Crangon* trawl fisheries and groundfish trawl fisheries use non-selective gears with small mesh sizes, generating unwanted bycatch that is thrown overboard, most of the time dead or dying. Deep-sea fisheries also catch large amounts of non-target species, of which survival is extremely small due to marked differences in environmental conditions between their usual habitat and the sea surface.

Discarding has been shown to affect the dynamics of target species, non-target species and community structure in all regions. Effort has been invested into research to develop more selective gears over the last decade, but the implementation of the new technology is slow. With only a limited uptake of more selective gears and their applicability in only some situations discarding remains a major ecological impact of fisheries. Given the high levels of fishing effort in most fisheries in the region and the low SSB (and hence small average size of fish) in most stocks, discarding has increased in some areas, for example the Celtic Sea (Borges *et al*., 2005) or the Iberian areas (Rochet *et al*., 2006; ICES, 2008a). The most successful programmes for implementing selective gears and reducing discards were those developed in close collaboration with the industry.

Marine mammals including harbour porpoise, common dolphin, striped dolphin, Atlantic white-sided dolphin, white-beaked dolphin, bottlenose dolphin, and long-finned pilot whale continue to be incidentally caught in fishing gear throughout the OSPAR area (ICES, 2008a). There are indications that the bycatch of marine mammals in the pelagic trawl fishery for albacore in Region V was as high as in the driftnet fishery that it replaced, although in later years this bycatch appears to have reduced considerably. However, at least four species of seabird (northern gannet *Morus basanus*, northern fulmar *Fulmarus glacialis*, Manx shearwater *Puffinus puffinus*, and Atlantic puffin *Fratercula arctica*, and two species of turtle, including the leatherback turtle *Dermochelys coriacea*, were also entangled (ICES, 2008a). Eight species of Cetacea were recorded as bycatch during these fishing operations, including common dolphins *Delphinus delphis*, and striped dolphins *Stenella coeruleoalba*. Using landings of albacore tuna as an indicator of effort, the extrapolated decadal scale data from Irish and other driftnet fleets operating in this area suggest that during the period 1990–2000 around 800 000 blue sharks were caught, with a substantial proportion being discarded. An estimated 24 358 dolphins were captured during these years by these fleets, about half of which were common dolphins and half were striped dolphins (CEC, 2002; ICES, 2008a).

Lost gears such as gillnets may continue to fish for a long time (ghost fishing). The catching efficiency of lost gillnets has been examined for some species and areas, but at present no estimate of the total effect is available. Other types of fishery-induced mortality include burst nets, and mortality caused by contact with active fishing gear such as escape mortality. Some small-scale effects are demonstrated, but the population effect is not known. A programme for retrieval of lost gear is in effect along the Norwegian coast towards the Norwegian Sea, and a high number of ghost fishing nets are retrieved. The need for such activity is probably larger than what is currently carried out, given the fish mortality observed in retrieved nets.

Effects on the sea bed and associated benthic communities and habitats

The physical impact of bottom tending gear on the benthos remains a concern, particularly with respect to the damage to coral reefs. In the Norwegian Sea (Region I), damage to deep-water coral reefs has been documented in the eastern shelf areas and has resulted in area closures for bottom trawling. It is estimated that 30–50% of the coral areas may be damaged or negatively impacted (Fosså *et al*., 2002; ICES, 2008b).

Effects on other bottom fauna could be expected from bottom trawling activities in the eastern shelf areas. On the Faroe Plateau trawling activity has caused a significant reduction of the distribution of corals (e.g. *Lophelia pertusa*) on the shelf and bank slopes, prompting the Faroese authorities to close three coral areas for trawling in 2004 (ICES, 2008a). This species also forms large bioherms or reefs on the offshore banks (Rockall and Hatton) in Region V (Freiwald, 1998; Rogers, 1999) and may occur on the seamounts in this region. Many areas remain to be surveyed for *Lophelia pertusa* and so the full extent of damage due to fishing gears has yet to be evaluated.

Fishing is a major disturbance factor of the continental shelf communities of OSPAR Region IV and in some areas the area disturbed has increased. The Great Mud Bank (Grande Vasière) stretching from north to south in the centre of the Bay of Biscay is heavily trawled especially by the *Nephrops* trawler fleet. On average, the northern part is swept six times a year and this is suspected to have changed the sediment grain size through resuspension of fine materials, causing a decrease in the proportion of muds found on the Grande Vasière grounds (Bourillet *et al*., 2004; Bourillet *et al*., 2005; ICES, 2008a). Such changes to the physical habitat have the potential to cause substantial and long-term changes to benthic ecosystems, including negative impacts on burrowing animals such as *Nephrops* (ICES, 2008a). In the heavily exploited areas, the dominant benthic species are opportunistic carnivorous species of minor or no commercial interest and there were no fragile invertebrates (Blanchard *et al.,* 2004).

Effects on community structure and food webs

Three of the most important fish populations in Region I – herring, cod, and capelin – have all undergone changes in the recent decades, due in part to overfishing of the top predators with very strong effects on fish community structure and the food web (Daan *et al*., 2005; ICES, 2008a). With these fish linked to one another through their population dynamics (Anon., 2006), the overfishing of one or the other has repercussions for all. Years with good recruitment of herring and cod have typically resulted in poor capelin recruitment and, subsequently, a weak capelin stock size. In recent years the stock size of capelin off Iceland has decreased from about 2000 Kt in 1996/97 to about 1000 Kt in 2006/07 (Anon., 2007). Herring were very abundant in the early 1960s, collapsed, and have then increased since 1970 to a historical high level in the last decade (ICES, 2008a). This inverse relationship between abundance of capelin and herring is well documented as the young herring are predators on capelin larvae. The reduced stock size of capelin has resulted in a lower food availability of capelin for feeding by the Icelandic cod stock and thus a poorer condition of cod since 2003 (Anon., 2006; ICES, 2008a). It appears that cod do not readily substitute herring for capelin in their diets. There is also evidence that a change in the distribution of capelin, resulting in less overlap with cod, may lead to a marked detrimental impact on cod growth.

In Region V overfishing has led to major changes in demersal deep-sea fish communities due to the loss of their larger predators and corresponding ecological functions (ICES, 2008b). In addition to catching target species, deep-water fisheries bycatch unwanted species that are either too small or unpalatable. Discarding rates are often high (in the order of 50%); in the roundnose grenadier fishery the bulk of the discarded catch consists of smoothheads (Alepocephalidae) because of their high abundance (Allain *et al*., 2003).

Ecosystem-wide effects of overfishing of the large predatory fish species and discarding of large numbers of immature fish has had an indirect effect on the trophic structure in much of the OSPAR region. Absolute numbers of small fish belonging to all species and of demersal species with a low maximum length have steadily and significantly increased over large parts of the North Sea (Region II) during the last 30 years while the abundance of large fish has decreased (Daan *et al*., 2005). In the Celtic Seas (Region III) discarding levels differ between the different fleets but can be as high as two thirds of the total catch, with increasing trends in recent years (Borges *et al*., 2005; ICES, 2008a). There is general agreement that the size structure of the fish community has also changed significantly; a decrease in the relative abundance of large piscivorous fishes such as cod and hake coincides with an increase in smaller pelagic species, which feed at a lower trophic level (Pinnegar *et al*., 2003). Zooplankton abundance has declined in the region in recent years and the overall substantial decline in *Calanus* abundance, which is currently below the long-term mean (ICES, 2008a), may have longer term consequences given the fish community shift towards smaller pelagic species feeding on zooplankton. Some evidence suggests that the decline in *Calanus* may be due to increased feeding pressure of these smaller fish and hence be an indirect effect of fishing; however, climate change factors are also implicated (ICES, 2008a). In the Bay of Biscay (Region IV), the mixed species fishery has increased its level of discards to the highest yet reported. In the Cantabrian Sea (Region IV), the mean trophic level of the demersal and benthic fisheries declined prior to 1993 and the fish communities are now largely dominated by lower trophic level planktivorous fish (blue whiting, horse mackerel) (ICES, 2008a).

Fisheries have a considerable influence on the distribution of seabirds at sea due to the supply of discard that are used as food for scavenging species. Studies of offshore seabirds in the Gulf of Cadiz, Galicia, and the Cantabrian Sea (Region IV) report a strong correlation between the spatial distribution of the scavengers and that of the demersal trawl fleet (Valeiras *et al*., 2007). Provision of discards to the environment by trawling fleets has impacted seabird communities directly through food subsidies and indirectly through the food web. In the North Sea (Region II) over the past decade, 12 out of 28 seabird species in the North Sea showed an increasing trend. Now that total discarding rates are expected to fall with declining effort and possible regulation, discards may be a less accessible food supply for seabirds (Parsons *et al*., in press).

Effects on genetic diversity

There is amounting evidence that fishing affects the genetics of populations (ICES, 2002, 2005, 2007c). Fishing may result in genetic change (Kenchington, 2003; Kenchington *et al*., 2003) and may lead to fisheries-induced evolution in heritable traits (Law, 2000). Genetic change can occur at different levels as fishing may lead to the extinction of genetically distinct local stocks, reduce the genetic variability within populations, or reduce the individual genetic variability (inbreeding).

Fishing mortality is a selective force that can affect the genetic composition of a target population. Fast-growing individuals tend to be selectively removed from the population and over time this may affect phenotypic traits such as size and age of maturation. Fisheries-induced evolutionary effects have been reported for a number of specific fish stocks in the OSPAR region, particular in the onset of sexual maturity, but there is no systematic assessment of the effect on all exploited stocks (Jørgensen *et al*., 2007). Northeast Arctic cod (Heino *et al*., 2002) and, in the North Sea, cod (Law and Rowell, 1993), haddock (Wright, 2005), and plaice (Grift *et al*., 2007) all show indications of fishing-induced effects on reproductive traits. The question is not whether fisheries-induced evolution happens, but rather the rate at which it happens; this is still debated in the scientific community (Dieckmann and Heino, 2007; Law, 2007; Marshall and Browman, 2007). ICES (2007c) advised that firstly, reducing harvest rates will slow the rate and extent of fisheries-induced evolution in most life-history traits; secondly that, raising the minimum size limit well above the size at maturation will slow down the rate of evolution in maturation schedules.

Fishery-induced loss of genetic diversity has been studied for some stocks in the OSPAR region, with diverging results: low effective population sizes were reported for one sub-stock of North Sea cod (Hutchinson *et al*., 2003) and for North Sea and Icelandic plaice (Hoarau *et al*., 2005). However, for another North Sea cod stock and for Baltic cod no loss of genetic diversity was reported (Poulsen *et al*., 2006). The effect of the loss of specific spawning populations on genetic diversity has not been studied.

Assessment of fisheries measures and their effectiveness

A variety of fisheries management measures have been introduced to NE Atlantic fisheries in the last 10 years. These have met with varying levels of success. Table 1.5.5.9.1.2 illustrates a number of these approaches with examples for a variety of types of measure.

Table 1.5.5.9.1.2 A variety of fisheries management measures introduced into European fisheries management in the past 10 years and an indication of their effectiveness.

FISHERY MEASURES:	AIM:	EFFECTIVENESS:	EVIDENCE:
CFP 2002	The 2002 reform of the CFP aimed at ensuring the sustainable development of fishing activities from an environmental, economic, and social point of view. http://ec.europa.eu/fisheries/cfp_en.htm	Over 20% of the European Community fish catch comes from stocks deemed to be outside safe biological limits. Levels of ecosystem impact remain high, e.g. discard rates, bycatch, and physical impacts on the sea floor.	ICES Advice
Cod Recovery Plan	Rebuild some cod stocks in the North, Irish, and Celtic Seas to be within safe biological limits. "The aim of the plan was to allow severely depleted stocks to recover at rates ranging from 5 percent to 30 percent per year." http://128.227.186.212/fish/InNews/cod2004.htm	SSB has declined from 250 000 t in the 1970s to 40 000 t in 2006. The limit value below which the productivity of stock is considered to be impaired is 70 000 t. North Sea cod effort has declined by 25% since 2000. F has been in decline since 1999/2000 but remains above the value needed to rebuild stocks in the required time frame.	ICES Advice
Sandeel management	To leave SSB = B_{pa} after each year of fishing.	Aim achieved after 3 years of compliance with Harvest Rule and a low F of 0.21 in 2007. SSB is estimated to have increased to above B_{pa} in 2008.	ICES Advice
GBTM – cetacean pingers	Reduce mortality on small cetaceans in EC waters to below the ASCOBAN levels of 'unacceptable' mortality.	Pingers are not widely used. The pingers in use target only one species, the harbour porpoise.	Very limited monitoring of the effectiveness of these measures seems to have occurred. Monitoring was a requirement of the Regulation.
Hake Recovery Plan	To increase SSB of northern hake to within safe biological limits.	Met the SSB of 140 000 t achieved in 2006 and 2007.	ICES Advice
GBTM – Mesh size increases and square mesh panels	Decrease bycatch mortality and discarding of non-target species and undersize targets.	Some reduction of discards in modified gear has been observed.	This report
Bay of Biscay anchovy closure in 2005.	Rebuild stocks of anchovy following a recruitment failure.	Only slight signs of stock recovery apparent in 2006 and 2007.	From scientific fishing in 2007; see this report
Closed areas to protect corals in Regions I and V; including Council Regulation (EC) no. 602/2004 of 22 March 2004	To protect vulnerable habitats and coldwater corals.	Fishing has virtually ceased in more than ten closed areas. No monitoring of the state of coral reefs has occurred.	WGDEC (ICES, 2008c)
Closed areas in EU Atlantic and North Sea waters	Variety of fish stock conservation measures and in one case for biodiversity conservation.	In most cases impossible to evaluate due to lack of studies or difficulty in separating effects of closed area from other measures taken for fisheries management. Closed area for biodiversity found to be too small.	STECF SGMOS 07-03 report (STECF, 2007)
EC data collection regulations	Regulation establishing the Community Programme for the collection, management and use of data (including ecosystem considerations) in the fisheries sector	Council Regulation (EC) No. 199/2008 only recently established	Scientific, Technical and Economic Committee for Fisheries

Conclusions and priorities for action

Fisheries are a major economic activity in the NE Atlantic Region. Fish stocks from the area supply almost 10% of the global fisheries yields, but many of the stocks are fished so heavily that the stocks are outside or very close to the safe biological limit for exploitation.

Fisheries management practices in the NE Atlantic continue to evolve with the priority of ensuring a European fishery that is environmentally, economically, and socially sustainable. With growing global pressure on the food supply and the need for high grade protein and health promoting substances such as polyunsaturated fatty acids that are abundant in seafood, the fisheries sector will remain under pressure to deliver high quantities of material. Managing the fishery within ecologically sustainable limits and meeting societal objectives for the conservation of biodiversity against this moral, social, and economic imperative will be a growing challenge for fisheries management.

Gear-based technical measures have made a contribution to reducing the environmental impact of some fisheries. Regulatory and market incentives can both lead to an improvement of fishing practice, as can education and outreach initiatives.

Overall levels of fisheries exploitation are very high and in most fisheries higher yields, more security of supply, and lower environmental impacts would follow from further reductions in fishing effort.

ICES advises that OSPAR should:

- work in partnership with Regional Fisheries Management Organisations (RMFOs) to help deliver ecologically sustainable fisheries and ensure adequate provisions are made for biodiversity conservation. This could include work on the development of ecosystem-based fisheries management plans;
- work with RFMOs to develop a more detailed and more consistent data coverage to underpin evidence-based management;
- continue the development of integrated marine monitoring plans and assessment techniques, for example through the setting of ecological quality objectives and integrated assessments;
- work with Contracting Parties and the European Commission to clarify conservation objectives and the links to management action in marine protected areas, particularly in relation to measures to regulate effects of fishing that compromise conservation objectives;
- encourage the collection of further data and information on elasmobranch species, including common skate, thornback ray, porbeagle, basking shark, blue shark, and thresher shark. Further biological studies to delineate stock structure should also be encouraged;
- develop international agreements to establish robust procedures for the gathering and interpretation of information to allow a full assessment of fisheries and their ecosystem impacts in deep waters and in higher latitudes;
- further encourage programmes for developing and implementing selective gears and reducing discards. These programmes should be in close collaboration with the fishing industry;
- encourage the further reduction in harvest rates in order to slow the rate and extent of fisheries-induced evolution and encourage raising the minimum size limit to levels well above the size at maturation in order to slow down the rate of evolution in maturation schedules;
- derive new measures (metrics) or continue to develop/apply existing ones (e.g. EcoQOs) in order to distinguish between different forces acting on the communities (i.e. partition effects between environmental, economic, and regulatory forces). Ultimately the goal would be to assess the effectiveness of existing management measures (through legislation and/or voluntary measures) to improve stocks and mitigate against detrimental environmental impacts. In addition, it would be informative, as new mitigation or conservation measures are implemented, to recommend or develop appropriate metrics (that can be easily monitored and reported) in order to measure the success of such measures.

References

Allain, V., Biseau, A., and Kergoat, B. 2003. Preliminary estimates of French deepwater fishery discards in the Northeast Atlantic Ocean. Fishery Research, 60: 185–192.

Anon. 2006. Nytjastofnar sjávar 2005/2006, aflahorfur fiskveiðiárið 2006/2007 (State of marine fish stocks in Icelandic waters 2005/2006, prospects for the quota year 2006/2007). Hafrannsoknastofnunin Fjolrit 126, 190 pp. (In Icelandic, English summary).

Anon. 2007. Nytjastofnar sjávar 2006/2007, aflahorfur fiskveiðiárið 2007/2008 (State of marine fish stocks in Icelandic waters 2006/2007, prospects for the quota year 2007/2008). Hafrannsoknastofnunin Fjolrit 129, 180 p. (In Icelandic, English summary).

Bergen Declaration. 2002. Ministerial Declaration of the Fifth International Conference on the Protection of the North Sea. Fifth International Conference on the Protection of the North Sea. Bergen, Norway. 20–21 March, 2002. 50 pp.

Blanchard, F., LeLoc' h, F., Hily, C., and Boucher, J. 2004. Fishing effects on diversity, size and community structure of the benthic invertebrate and fish megafauna on the Bay of Biscay coast of France. Marine Ecology Progress Series, 280: 249–260.

Borges, L., Rogan, E., and Officer, R. 2005. Discarding by the demersal fishery in the waters around Ireland. Fisheries Research, 76: 1–13.

Bourillet, J-F., Folliot, B., Lesueur, P., and Goubert, E. 2004. Architecture des sédiments holocènes de la plate forme armoricaine et lien avec l'eustatisme. *In*: Les incisions et dépôts de la marge atlantique française depuis le néogène: états de lieux (Ed SGF-ASF), Paris, 25–26 novembre 2004. 7 pp.

Bourillet, J.-F., Dubrulle, C., Goubert, E., Jouanneau, J-M., Cortijo, E., Weber, O., and Lesueur, P. 2005. La Grande Vasière: architecture, mise en place et estimation des facteurs de son évolution, Colloque Golfe de Gascogne, 22–24 mars 2005.

CEC. 2002. Incidental catches of small cetaceans. Report of the meeting of the subgroup on fishery and the environment (SGFEN) of the Scientific, Technical and Economic Committee for Fisheries (STECF), Brussels December 2001. SEC (2002) 376. Commission of the European Communities, Brussels.

COM. 2007. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. An Integrated Maritime Policy for the European Union. Brussels, 10.10.2007. COM(2007) 575 final. 16 pp.

Daan, N., Gislason, H., Pope, J. G., and Rice, J. C. 2005. Changes in the North Sea fish community: evidence of indirect effects of fishing? ICES Journal of Marine Science, 62: 177–188.

Dieckmann, U., and Heino, M. 2007. Probabilistic maturation reaction norms: Their history, strengths, and limitations. Marine Ecology Progress Series, 335:253 269.

FAO. 2007. The State of the World Fisheries and Aquaculture 2006. FAO Fisheries and Aquaculture Department. Food and Agricultural Organization of the United Nations. Rome, Italy. 2007. 180 pp.

Fosså, J. H., Mortensen, P. B., and Furevik, D. M. 2002. The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. Hydrobiologia, 471: 1–12.

Freiwald, A., and Wilson, B. J. 1998. Taphonomy of modern deep, cold-temperate water corals reefs. Historical Biology, 13: 37–52.

Grift, R. E., Heino, M., Rijnsdorp, A. D., Kraak,S. B. M., and Dieckmann, U. 2007. Three-dimensional maturation reaction norms for North Sea plaice. Marine Ecology Progress Series 334: 213–224.

Heino, M., Dieckmann, U., and Godø, O. R. 2002. Reaction norm analysis of fisheries-induced adaptive change and the case of the Northeast Arctic cod. ICES Document CM 2002/Y:14.

Hoarau, G., Boon, E., Jongma, D. N., Ferber, S., Pálsson, J., Van der Veer, H. W., Rijnsdorp, A., *et al.* 2005. Low effective population size and evidence for inbreeding in an overexploited flatfish, plaice (*Pleuronectes platessa* L.). Proceedings of the Royal Society of London B, 272: 497–503.

Hutchinson, W. F., van Oosterhout, C., Rogers, S. I., and Carvalho, G. R. 2003. Temporal analysis of archived samples indicates marked genetic changes in declining North Sea cod (*Gadus morhua*). Proceedings of the Royal Society of London B, 270: 2125–2132.

ICES. 2002. Report of the Working Group on the Ecosystem Effects of Fishing Activities (WGECO). ICES Document CM 2002/ACE:02 Ref. D,E,G. 195 pp.

ICES. 2005. Report of the Working Group on the Application of Genetics to Fisheries and Aquaculture (WGAGFM). ICES Document CM 2005/F:01. Ref I. ACME,ACE. 51 pp.

ICES. 2007a. Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO). ICES Document CM 2007/ACE:04. 162 pp.

ICES. 2007b. Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems, 2007. ICES Advice. Books 1–10. 1333 pp.

ICES. 2007c. Report of the Study Group on Fisheries-Induced Adaptive Change (SGFIAC). ICES Document CM 2007/RMC:03. Ref. ACFM, ACE. 25 pp.

ICES. 2008a. Report of the Working Group on Ecosystem Regional Description (WGRED). ICES Document CM 2008/ACOM:47, 203 pp.

ICES. 2008b. Report of the Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES CM 2008/ACOM:14. 13 pp.

ICES. 2008c. Report of the Working Group on Deep-water Ecology (WGDEC). ICES CM 2008/ACOM:45. 122 pp.

ICES. 2008d. Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO). ICES CM 2008/ACOM:41. 162 pp.

Jørgensen, C., Enberg, K., Dunlop, E. S., Arlinghaus, R., Boukal, D. S., Brander, K., Ernande, B., *et al*. 2007. Managing evolving fish stocks. Science, 318: 1247–1248.

Kenchington, E. 2003. The effects of fishing on species and genetic diversity. *In:* Responsible fisheries in the marine ecosystem. Chapter 14: pp. 235–253. Ed. by Sinclair, M., and Valdimarson, G. CAB International, Wallingford, Oxon, UK, 448 pp.

Kenchington, E., Heino, M., and Nielsen, E. E. 2003. Managing marine genetic diversity: time for action? ICES Journal of Marine Science, 60: 1172–1176.

Law, R. 2000. Fishing, selection and phenotypic evolution. ICES Journal of Marine Science, 57: 659–668.

Law, R., and Rowell, C. A. 1993. Cohort-structured populations, selection responses, and exploitation of the North Sea cod. *In:* The exploitation of evolving resources, pp 155–173, Ed. by. Stokes, T. K., McGlade, J. M., and Law, R. Lecture Notes in Biomathematics 99, Springer-Verlag, Berlin.

Law, R. 2007. Fisheries-induced evolution: present status and future directions. Marine Ecology Progress Series, 335: 271–277.

Mahé, J-C. 2001. International Program of Standardised Trawl Surveys (IPROST). Study EC-DGXIV No. 98–0587. Ifremer – Marine Laboratory – Marine Institute. 122 pp.

Marshall, C. T., and Browman, H. I. 2007. Disentangling the causes of maturation trends in exploited fish populations. Marine Ecology Progress Series, 335: 249–251.

OSPAR Commission. 2000. Quality Status Report 2000. OSPAR Commission, London. 108 + vii pp.

Parsons, M., Mitchell. I., Butler, A., Ratcliffe, N., Frederiksen, M., Foster, S., and Reid, J. B. (in press). Seabirds as marine environmental indicators. Marine Pollution Bulletin.

Pinnegar, J. K., Jennings, S., O'Brien, C. M., and Polunin, N. V. C. 2002. Long-term changes in the trophic level of the Celtic Sea fish community and fish market price distribution. Journal of Applied Ecology, 39: 377–390.

Pinnegar, J. K., Trenkel, V. M., Tidd, A. N., Dawson, W. A., and Du Buit, M. H. 2003. Does diet in Celtic Sea fishes reflect prey availability? Journal of Fish Biology, 63 (Supplement A): 197–212.

Pinnegar, J. K., Hutton, T. P., and Placenti, V. 2006. What relative seafood prices can tell us about the status of stocks. Fish and Fisheries, 7 (3): 219–226.

Poulsen, N. A., Nielsen, E. E., Schierup, M. H., Loeschcke, V., and Grønkjær, P. 2006. Long-term stability and effective population size in North Sea and Baltic Sea cod (*Gadus morhua*). Molecular Ecology, 15: 321–331.

Rochet, M-J., Trenkel, V., Bellail, R., Coppin, F., Le Pape, O., Mahé, J-C., Morin , J., Poulard, J. C., Schlaich, I., Souplet, A., Vérin, Y., and Bertrand, J. A. 2005. Combining indicator trends to assess ongoing changes in exploited fish communities: diagnostic of communities off the coasts of France. ICES Journal of Marine Science, 62: 1647–1664.

Rochet, M-J., Bertignac, M., Fifas, S., Gaudou, O., and Talidec, C. 2006. Estimating discards in the French *Nephrops* fishery in the Bay of Biscay. ICES CM 2006/K:24, Abstract, p. 202.

Rogers, A. D. 1999. The biology of *Lophelia pertusa* (Linnaeus 1758) and other deep-water reef-forming corals and impacts from human activities. International Review of Hydrobiology, 84: 315-406.

Salz, P., Buisman, E., Smit, J., and de Vos, B. 2004. Employment in the fisheries sector: Current situation. European Commission, Fish/2004/4. 185 pp. (http://ec.europa.eu/fisheries/publications/studies/employment_study_2006.pdf).

Sparholt, H., Bertelsen, M., and Lassen, H. 2007. A meta-analysis of the status of ICES fish stocks during the past half century. ICES Journal of Marine Science, 64: 707–713.

STECF. 2006. Commission Staff Working paper: Report of the Scientific and Technical and Economic Committee/Subgroup on Research needs on data collection: environmental integration and move towards an ecosystem approach, Brussels 19–23 June, 2006. 88 pp.

STECF. 2007. STECF SGMOS 07-03 report. Can be downloaded from STECF's website at: (https://stecf.jrc.ec.europa.eu/24;jsessionid=b50cae911a3011e806ef7b4d4907?p_p_id=20&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-1&p_p_col_count=2&_20_struts_action=%2Fdocument_library%2Fview&_20_folderId=2516).

Suuronen, P., and Sarda, F. 2007. The role of technical measures in European fisheries management and how to make them work better. ICES Journal of Marine Science, 64: 751–756.

Valdemarsen, J. W., and Suuronen, P. 2003. Modifying fishing gear to achieve ecosystem objectives. *In:* Responsible Fisheries in the Marine Ecosystem, pp. 321–341. Ed. by Sinclair, M., and Valdimarsson, G. FAO, Rome and CABI International Publishing.

Valeiras, X., Abad, E., Serrano, A., Preciado, I., and Sánchez, F. 2007. Distribution and abundance of seabirds at fishing boats in Galician and Cantabrian waters in relation to environmental and fisheries factors and discards. Journal of Marine Systems (accepted).

Wright, P. J. 2005. Temporal and spatial variation in reproductive investment of haddock in the North Sea. ICES Document CM 2005/Q:07.

1.5.5.9.2 Regional QSR I: Arctic

Introduction

OSPAR Region I is a very large and diverse region. The fish stocks and fisheries of the region are equally diverse, with major differences between parts of the region. This makes summarizing the fisheries of the region, as well as the effects of these fisheries, comparatively difficult. The major demersal stocks in the OSPAR Arctic area include cod, haddock, saithe, and shrimp. In addition, redfish, Greenland halibut, wolf-fish, and flatfishes (e.g. long rough dab, plaice) are common on the shelf and along the continental slope, with ling and tusk also found on the slope and in deeper waters. In the Barents Sea, the spawning stock of the Northeast Arctic cod has been healthy since 2002 and fishing mortality has been reduced, but surveys indicate that the abundance of recent year classes are just above (years 2004 and 2005) or below average. The stock of the Norwegian coastal cod has decreased to a very low level – recruitment is declining rapidly and present fishing mortality is far too high. The stocks of Northeast Arctic haddock and saithe are high, and recent recruitment is above average. Abundance of demersal species around Iceland has been trending downward irregularly since the 1950s, with aggregate catches dropping from over 800 Kt to under 500 Kt in the early 2000s. Large spawning cod have been found in limited areas off East Greenland, indicating that a Greenland offshore spawning stock is being established. At the Faroes, the haddock and saithe stocks are harvested sustainably, but the cod stocks are depleted.

The major pelagic stocks in the area are herring, blue whiting, mackerel, capelin, and polar cod. The spawning stock of Norwegian spring-spawning herring was about 12 million tonnes in 2007, which means it is back to the level it had in the 1950s. The annual catch has been kept at a low level, at about 1.5 million tonnes. The spawning stock of blue whiting may have been close to 12 million tonnes in 2003, but in 2007 it had declined to about half of that level, due to heavy fishing and poor recruitment. The mackerel stock has its main distribution area in the North Sea and west of the British Isles, but large parts of the stock feed in the Norwegian Sea during summer, and its distribution area is expanding to the north and west. There has been no fishery for Barents Sea capelin since 2004, as the spawning stock biomass was too low. The exploitation of polar cod in the Barents Sea has been very low since the 1970s.

In Iceland/East Greenland/Jan Mayen, capelin abundance has been oscillating on roughly a decadal period since the 1970s, producing a yield of just under 1600 Kt at the most recent peak. In recent years the stock size of capelin has decreased from about 3000 Kt in 1995/96 to about 1000 Kt in 2006/07 (ICES, 2008a). Herring around Iceland were very abundant in the early 1960s, collapsed, and then have increased since 1970 to a historically high level in the last decade.

The most widespread demersal gear used is the bottom trawl, but also Danish seines, longlines, and gillnets are used in the demersal fisheries. Purse seines and pelagic trawls are the most commonly used gears for the pelagic fisheries. A range of mitigation measures are in force to limit the adverse impact of these fisheries, including closed areas to protect sensitive seabed habitats, and other technical mesh regulations to prevent capture of juvenile fish.

The development of fisheries management and policy since 1998, and an assessment of their effectiveness

Although Icelandic shrimp trawlers often use a double-rigged gear with a minimum codend square-mesh of only 36 mm, the impact of the fishery on undersized or juvenile fish has been alleviated since the mid-1990s by the compulsory use of a Nordmøre grid, as well as a shrimp sorting grid and 40 mm square-mesh codend in areas known to have large numbers of juvenile fish.

In the Barents Sea, sorting grids in shrimp trawls were made compulsory from January 2003, in order to reduce mortality of young fish. The use of grids in “large mesh” trawls was made compulsory from January 2007 – first in the Barents Sea and later in all areas north of 62°N. There has also been a gradual change from “open” or “Olympic” fisheries to vessel quotas, development of management strategies for the most important commercial species, and a focus on the development of bilateral control regimes in order to ensure that quotas are not exceeded.

In order to prevent further destruction of deep-water corals, trawling in known coral areas is now prohibited in Norwegian and Icelandic waters. A Norwegian programme for mapping the sea bottom, including coral areas, is in progress.

Areas around Spitsbergen and along the Norwegian coast are closed for fishing with specific gears permanently or for part of the year in order to protect juvenile fish or specific stocks.

Since 1 June 1996, a management system based on a combination of area closures and individual transferable effort quotas in days within fleet categories has been in force in the Faroes.

The Faroe Bank shallower than 200 m is closed to all trawl and gillnet fisheries. Technical measures such as area closures during the spawning periods, to protect juveniles and young fish and mesh size regulations are a natural part of the fisheries regulations. On the Faroe Plateau, three coral areas were closed to trawling in 2004.

A programme for retrieval of lost gear is in effect along the Norwegian coast towards the Norwegian Sea, and a high number of ghost fishing nets are retrieved.

In Iceland a system of transferable boat quotas was introduced in 1984. In 1990, an individual transferable quota (ITQ) system was established for the fisheries and they were subject to vessel catch quotas. The quotas represent shares in the national total allowable catch (TAC) for each species, and all of the Icelandic fleets now operate under this system.

With the extension of the fisheries jurisdiction to 200 miles in 1975, Iceland introduced new measures to protect juvenile fish. A ‘real-time’ closure system has been in force since 1976 aimed at protecting juvenile fish. Fishing is prohibited for at least two weeks in areas where the number of small fish in the catches has been observed by inspectors to exceed a certain percentage. If several consecutive quick closures are introduced in a given area the Minister of Fisheries can close this area for a longer time, forcing the fleet to operate in other areas (Figure 1.5.5.9.2.1). In 2005, 85 such closures took place.

In addition to allocating quotas on each species, there are other measures in place to protect fish stocks. Based on knowledge of the biology of various stocks, many areas have been closed temporarily or permanently to protect juveniles. Figure 1.5.5.9.2.1 shows a map of the legislation in force in 2004. Some of the closures are temporary, while others have been closed to fisheries for decades.

A way to ensure that a mixed fishery does not over-harvest one of the constituent stocks of the fishery is to predict the effects of mixed fisheries. ICES has examined the technical interactions between the fisheries in the Barents Sea using correlations in fishing mortalities among species. The correlation in fishing mortality is positive for Northeast Arctic cod and coastal cod and also for haddock and coastal cod, confirming the linkage in these fisheries. There is also a significant relationship between saithe and Greenland halibut although the linkage in these fisheries is believed to be low. Though this approach is promising, it has yet to be implemented as the correlations are influenced by too many confounding factors, the effects of which cannot be removed without a detailed analysis of data at a higher resolution than is available at present (see Section 2.1).

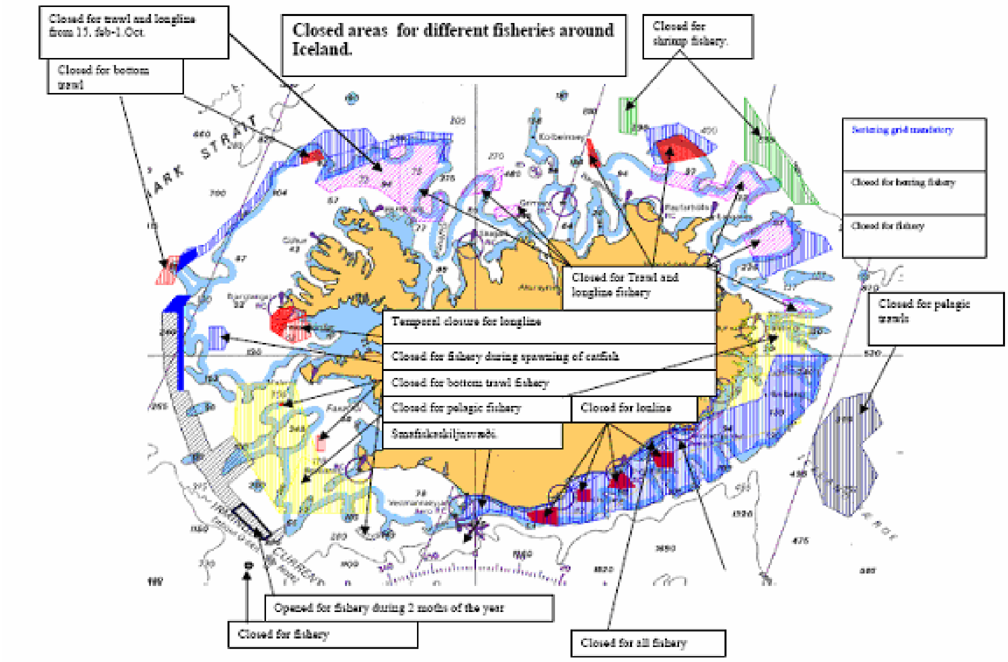


Figure 1.5.5.9.2.1 Overview of closed areas around Iceland. The boxes are of various nature and can be closed for different time periods and gear types (see text for further detail) (ICES, 2008b).

Estimates of unreported catches of cod and haddock in the Barents Sea 2002–2007 are relatively high (ICES, 2008a). Discarding of cod, haddock, and saithe is thought to be significant at times even though the discarding of these, and a number of other species, is illegal in both Norway and Russia.

Discarding measurements have been carried out in Icelandic fisheries since 2001, based on extensive data collection and length-based analysis of the data (Pálsson, 2003). The data collection is mainly directed towards fisheries for cod *Gadus morhua* and haddock *Melanogrammus aeglefinus* and towards saithe *Pollachius virens* and golden redfish *Sebastes marinus* fisheries in demersal trawl and plaice in Danish seine. Sampling for other species is not sufficient to warrant a satisfactory estimation of discarding. The discard rate for cod has been less than 1–2% of the reported landings over the time investigated. The discard estimates for haddock are somewhat higher, ranging between 2% and 6% annually. Discarding of saithe and golden redfish has been negligible in the time period investigated. Estimates of discards of cod and haddock in 2006 by individual fleets are given in Table 7.2. These relatively low discard rates compared to what is generally assumed to be a side effect of a TAC system may be a result of the various measures, including the flexibility within the Icelandic ITQ system. Since the time-series of discards is relatively short, it is not included in the assessments (ICES, 2008).

Fishing activities in OSPAR Region I

In Iceland the number of demersal trawlers has decreased from about 110 to 60 since around 1990, while their total demersal catch has dropped from roughly 350 000 tonnes to 200 000 tonnes (Figure 1.5.5.9.2.2). The gross tonnage of the bottom-trawler fleet has remained stable in the last decade at around 100 000 tonnes, but total engine power has decreased by 25% or from 200 000 to 150 000 kW. The most significant development in recent years in Icelandic pelagic fisheries is an increasing size of pelagic trawls and ability to fish deeper due to increasing engine power. There have also been substantial improvements with respect to technological aspects of other gears such as bottom trawl, longline, and handline.

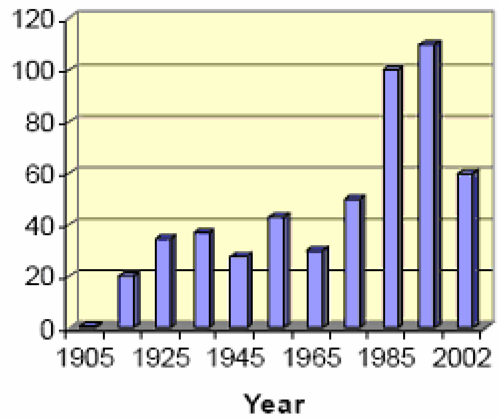


Figure 1.5.5.9.2.2 Number of Icelandic trawlers during the period 1905–2002 (Garcia *et al.*, 2006).

In addition to the Icelandic bottom-trawl fishery, an offshore shrimp-trawl fishery developed rapidly in the 1980s with catches surpassing 70 000 tonnes by the mid-1990s. Catches have decreased to around 10 000 tonnes or less in recent years. The offshore shrimp fishery led to an increase in bycatch of cod and Greenland halibut on the continental slopes and in deeper muddy areas off the northern part of the country. The fishery for shrimp has in the most recent year been greatly reduced, associated with a decrease in trawling activities in these areas. Trawling effort measured in standardized trawling hours has decreased by some 50% in the last decade with further decrease in the most recent years.

Icelandic *Nephrops* catches reached a historical maximum of 6000 tonnes in 1963, but they decreased quickly to some 1500 tonnes a year in the last decade. Due to the use of 80 mm codend mesh, bycatch and discard of juvenile fish may be considerable (Figure 1.5.5.9.2.3). Fishing effort measured in number of trawling hours decreased by some 60–70% in the last decade compared to the early 1970s.

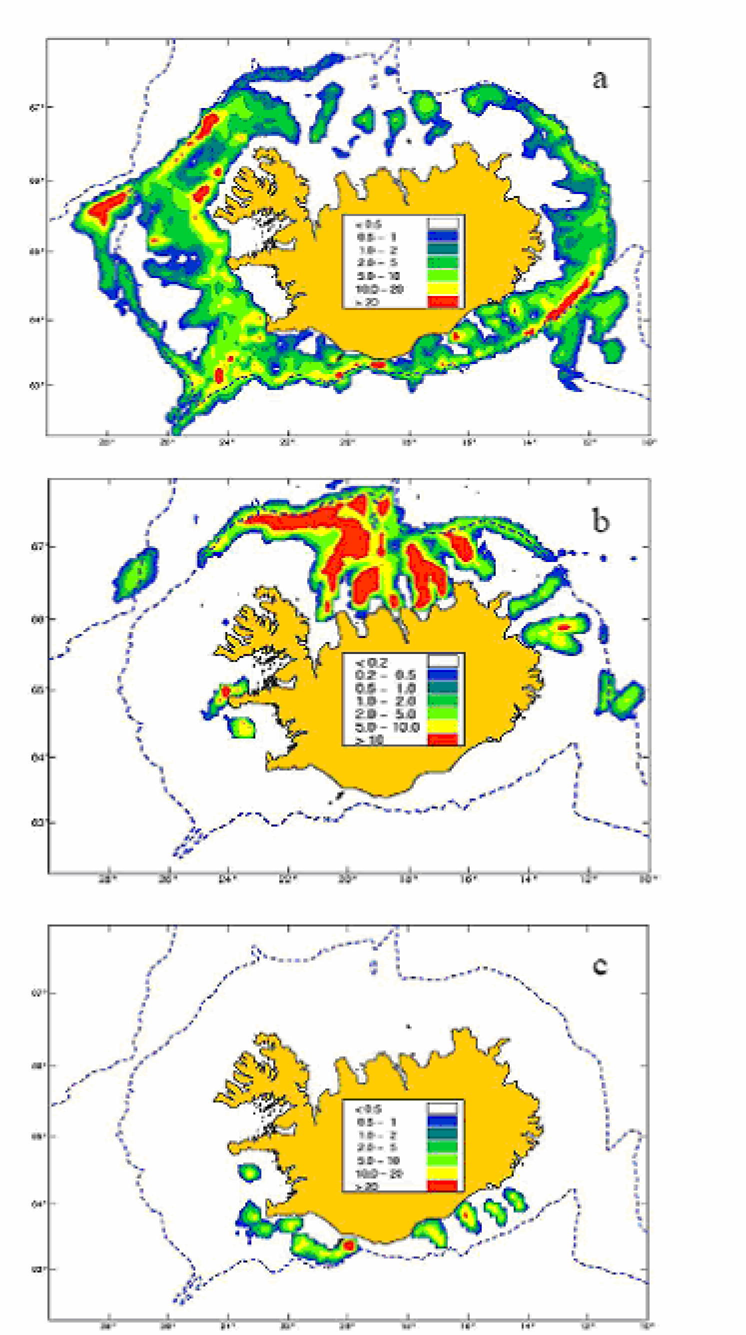


Figure 1.5.5.9.2.3 Distribution of total otter trawling effort (tow duration) in Icelandic waters targeting a) demersal fish, b) shrimp, and c) *Nephrops* between 2000 and 2004. The 300 m depth contour is shown (Garcia *et al.*, 2006).

Icelandic scallop stocks have been largely depleted following relatively stable catches, averaging about 10 000 tonnes in 1990–2000, partly due to high natural mortality and low recruitment. It was not possible to rule out the effects of fishing and all local scallop fisheries had been suspended by the year 2003. In Breiðafjörður, West Iceland, the stock was estimated in 2006 to be less than 30% of its average size between1993–2000 and at only some 20% of its estimated historical high in the early 1980s. Due to the heavy weight of the scallop dredges and a relatively high towing speed of up to four knots or more, the impact on benthic life is thought to be considerable. These areas had been mostly undisturbed by other towed-bottom gear prior to 1970. Total scallop trawling and dredging effort measured in fishing hours has decreased considerably over recent years (Figure 1.5.5.9.2.4), especially since early 1990 as a result of technological advances and the significant decreases in stock sizes of commercial fish species.

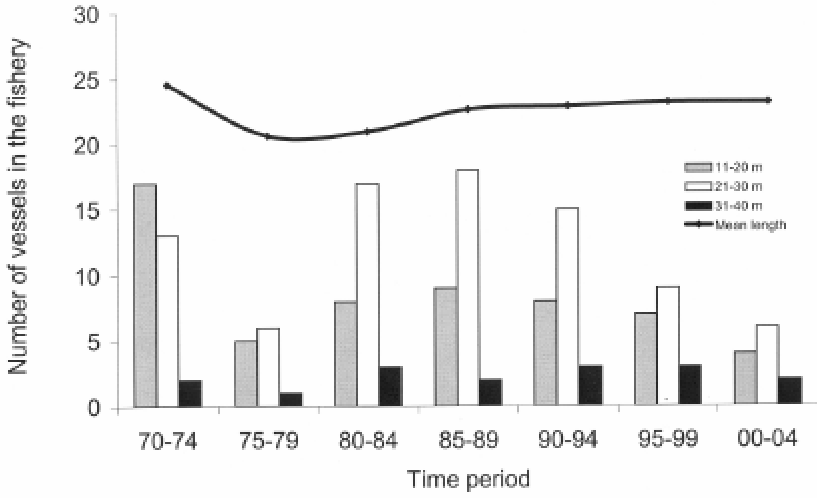


Figure 1.5.5.9.2.4 Number of vessels in the Icelandic scallop fleet and mean length of vessel 1970–2004, grouped in 5-year intervals (Garcia *et al.*, 2006).

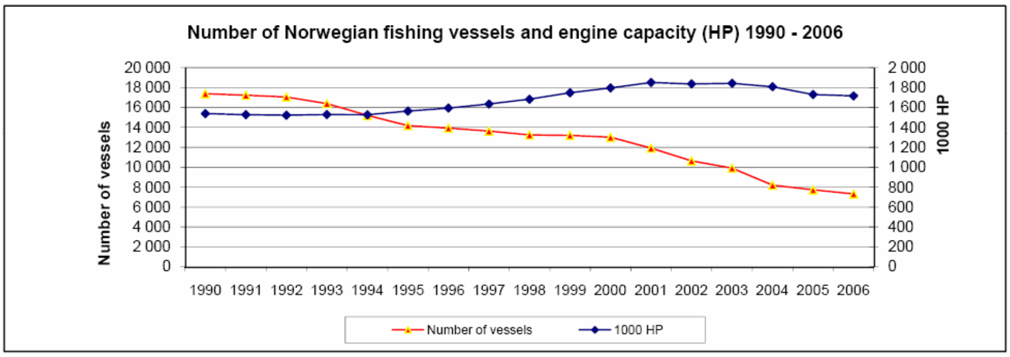


Figure 1.5.5.9.2.5 Number of Norwegian fishing vessels and aggregated engine capacity 1990–2006.

The Norwegian fishing fleet has been reduced in number of vessels since 1998, but the fishing capacity, measured in tonnes or horsepower, has been maintained (Figure 1.5.5.9.2.5). Partly due to the decline of traditional demersal and shrimp fisheries, trawlers turned to an offshore scallop fishery in the Jan Mayen, Svalbard, and Bjørnøya areas around 1985. In the peak years some 20–25 scallop trawlers, many with onboard freezing facilities, took part in the fishery towing up to three large dredges simultaneously. The Jan Mayen area was closed to dredging in 1987, although a small-scale fishery continued in other areas, mostly around Bjørnøya. Thus, total trawling and dredging effort has decreased in the Barents Sea and Svalbard areas in recent years compared to previous decades, as has happened in Iceland and Greenland (Figures 1.5.5.9.2.6 and 1.5.5.9.2.7). No trawling and dredging effort has taken place in Icelandic waters since 2003.

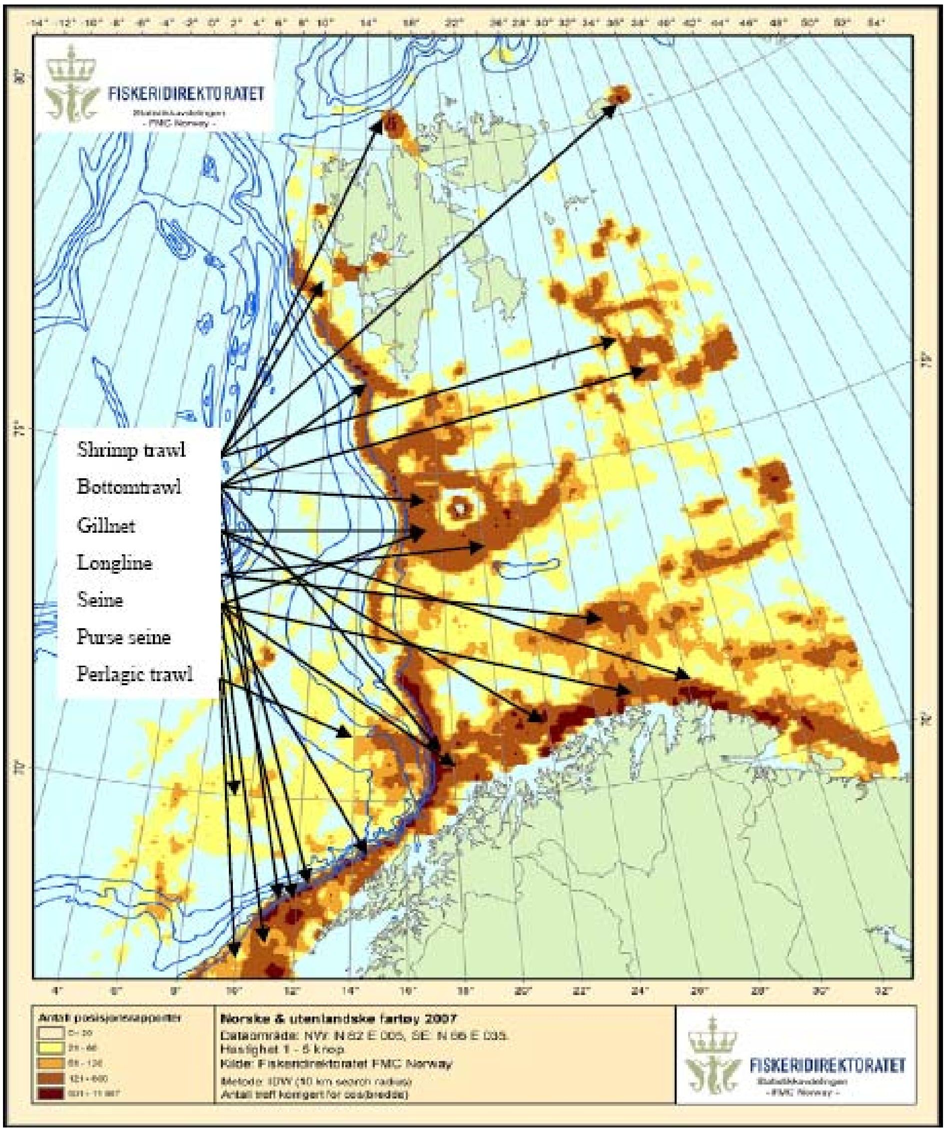


Figure 1.5.5.9.2.6 Distribution of fishing effort in the Barents Sea in 2007, based on Norwegian VMS data (vessels moving slower than 6 knots). Darker colour indicates a higher number of position reports.

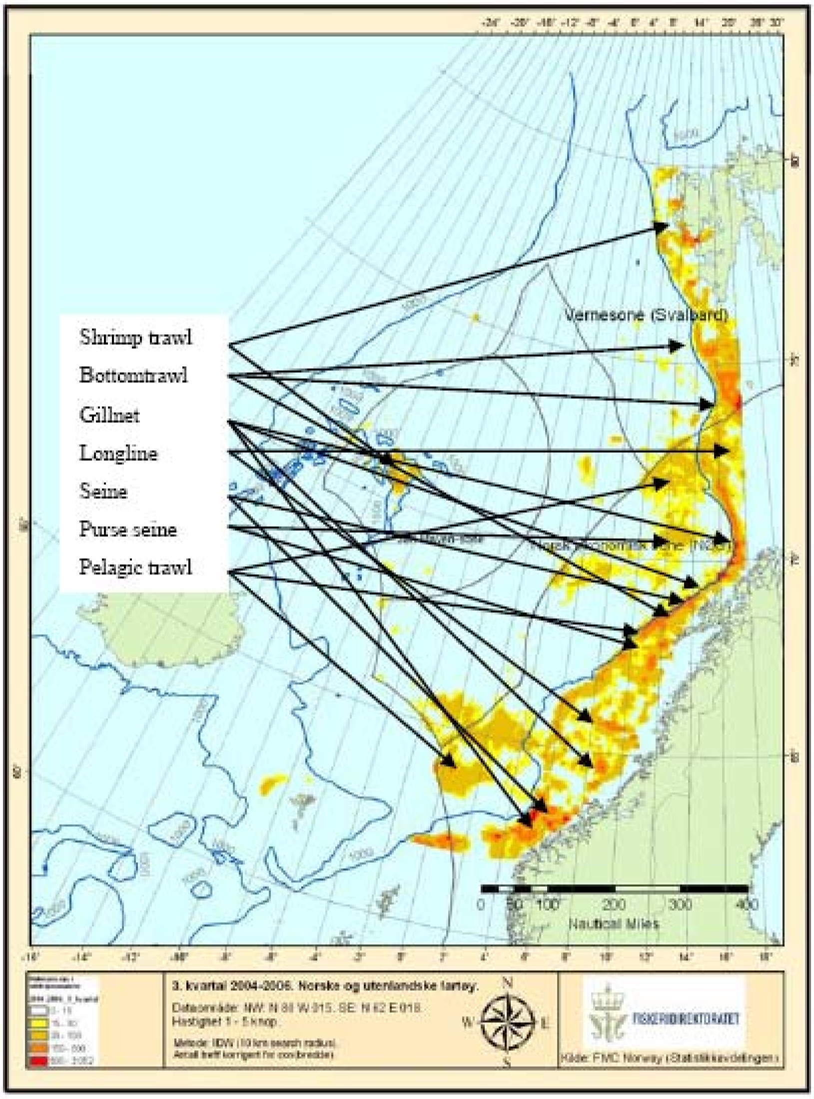


Figure 1.5.5.9.2.7 Distribution of fishing effort in the 3rd quarter in the Norwegian Sea, aggregated over the years 2004–2006, based on Norwegian VMS data (vessels moving slower than 5 knots). Darker colour indicates a higher number of position reports.

The geographic distribution of fishing effort in the Barents Sea and Norwegian Sea based on Norwegian VMS data shows the concentration of effort in inshore areas, on banks, and associated with ridges (Figures 1.5.5.9.2.6 and 1.5.5.9.2.7). Large areas receive little fisheries impact.

The main fisheries in Faroese waters are mixed-species, demersal fisheries, and single-species pelagic fisheries. There has been an increased effort in recent years in Faroese waters as the deep-water fleet has reduced its effort in other areas.

In the 1990s, a gillnet fishery directed at monkfish *Lophius piscatorius,* and Greenland halibut *Reinhardtius hippoglossoides,* developed in ICES Area Vb and is now well established; bycatches in this fishery are, among others, deep-sea red crab and blue ling. More recently exploratory trap fisheries for deep-sea red crab have been performed.

Impacts of fisheries on the ecosystem

Commercial fishing has direct and indirect effects on the marine ecosystem; these can be summarized as effects on:

1. commercial fish stocks;
2. non-target species, including birds, marine mammals, and discarded fish;
3. the seabed and associated benthic communities and habitats; and
4. community structure and food webs.

Effects on commercial fish stocks

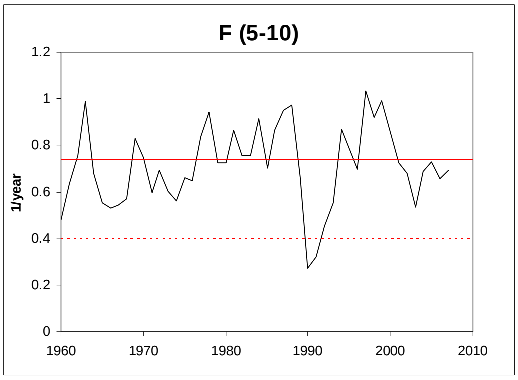
The most important impacts of fishing are likely to be on the fish stocks themselves. Fishing will usually change the age structure of a stock (fewer old and large individuals), and as the fishing mortality increases the spawning stock is likely to become smaller, and based on fewer year classes. This reduces a stock's ability to resist and recover from both natural and human pressures.

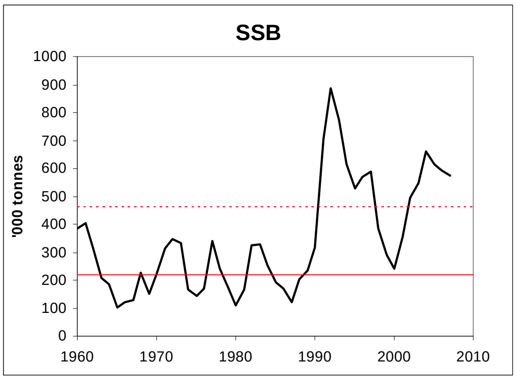
Biomass and fishing mortality limit reference points have only been defined for seven of the ICES assessed stocks allocated to Region I. Total landings from these stocks accounted for 40.75 million tonnes or 47.2% of the total reported landings of 86.28 million tonnes of fish and shellfish from this region in the period 1986 to 2006. Temporal trends in the spawning-stock biomass (SSB) and fishing mortality (F) of these stocks in relation to their limit reference points are shown in Figure 1.5.5.9.2.8.

ICES prefers to give precedence to an analysis based on stocks for which reference points have been defined as the main indicator of fishing impacts on commercial stocks because it is not straightforward to define stock status in relation to a management objective when reference points have not been defined. For demersal stocks, significant fishing impacts on assessed species are often indicative of significant fishing impacts on larger more vulnerable species that are not assessed, but taken as bycatch.

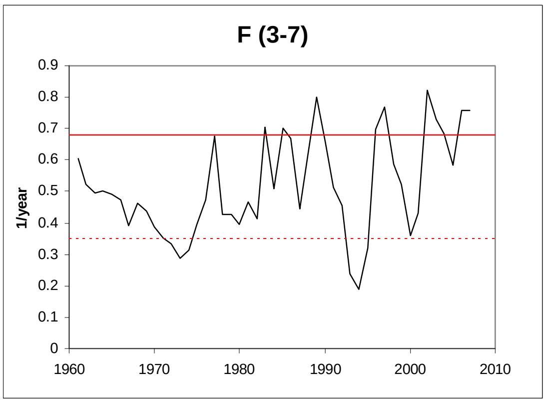
The overall status of assessed stocks for which all reference points have been defined is shown in Figure 1.5.5.9.2.9. To determine the status of assessed stocks in relation to reference points ICES used 2005 rather than 2007 estimates of F and SSB. This is because the 2007 estimates are less precise in the most recent time-series due to the so-called "convergence" feature of the methods used in fish stock assessment. Thus in 2005, 29% (i.e., 2) of those stocks were harvested unsustainably (Faroe Plateau cod (ICES Subdivision Vb1) and Faroe saithe (ICES Subdivision Vb)) with fishing effort, F, below F_{lim}. Of the remaining 5 stocks, 3 are at risk of being harvested unsustainably (Northeast Arctic cod (Subareas I and II), Northeast Arctic haddock (Subareas I and II), and blue whiting combined stock (Subareas I–IX, XII, and XIV) with F above F_{pa}. Faroe haddock (Division Vb) and Northeast Arctic saithe (Subareas I and II) are harvested sustainably. Only one stock, Faroe Plateau cod (ICES Subdivision Vb1) is suffering reduced reproductive capacity (Figure 1.5.5.9.2.9); all others have full reproductive capacity with SSB above precautionary levels (B_{pa}).

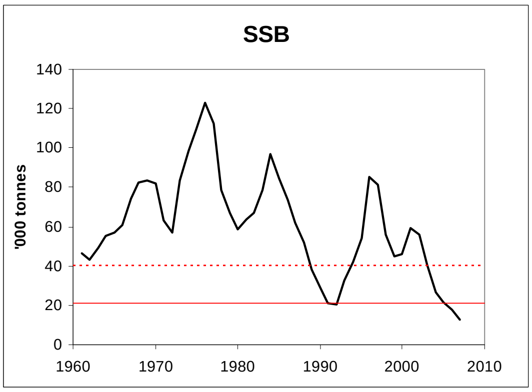
The biological reference points F_{pa} and B_{pa} are developed to increase precision in the most recent estimates F and SSB when developing fisheries management advice for fish quotas in the near future. Thus, when considering historical performance of fish stocks, F_{pa} and B_{pa} are not as relevant as F_{lim} and B_{lim} and the focus is therefore only on the limit reference points. This means that there is no distinction between stocks that are harvested sustainably and at risk of being harvested unsustainably (since in both cases $F > F_{lim}$), and no distinction is made between stocks at risk of suffering reduced reproductive capacity and at full reproductive capacity (in both cases $B < B_{lim}$). This is unfortunate, but does reflect the focus of current ICES advice on the avoidance of limits rather than the achievement of targets.



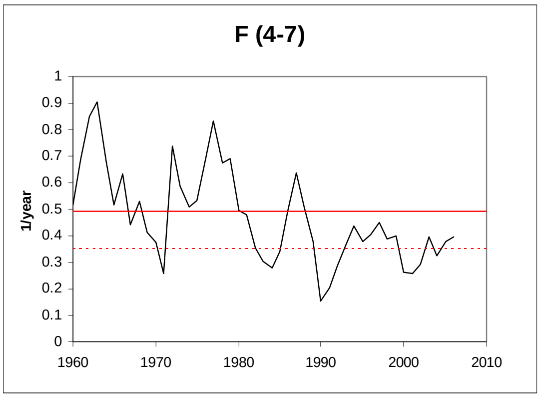


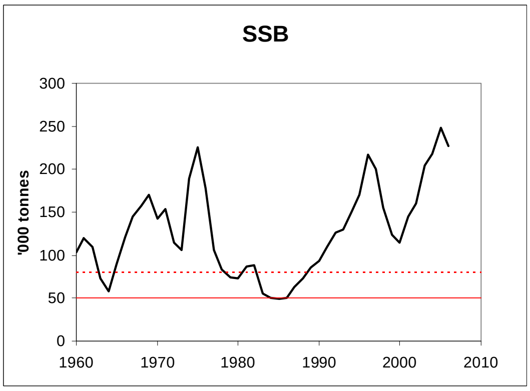
North-East Arctic cod (Sub-areas I and II)



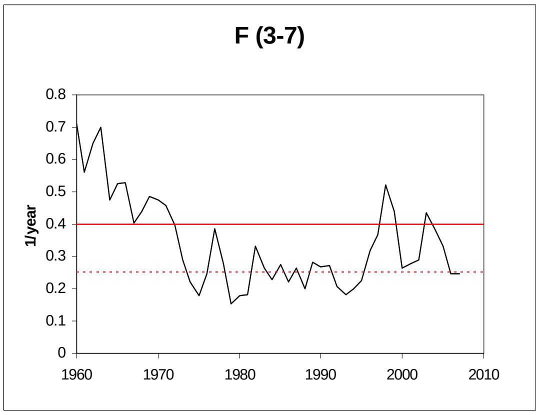


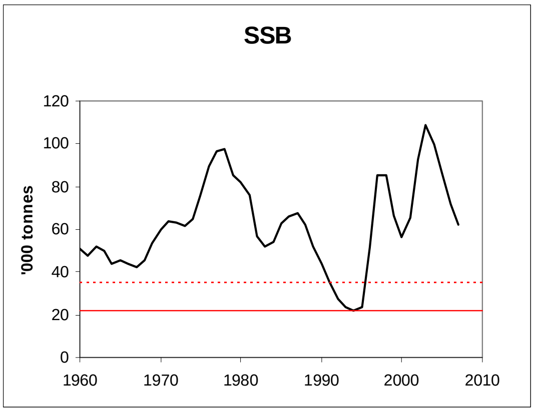
Faroe Plateau cod (Sub-division Vb1)



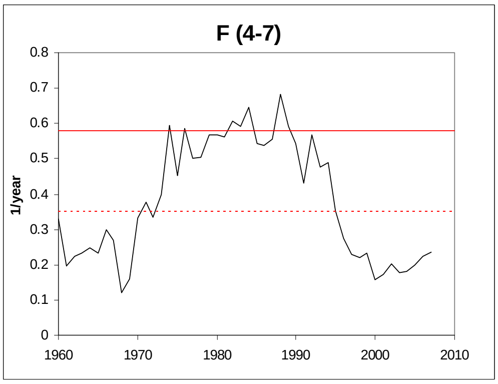


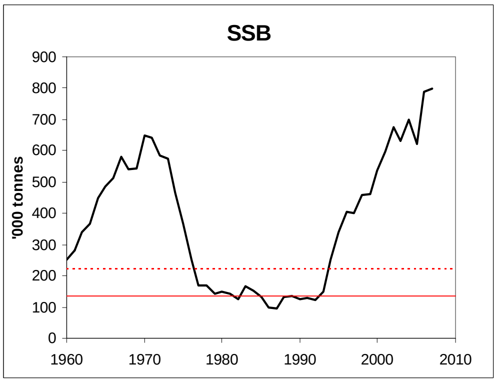
North-East Arctic haddock (Sub-areas I and II)



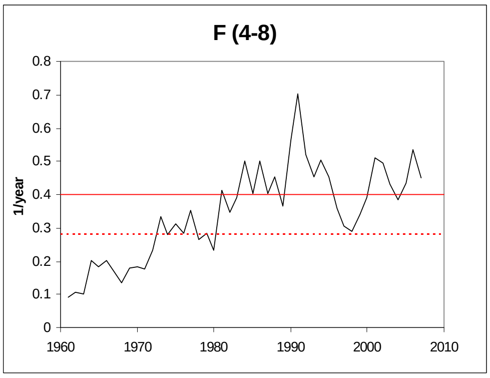


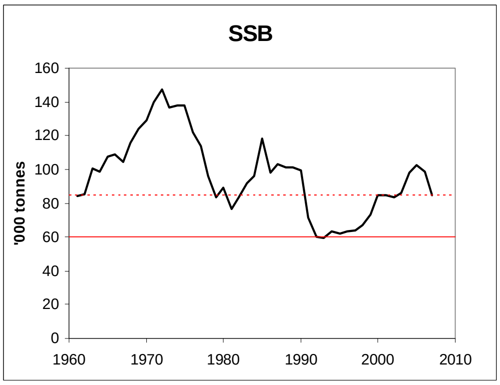
Faroe haddock (Division Vb)



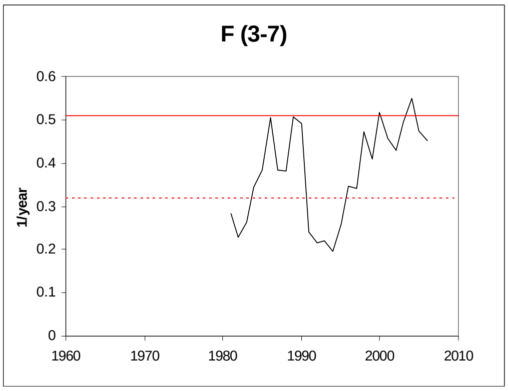


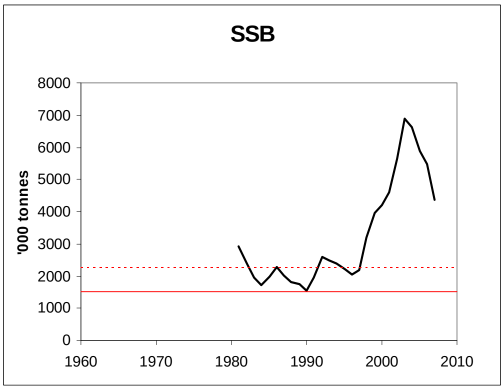
North-East Arctic saithe (Sub-areas I and II)





Faroe saithe (Division Vb)





Blue whiting combined stock (Sub-areas I-IX, XII & XIV)

Figure 1.5.5.9.2.8 Trends in fishing mortality (F) and spawning-stock biomass (SSB) in assessed stocks allocated to OSPAR Region I and for which fishing mortality and biomass reference points have been defined. Continuous red horizontal lines show the limit reference points (F_{lim} and B_{lim} respectively), while broken red horizontal lines show the precautionary reference points (F_{pa} and B_{pa} respectively, where defined). The age classes for which values of F were calculated are shown in parentheses.

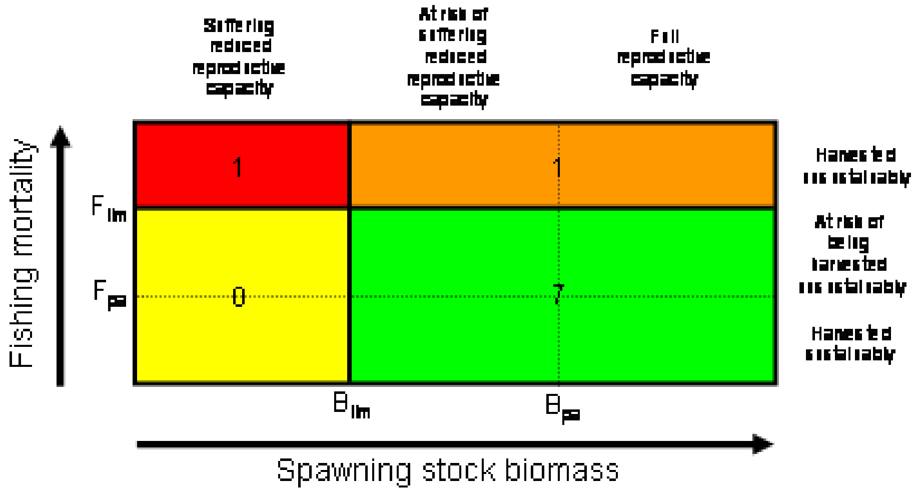


Figure 1.5.5.9.2.9 Summary of the status of assessed fish stocks in OPSAR Region I in 2005. Only those stocks for which F_{lim}, F_{pa}, B_{lim}, and B_{pa} have been defined are included.

Analyses have shown that the fisheries were a major factor driving the collapse of the stock of Norwegian spring-spawning herring observed during the late 1960s. The stock has gradually been rebuilt since the 1980s (ICES, 2008a).

The demersal fisheries in the Barents Sea are highly mixed, usually with a clear target species dominating, and with low linkage to the pelagic fisheries. Analyses show considerable catches of Norwegian coastal cod and redfishes *Sebastes mentella* and *S. marinus* in the mixed fisheries for Northeast Arctic cod.

Estimates of unreported catches of cod and haddock in the Barents Sea in 2002–2006 indicate that illegal, unreported, and unregulated fishing (IUU) is a considerable problem, adding around 20% to official catches in the period 2002–2005. Discarding of cod, haddock, and saithe is also believed to be significant in periods although the discarding of these and a number of other species, is illegal in both Norway and Russia. Data on discards are scarce. Haddock recruitment has been particularly strong in recent years. Except for 2001, all year classes between 1998 and 2003 have been strong. In fact, the 2003 year class is estimated to be the strongest in 45 years.

Northern shrimp off East Greenland in ICES Divisions XIVb and Va is assessed as a single population, separate from the offshore shrimp stock in northern Icelandic waters. The fishery started in 1978 and, until 1993, occurred primarily in the area of Stredebank and Dohrnbank as well as on the slopes of Storfjord Deep, from approximately 65°N to 68°N and between 26°W and 34°W. In 1993 a new fishery began in areas south of 65°N down to Cape Farewell. Access to these fishing grounds depends strongly on ice conditions. From 1996 to 2003 catches in the area south of 65°N accounted for more than 60% of the total catch. Catches and effort in the area south of 65°N in 2004 and 2005 only accounted for 29% and 47%, respectively, and decreased further in 2006 (Figure 1.5.5.9.2.10).

A multinational fleet exploits the East Greenland shrimp stock. In the recent ten years, vessels from Greenland, Denmark, the Faroe Islands, and Norway have fished in the Greenland exclusive economic zone (EEZ). Only Icelandic vessels are allowed to fish in the Icelandic EEZ. In the Greenland EEZ, the minimum permitted mesh size in the cod-end is 44 mm, and the fishery is managed through catch quotas allocated to national fleets. In the Icelandic EEZ, the mesh size is 40 mm and there are no catch limits. In both EEZs, sorting grids with 22 mm bar spacing to reduce bycatch of fish are mandatory. Discarding of shrimp is prohibited in both areas.

Total catches from the East Greenland shrimp stock increased rapidly to about 15 500 tonnes in 1987 and 1988, but declined thereafter to about 9000 tonnes in 1992 and 1993. Following the extension of the fishery south of 65°N catches increased again to about 13 800 tonnes in 1997. Catches from 1998 to 2003 have been around 12 000 tonnes, but have since decreased. Catches decreased in 2005 to 8000 tonnes and in 2006 further to about 5100 tonnes. Catches in 2007 were projected to stay at this level. Catches in the Iceland EEZ had decreased from 2002 to 2005, and no catches were taken in 2006 and 2007.

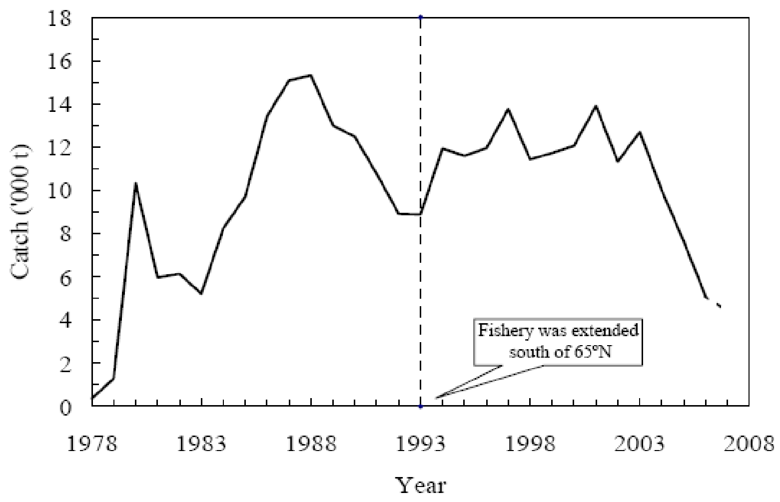


Figure 1.5.5.9.2.10 Total catch of shrimp in Denmark Strait and off East Greenland: (2007 catches until October 2007).

The Greenland fishing fleet, (catching 40% of the total East Greenland shrimp catch), has decreased its effort in recent years, and this creates some uncertainty as to whether recent values of the indices accurately reflect stock biomass. The decrease may be related to the economics of the fishery.

Effects on non-target species, including birds, marine mammals, and discarded fish

Incidental catch of non-target species in fishing gears remains an issue. Work is carried out within the framework of ICES in order to sort out the scale of unintentional bycatch of salmon in the pelagic fisheries in the Norwegian Sea, but no such major effects have been documented so far. Estimates of unreported catches of cod and haddock in the Barents Sea in 2002–2006 indicate that IUU fishing is a considerable problem; around 20% in addition to official catches in the period 2001–2005. Discarding of cod, haddock, and saithe is also believed to be significant, although discarding of these and a number of other species is illegal in both Norway and Russia.

Mortality of seabirds occurs in longline fisheries; however, the magnitude and species composition is unknown. In episodes of coastal invasion of arctic seals along the Norwegian coast large mortality of seals has been observed in net fisheries. This mortality has not been regarded as problematic for the state of the seal stocks due to the general good condition and low harvesting level of the stocks. The harbour porpoise, which is common in the Barents Sea region south of the polar front and is most abundant in coastal waters, is subject to bycatches in gillnet fisheries (Bjørge and Kovacs, 2005). In 2004 Norway initiated a monitoring programme on bycatches of marine mammals in fisheries, but no results are available yet.

Effects on the seabed and associated benthic communities and habitats

In the Norwegian Sea, loss of deep-water coral reefs has been documented in the eastern shelf areas and has resulted in area closures for bottom trawling. It is estimated that 30% to 50% of the coral areas may be impacted (Fosså *et al*., 2002). Up to the mid-1900s it was common for fishers as well as scientists to catch large 'Bubblegum Tree Coral' *Paragorgia arborea* (up to 4 m tall) in bottom gear. This situation has changed and large individual colonies of *P. arborea* are now rarely reported or seen. Large colonies of this species can be more than one hundred years old. Other species of coral, such as the octocoral *Primnoa* spp, are also slow-growing and long-lived and have decreased in abundance. In Faroese waters, trawling activity has caused a significant reduction in the distribution of the reef-building coral *Lophelia pertusa* on the shelf and bank slopes. This led the Faroese authorities to close three coral areas to trawling in 2004. The lack of detailed information on the distribution of soft and stony coral emphasizes a need for coherent mapping of species and habitats in all parts of the region (Klages *et al*., 2004; Garcia *et al*., 2006).

The impacts of experimental trawling have been studied on an offshore fishing ground in the Barents Sea (Kutti *et al*., 2005). Trawling seems to affect the benthic assemblage mainly through resuspension of surface sediment and through relocation of shallow burrowing infaunal species to the surface of the seafloor. These results have not been extrapolated to determine any total fleet effect.

Longlines and gillnets are also used for fishing in coral areas. In such areas, these fishing techniques may cause relatively little breakage and disturbance of corals per fishing operation, but due to the long recovery time, overall damage will depend on the frequency and intensity of fishing operations.

During ROV surveys of reef areas off Norway, lost longlines, gillnets, and other types of fishing equipment have been observed on the seabed. Lost nets have been found covering parts of the coral colonies, but the effect of this is not known. Lost gear may continue to fish for a long time (ghost fishing). The catching efficiency of lost gillnets has been examined for some species and areas, but at present no estimate of the total effect is available. A programme for retrieval of lost gear is in effect along the Norwegian coast towards the Norwegian Sea, and a high number of ghost fishing nets are retrieved.

Several bird-scaring devices have been tested in longline fisheries in the Norwegian Sea and a simple one, the bird-scaring line (Løkkeborg, 2003), not only reduces significantly bird bycatch, but also increases fish catch, as bait loss is reduced. This way there is an economic incentive for the fishers, and where bird bycatch is a problem, the bird-scaring line is used without any forced regulation.

Effects on community structure and food webs

The benthic assemblages of offshore sandy seabeds appear to be relatively unaffected by trawling disturbance due to common natural disturbance and large natural variability. Studies on impacts of shrimp trawling on clay-silt bottoms have not demonstrated clear and consistent effects, but potential changes may be masked by the more pronounced temporal variability in these habitats.

Three of the most important fish populations in Region I – herring, cod, and capelin – have all undergone changes in the last decades, due in part to overfishing of the fish predators which has very strong effects on fish community structure and the food web. With these fish linked to one another through their population dynamics, the overfishing of one or the other has repercussions on all. In the Barents Sea, years with good recruitment of herring and cod have typically resulted in poor capelin recruitment and, subsequently, a weak capelin stock size. Abundance of demersal species off Iceland has been decreasing irregularly since the 1950s, with aggregate catches dropping from over 800 Kt to under 500 Kt in the early 2000s.

Cod in Greenland's waters are at the edge of their range and thus subject to considerable fluctuations in abundance. It is therefore difficult to distinguish these fluctuations in such an important species in the foodweb with any shifts in community structure in these waters.

The impacts of experimental trawling have been studied on an offshore fishing ground in the Barents Sea. Trawling seems to affect the benthic assemblage mainly through resuspension of surface sediment and through relocation of shallow burrowing infaunal species to the surface of the seafloor.

References

Bjørge, A., and Kovacs, K. M. 2005. Report of the Working Group on Seabirds and Mammals. The Scientific Basis for Environmental Quality Objectives (EcoQOs) for the Barents Sea Ecosystem. Norway, 2005. (http://barentshavet.imr.no/).

Fosså, J. H., Mortensen, P. B., and Furevik, D. M. 2002. The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. Hydrobiologia, 471: 1–12.

Garcia, E. G., Ragnarsson, S. A., Steingrímsson, S. A., Nævestad, D., Haraldsson, H., Fosså, J. H., Tendal, O. S., *et al.* 2006. Bottom Trawling and Scallop Dredging in the Arctic: Impacts of fishing on non-target species, vulnerable habitats and cultural heritage. TemaNord 2006:529. Nordic Council of Ministers. 375 pp.

ICES. 2008a. Report of the Working Group for Regional Ecosystem Description (WGRED), 25–29 February 2008, ICES, Copenhagen, Denmark. ICES CM 2008/ACOM:47. 203 pp.

ICES. 2008. Report of the North-Western Working Group, 2008.

Klages, M., Thiede, J., and Foucher, J-P. 2004.The expedition ARKTIS XIX/3 of the research vessel POLARSTERN in 2003. Reports of Legs 3a, 3b and 3c. *Berichte zur Polarforschung und Meeresforschung,* 488, 355 pp.

Kutti, T., Høisæter, T., Rapp, H. T., Humborstad, O. B., Løkkeborg, S., and Nøttestad, L. 2005. Immediate effects of experimental otter trawling on a sub-arctic benthic assemblage inside Bear Island Fishery Protection Zone in the Barents Sea. *In*: Benthic Habitats and the Effects of Fishing. P. W. Barnes and J. P. Thomas (Eds.). American Fishery Society Symposia.

Løkkeborg, S. 2003. Review and evaluation of three mitigation measures – bird-scaring line, underwater setting and line shooter – to reduce seabird by-catch in the North Atlantic longline fishery. Fisheries Research, 60 (1): 11–16.

1.5.5.9.3 Regional QSR II: Greater North Sea

Introduction

The fish resources of the North Sea have been exploited for many centuries. At the peak of the fishery in the 1980s the North Sea provided almost 10% of the global reported fish landings, and the current landings (Figure 1.5.5.9.3.1) are still close to 3% of global landings.

Since the 1980s, the North Sea has supported major pelagic fisheries for herring and mackerel, demersal fisheries for whitefish (cod, haddock, whiting, saithe), flatfish (plaice, sole), and shellfish (*Nephrops*, crab, lobster, shrimp, scallops), and industrial fisheries focusing mainly on Norway pout and sandeels.

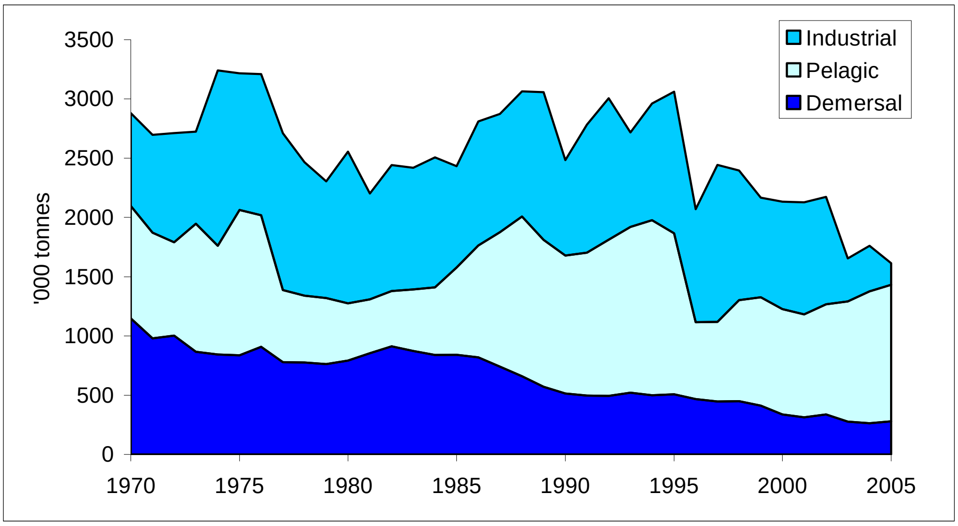


Figure 1.5.5.9.3.1 Landings (and discards) of industrial, pelagic, and demersal fisheries in the North Sea and Division IIIa (ICES, 2007 – Book 6, p. 31).

The development of fisheries management and policy since 1998, and an assessment of their effectiveness

The major driver of the patterns and intensity of fisheries exploitation in the greater North Sea in the last 10 years has been the introduction of specific management measures to halt the decline and promote recovery of the cod stocks ((EEC) No. 2847/93). As cod generally occur alongside other species, notably haddock, whiting, and in places *Nephrops,* the cod management measures have impacted other fisheries too.

Much management effort has been invested in promoting the recovery of the North Sea cod. Analysis of data and previous advice shows that cuts of at least 60% in the rate of fishing mortality from the high levels experienced in 2000 would be needed to promote recovery. The key to achieving recovery over a period of about a decade, short of complete closure of the North Sea, is through achieving a substantial reduction in F through reduced effort. Technical measures, while having a role to play, can only provide a modest reduction in F on cod.

In 2001, the EU implemented a 10-week area closure for parts of the North Sea because agreement could not be reached on catch or effort reductions. For 2003, a cod Total Allowable Catch (TAC) was agreed that was consistent with a 65% reduction in fishing mortality. The Recovery Plan was finalized in 2004 for cod stocks in the North Sea, Kattegat, west of Scotland, and the Irish Sea. For North Sea cod TAC levels were set that were predicted a 30% annual increase in spawning-stock biomass. In practice, the cut in quota had limited impact because it was not matched by the necessary cuts in effort.

Monitoring the progress of North Sea cod recovery is made difficult by uncertainties in stock assessments associated with low stock size, variable survey indices, and inaccurate catch data. Recent cuts in fishing mortality by restrictions on North Sea effort have reduced fishing mortality rates by about 37%. This is considered insufficient to ensure recovery to the precautionary spawning-stock biomass reference point (B_{pa}) of North Sea cod within the next decade. The EC regulation for cod was amended in 2004 to address this issue (*amending Regulation (EC) No. 423/2004 as regards the recovery of cod stocks and amending Regulation (EEC) No. 2847/93*) and speed the recovery of cod in community waters.

Sandeel landings in the North Sea dropped abruptly in 2003/4 to around 350 000 tonnes and further declined the following years as a result of the low total stock size. Landings remained low in 2007 due to a low TAC. In 2007 a TAC of 170 000 t was set for the whole of the North Sea. Because there was no agreement between EU and Norway on how to share the sandeel, the TAC was overfished by 21%, notwithstanding the fishing mortality in 2007 was at the historically lowest level. There are still several fishing grounds in the northern part of the North Sea that have very low abundance of sandeel. ICES advice for sandeel management is that local depletion of sandeel aggregations should be avoided, particularly in areas where predators congregate. Since 2000, the Firth of Forth area on the east coast of Scotland has been closed to ensure sandeel availability to other parts of the ecosystem, e.g. for breeding kittiwakes. In 2004 and 2005, the EU regulated the fishery using effort limitations, while Norway imposed a shorter fishing season in 2005 (1 April to 23 June) to protect 0-group sandeel. Mesh sizes in sandeel trawls are limited to less than 16 mm, and bycatches are restricted to a maximum five percent in the EU zone and 10% in the Norwegian zone. The spawning stock of sandeel has been at a low level for almost a decade until a recovery in 2008 and is considered to have had reduced reproductive capacity from 2001 to 2006. ICES have advised that in-year real-time management, based on monitoring of the sandeel fishery is desirable, to prevent overfishing.

In the North Sea, gear changes have since 1998 been driven by a combination of economic pressures, particularly fuel prices, a myriad of new technical measures, the introduction of the EU cod recovery programme leading to effort control measures, and also increasingly negative public perception forcing fishers in certain countries to adopt more selective gears.

Scottish and Danish demersal vessels tended to diversify away from more traditional methods such as seining and pair trawling/seining for cod, haddock, and whiting to twin and multi-rig gears, fishing with three or more nets targeting monkfish, *Nephrops,* and mixed demersal species. The main motivation was to reduce fuel combustion and/or improve catching efficiency through increasing the area swept by the gear. This has seen the development of new trawl designs with increased footrope lengths and long wings, so-called "scraper trawls", as well as designs incorporating wider mouth sections such as double bosom and double bag trawls. Net design for targeting roundfish species such as haddock, whiting, and cod in the North Sea have also developed over the period. Generally nets used in these fisheries are high standing heavy rockhopper trawls, allowing effective fishing even over the hardest bottom. Similar designs have also been employed by Scottish fishers specifically to target squid in inshore areas. This fishery has grown in importance in the period since 2005 and the trawls used are fished with 40 mm codends. Discarding of small cod and haddock has been reported to be high in this fishery. There has also been considerable experimentation with trawls constructed in low diameter, high tenacity polyethylene netting and materials such as dyneema to reduce drag. In many cases, when fuel prices were relatively low, the reductions in drag attained were negated as fishers have actually increased trawl size or increased towing speed in an effort to increase capture efficiency. In recent years this tendency has died out and fishers are increasingly down-sizing gear to reduce fuel consumption. The Norwegian fleet fishing for saithe in the northern North Sea is also increasingly using twin-trawl as opposed to the traditional single trawl, giving an approximately 1.9 increase in catch per unit effort with the twin trawl.

With the recent dramatic increases in fuel prices there has also been a trend amongst trawling fleets to use more fuel-efficient gears. There is evidence, particularly in Scotland, of fishers reverting back to seining and pair trawling/seining. In 2006 it was estimated that approximately 20 twin-rig vessels (16–30m) paired up and concentrated on mixed roundfish, e.g. haddock and whiting. The motivation for this was that vessels can catch their quota with a reduction in fuel cost by 33–50% and similarly fewer days at sea for each boat since the catching power (for haddock and whiting) of a vessel in a pair team may be up to 50 to 100% more than a single vessel operating on its own. The re-emergence in recent years of seining as a fishing method has been accompanied by a move to using much heavier seine rope (40–45 mm diameter), and also heavier footropes incorporating rockhopper sections to increase the range of seabed types that can be fished by seiners.

In both the Netherlands (from the beam trawl fleet) and France (demersal trawl fleet) there has also been a shift from beam trawling to Danish seining, again driven by increased fuel costs. These vessels have tended to target non-quota species such as red mullet, squid, and gurnard, as well as experimenting with trawl warps made of dynex rope and also switching to more fuel-efficient methods such as Scottish seining or gillnetting. These shifts seem likely to continue as fuel prices continue to rise.

Changes in the beam trawling fisheries prosecuted by the Netherlands, Belgium, and UK have focused on lessening the impact on benthic communities and diminishing discarding of target species, sole and plaice, but recently also to decrease fuel consumption. There has been considerable research into ways of reducing the drag of the beam trawl by decreasing the length of the beam or reducing the drag of the shoes (e.g. fly-beam, roller gear). The development of electrified beam trawling for flatfish species has also been tested in the Netherlands, although there are still concerns about the possible ecosystem effects of using this system. Beam trawl skippers are also reportedly towing slower and changing gear components, including using larger mesh sizes in forward parts of the trawl and thinner twines in codends. Since around 2004, some beam trawlers have begun to look at alternative fishing methods. These have included converting to outrigger trawling, i.e. towing two sets of smaller trawls from each beam with smaller trawl doors, changing over to single or twin-rig trawling, seining, or even changing to gillnetting and longlining. Indications are that this trend will continue in Belgium, the Netherlands, and the UK.

Over recent years the importance of the purse net in the North Sea to target pelagic species has declined with pelagic trawling gaining ground. Midwater trawling has the main advantage of being able to target the fish in deeper water than a purse net can be set in. In Scotland and the Netherlands the tendency has been to use large circumference, large mesh trawls for mackerel and horse mackerel, and smaller circumference, smaller mesh trawls for targeting herring. In Scotland pelagic trawling began as a pair fishing method; however, with the arrival of new modern vessels, they now have sufficient power to single trawl. Single boat pelagic trawlers have also adopted modern, hydrodynamic buoyant trawl doors, and there has also been a tendency to fish nets tight to the seabed, particularly when targeting horse mackerel. Most of the design modifications have been stimulated by the need to improve fishing efficiency by increasing trawl opening, improving water flow within the gear, and also improving fish quality through reduced damage against the mesh.

Developments in static gear fisheries have been fairly limited since 1998 in the North Sea. There has been an increase in the use of multi-wall trammel nets for targeting sole, particularly in the Channel. A shift of effort by deep-water gillnetters targeting monkfish from Area VI and VII into the northern North Sea has also been noted, following the introduction of new EU regulations in 2006 restricting the activities of vessels in this fishery with respect to gear length, soak times, and maximum depth. This effort shift is reported to be quite substantial and may lead to gear conflict and the ghost net issues which have occurred in western waters. Another issue to note with respect to static gear fisheries is that driven by high fuel prices, a number of North Sea countries have been experimenting with pots for *Nephrops* and also lately for fish species, particularly cod and ling. Initial indications are that potting for fish is technically possible, but economic viability is questionable at this stage. There has also been an increase in the use of automatic jigging machines for pollack, mackerel, and to a limited extent squid in inshore waters around the UK.

There have been several developments in fish finding and gear monitoring equipment on-board vessels and a number of North Sea fleets have adopted these devices. For instance, Belgium beam trawlers are increasingly being equipped with 3D mapping sonar which has opened up new areas to fishing (close to wrecks). This 3D system opens more grounds that were previously unfishable. Another development seen in the Dutch beam trawl fleet is the installation of automatic winch controls, thus avoiding gear fasteners leading to smaller losses in fishing time, and possibly working on new grounds. Pelagic vessels and indeed larger demersal trawlers have increasingly fitted very sophisticated sonar and used sensors fitted to the trawls to monitor gear performance, particularly flow and trawl symmetry as well as catch size and gear damage. There is also increasing use of econometers to monitor fuel consumption.

Considerable research into fishing gear-based measures to improve selectivity has been undertaken in the North Sea over the period. The different behaviours exhibited by the main discarded species in trawl fisheries have increasingly been exploited to improve the selectivity of trawls. Whiting and haddock rise when inside the trawl, while *Nephrops* and cod remain near the bottom. Separating cod, and other groundfish, from *Nephrops* remains the most challenging task for gear technologists. Designs involving square mesh panels, constructed with differing mesh sizes, materials, and positioning within the trawl have been tested extensively (see Section 4.3.4.2). Modified selective trawl designs incorporating escape panels or separator panels as well as rigid sorting grids have also been trialled. Despite this research, very few of these designs have been adopted into legislation and voluntary uptake remains low in the absence of real incentives. Nevertheless, with the recent adoption of effort restriction management in the North Sea by the EU as a way to maintain or increase fishing opportunities, fishers have increasingly moved to selective gears. In Sweden, for instance, a result of the extra effort and also national legislation requiring the use of species-selective *Nephrops* trawls has been a steady increase in the use of a rigid Nordmore grid in the *Nephrops* fisheries in the Skagerrak and Kattegat areas.

A number of gear modifications have been tested to improve fish selectivity in flatfish beam trawls, aimed at reducing demersal fish discards in the flatfish beam trawl fisheries. In general it was found that species selectivity of beam trawls could be improved with respect to whiting and haddock, but much less so for cod. In the framework of the Council Regulation laying down certain technical measures for the conservation of fisheries resources (850/98), a general increase in mesh size and the use of square mesh panels in towed gears was suggested to improve the selectivity of towed fishing gears. On the 19th of October 2001, EU Regulation 2056/2001 was adopted, establishing additional technical measures for the recovery of the stocks of cod in the North Sea and to the west of Scotland. It included a provision that the minimum codend mesh size of beam trawls in the North Sea must be 80 mm south of 56°N, and 120 mm north of 56°N (with a restricted area in the western part of the central North Sea, where codends of 100 mm mesh size were made compulsory). However, a general increase in mesh size as first suggested in earlier drafts of the regulations, was firmly rejected due to perceived losses of sole catches. These regulations also included the mandatory insertion of a panel of no less than 180 mm in the top panel of all beam trawls. The effects of the top panel have not been assessed. Mitigating the effects of flatfish beam trawls on benthic invertebrates has also been investigated by the Dutch, Belgian, and UK fleets. Bycatch mortality of benthic organisms accounts for 5–10% of the total benthic mortality caused by beam trawling. Commercially acceptable technical modifications have also been developed for the catch mortality. The benthos release panel tested in UK, the Netherlands, and Belgium seems to be a simple and practical solution to release bycaught benthic invertebrates from a flatfish beam trawl without substantial loss of commercial fish species. The mesh size used needs to balance the need to reduce the benthos catch against the loss of commercial fish species through the panel. Based on the research work carried out with this gear modification, a mesh size of 150 mm seems to be the best compromise. The benthos release panel has been used voluntarily by some beam trawlers since 2005. In January 2003, legislation was introduced requiring all fishers in the EU *Crangon crangon* (brown shrimp) beam trawl fisheries to use selective gear (sieve net or a selection grid) that reduces the incidental bycatch of juvenile commercial fish species (see Section 4.3.4.3). Compliance is reportedly to be reasonably high and the discard problem in this fishery has been partially negated; however, issues regarding 0-age plaice and the introduction of derogations allowing vessels to fish without the sieve net are identified as problems in such fisheries in the North Sea.

Due to the bycatch of harbour porpoises, the use of acoustic devices, or 'pingers', was made mandatory for gillnet fisheries from June 2005 in the North Sea and western Channel, and in the eastern Channel in 2007, for all vessels over 12 m (see Section 4.5.3.). Since its inception a number of practical, technical, and economic issues have arisen that have largely negated effectiveness of this regulation. According to ICES (2008a) only Denmark and Sweden have fully implemented this regulation in the North Sea. There is ongoing German research to develop a device for monitoring acoustic deterrent devices at sea on patrol vessels.

Bycatch of common dolphins has also continued in the Channel bass fishery prosecuted by French and Scottish pelagic trawlers. Research into possible mitigation measures is ongoing and looking mainly at acoustic deterrent devices and excluder grids or panels. Some promising results have been found, but the work remains in a developmental phase.

The insertion of a square-mesh panel into the topsheet of single-rigged *Nephrops* trawls has been mandatory since 1991/92 and an additional 140 mm diamond mesh panel inserted behind the headline since January 2002. Furthermore, prior to 2002 the minimum legal codend mesh size was 70 mm for single-rigged trawls, but since January 2002, this has been increased to 80 mm. The threat of severe restrictions to fishing opportunities or closure of the English *Nephrops* fishery in 2002 in conjunction with the new regulations imposed on other fisheries provided the incentive to implement these gear changes.

The composition of catches was monitored just before and after these regulatory changes. The trawl modifications demonstrated a reduction in discard rate for whiting of 11%. A second more recent study, utilising observer data to compare a longer period before and after the introduction of these changes has also shown that whiting selectivity has improved.

It is apparent that technical measures, i.e. the gear modifications highlighted can in this case provide a partial solution to discarding problems in the North Sea *Nephrops* fisheries.

In January 2003, legislation was introduced requiring all fishers in the European *Crangon crangon* (brown shrimp) fisheries to use selective gear (sieve net or a selection grid) that reduces the incidental bycatch of juvenile commercial fish species. Each member state was responsible for implementing their own legislation enforceable within their national waters. The efficacy of the UK legislation (The Shrimp Fishing Nets Order) was formally evaluated in a multidisciplinary study using social, biological, and economic methods. The analysis of the societal aspects of the changes seen after the introduction of the legislation was used to identify the changes in fleet structure and fishing patterns and the extent of compliance and enforcement. The biological analysis evaluated the performance of commercially used selective gear and also identified changes in fish stocks of bycatch species. The economic analysis assessed the economic implications of the legislation. The retrospective change in productivity of the brown shrimp fleet as a consequence of the use of sieve nets was estimated using a production function approach. The analysis utilized vessel logbook data, detailing brown shrimp landings by individual trip during the period January 1999 to August 2006. The analysis showed a reduction in fleet productivity of 14% following the introduction of the legislation.

The gear measures introduced into the *Crangon* beam trawl fisheries have largely been effective although the introduction of derogations for some fleets has reduced the effectiveness. This has been a weakness in a number of technical measures regulations.

Fishing activities in OSPAR Region II – Greater North Sea

The amount of fishing effort, expressed in terms of kW days-at-sea and total hours fished, has declined by around 25% from 2000 to 2006 (Figures 1.5.5.9.3.2, 1.5.5.9.3.3, and 1.5.5.9.3.4). Both otter and beam trawling show similar patterns of decline, the greatest change occurring from 2002 to 2003 with the measures, particularly effort control (days-at-sea limits), introduced as part of the CFP reform. In part this reduction in vessel effort may be offset by increases in the fishing efficiency through improved gear design and use (technical creep), hence changes in effort are not directly related to changes in mortality.

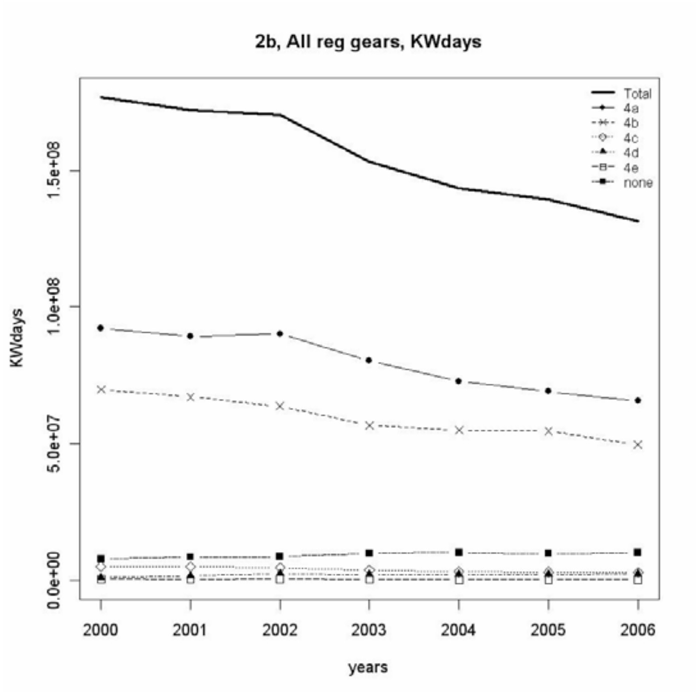


Figure 1.5.5.9.3.2. Trends in nominal fishing effort (kW*days-at-sea) in the Skagerrak, North Sea, & Eastern Channel by gear type. Gear codes are 4a: demersal trawl, 4b: beam trawl, 4c: gillnet, 4d: trammelnet, 4e: longline, none: unidentified (STECF, 2007).

Roundfish are caught in otter trawl and seine fisheries, with a 120 mm minimum mesh size. This is a mixed demersal fishery with more specific targeting of individual species in some areas and/or seasons. Cod, haddock, and whiting form the predominant roundfish catch in the mixed fisheries, although there can be important bycatches of other species, notably saithe and anglerfish in the northern and eastern North Sea and of *Nephrops* in the more offshore *Nephrops* grounds.

Beam trawling takes place predominantly in the southern North Sea. As total beam trawl effort has declined, effort has reduced more or less evenly across the entire impacted area (Figure 1.5.5.9.3.3). Otter trawling targeting fish takes place across the entire North Sea, but with activity levels highest in the north. As total effort has declined the greatest reductions have occurred in this northern region (Figure 1.5.5.9.3.4). Otter trawling targeting *Nephrops* is generally restricted to specific muddy areas of the North Sea that are the preferred habitat of the target species. Effort levels by this gear increased over the period for which spatial information was available, and this has been associated with an expansion of this fishing activity into new areas (Figure 1.5.5.9.3.5). Seine nets are mainly used in the northern North Sea with little or no use of this gear in the extreme south. As total seine effort has declined, marked reductions in activity have occurred in the northern North Sea, but the extent of the area impacted has also declined (Figure 1.5.5.9.3.6).

STECF (2007) concluded that there had been no large-scale and consistent changes in the recent geographical distribution patterns of demersal trawl effort, although local variations in the intensity and distribution of fishing effort have been observed and there was a consistent shift in the distribution of beam trawlers using 70–89 mm and ≥120 mm mesh. These beam trawlers, from Belgium, Germany, and UK, fish more frequently in the southern North Sea (Figure 1.5.5.9.3.3). It remains unclear whether the observed changes in the distribution of beam trawling effort are due to changes in the abundance of target stocks, economic considerations, or effort regulations.

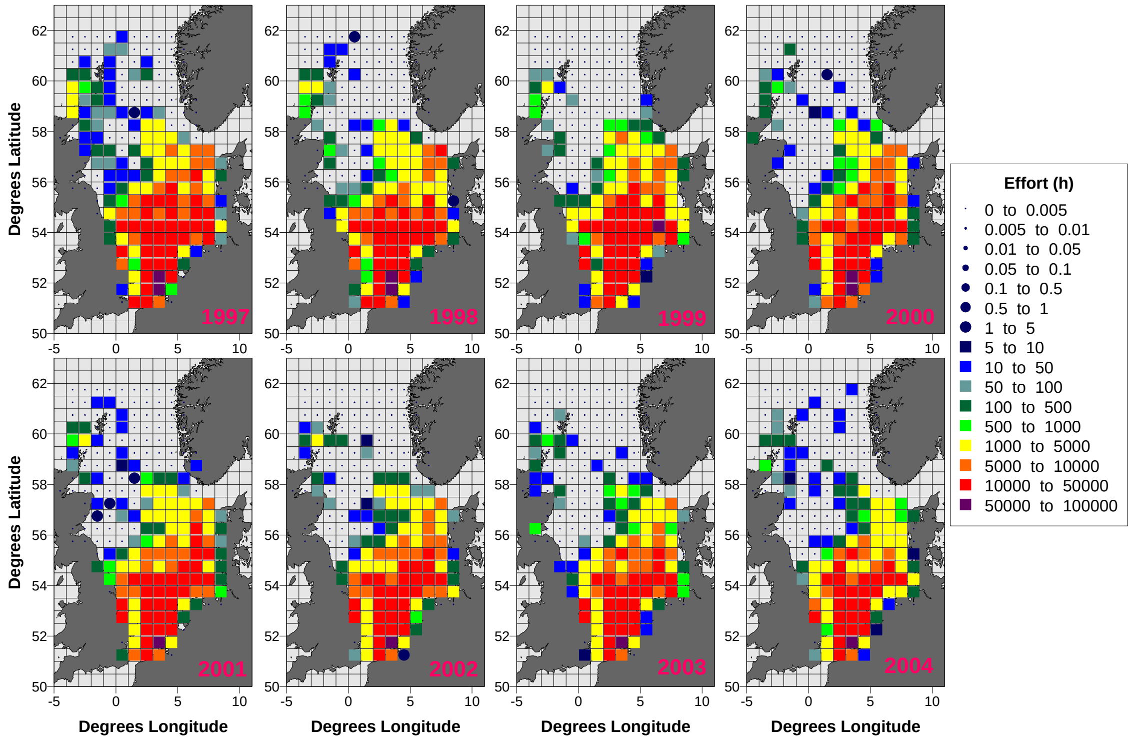


Figure 1.5.5.9.3.3 Spatial distributions of fishing effort (hours-fishing) using beam trawl by the nine major fishing nations operating in the North Sea in each of the years between 1997 and 2004. Greenstreet *et al.*, 2007.

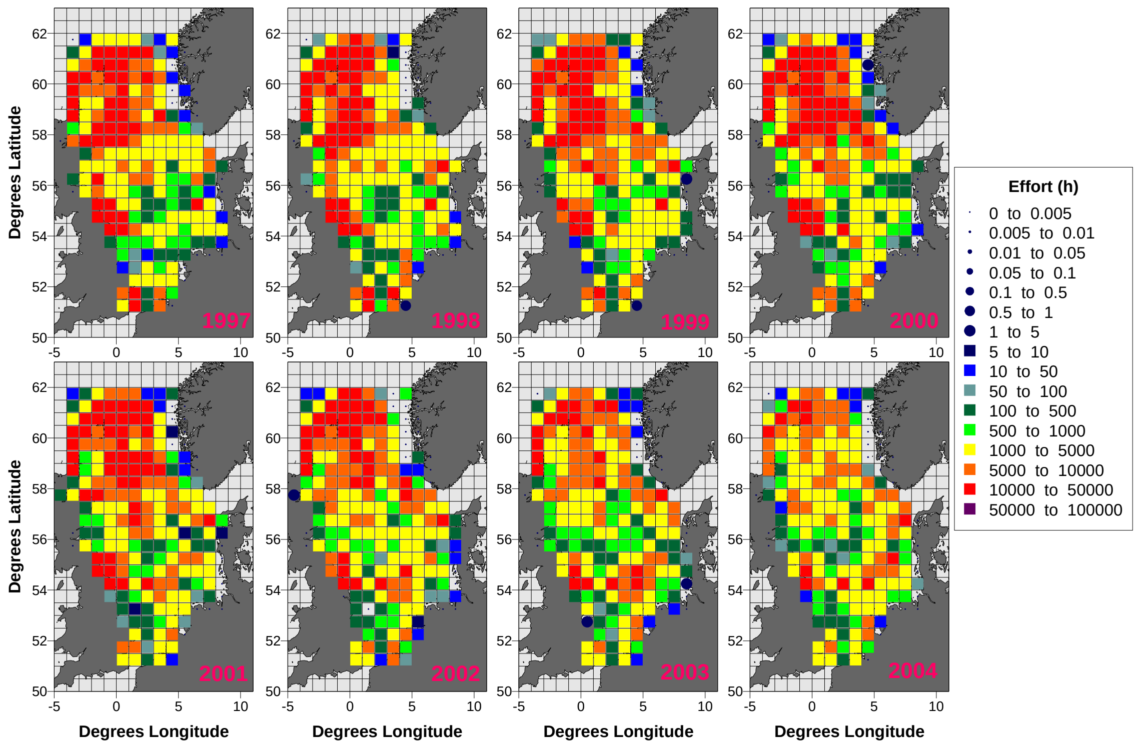


Figure 1.5.5.9.3.4 Spatial distributions of fishing effort (hours-fishing) using otter trawl directed at fish for human consumption by the nine major fishing nations operating in the North Sea in each of the years between 1997 and 2004. Greenstreet *et al.*, 2007.

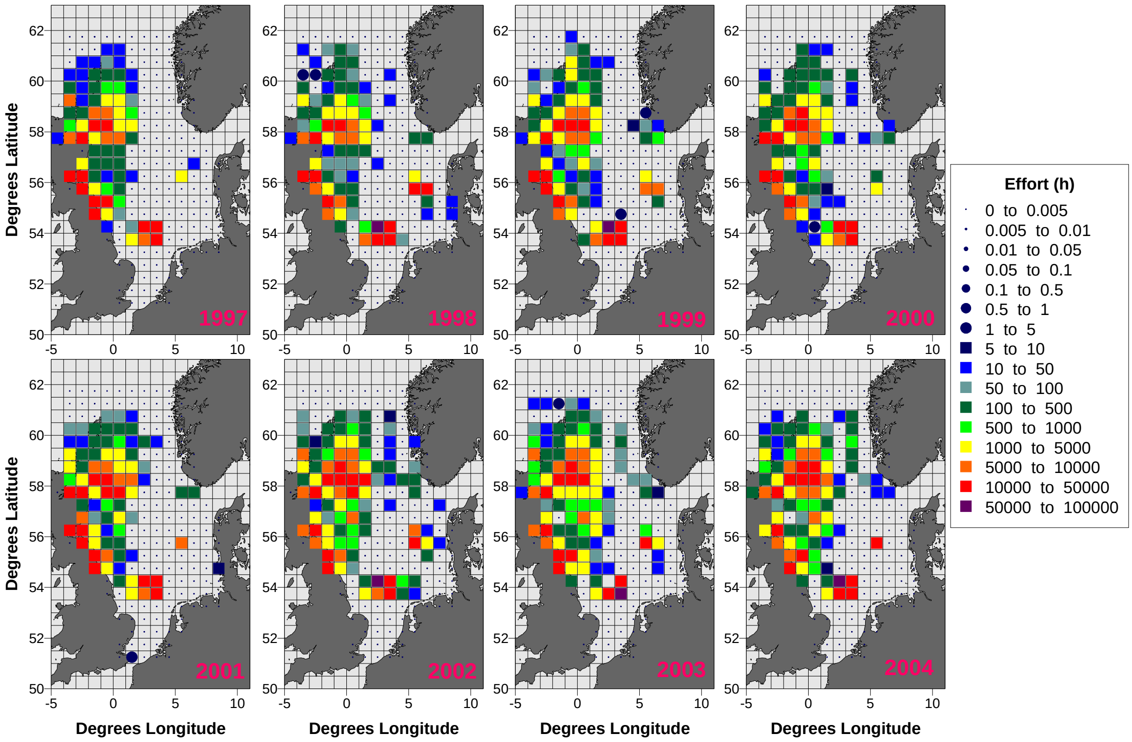


Figure 1.5.5.9.3.5 Spatial distributions of fishing effort (hours-fishing) using otter trawl directed at *Nephrops* by the nine major fishing nations operating in the North Sea in each of the years between 1997 and 2004. Greenstreet *et al.*, 2007.

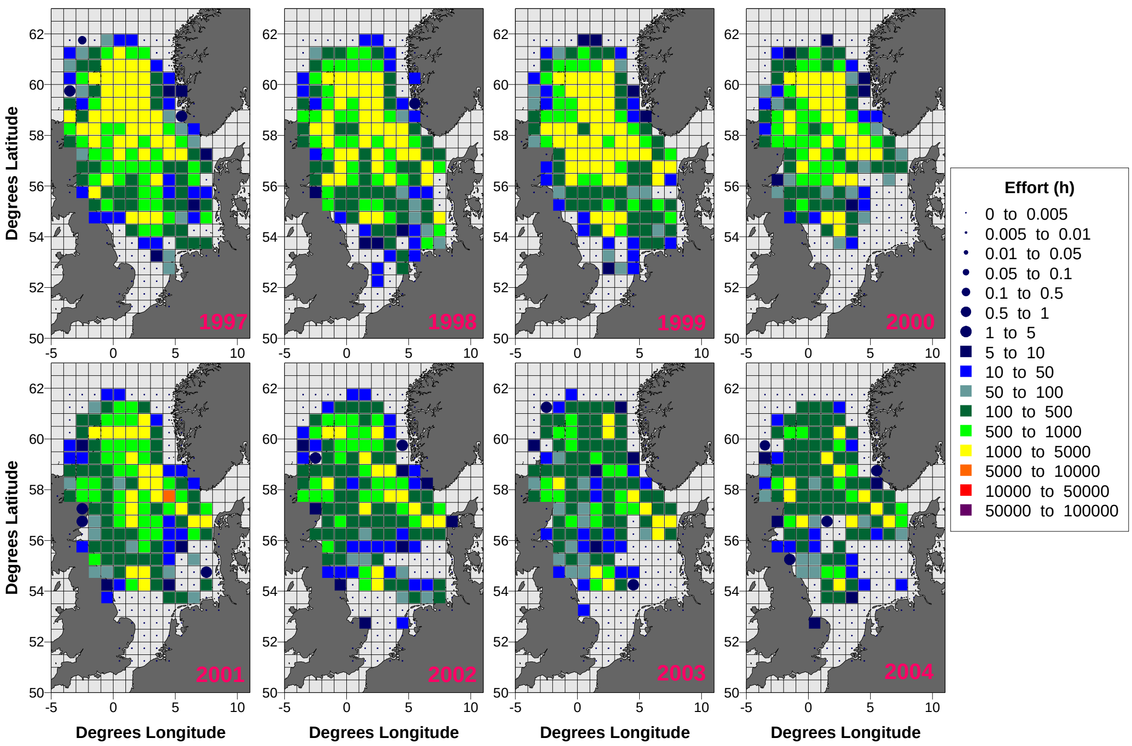


Figure 1.5.5.9.3.6 Spatial distributions of fishing effort (hours-fishing) using seine gear by the nine major fishing nations operating in the North Sea in each of the years between 1997 and 2004. Greenstreet *et al.*, 2007.

Impacts of fisheries on the ecosystem

Commercial fishing has direct and indirect effects on the marine ecosystem, which can be summarized as effects on:

1. commercial fish stocks;
2. non-target species, including birds, marine mammals, and discarded fish;
3. the seabed and associated benthic communities and habitats;
4. community structure and food webs.

Effects on commercial fish stocks

Biomass and fishing mortality limit reference points have only been defined for nine of the stocks assessed by ICES and allocated to Region II. Total landings from these stocks accounted for 13.11 million tonnes, or 20.5% of the total reported landings of 64.02 million tonnes of fish and shellfish from this region in the period 1986 to 2006. Temporal trends in the spawning-stock biomass (SSB) and fishing mortality (F) of these stocks in relation to their limit reference points are shown in Figure 1.5.5.9.3.7.

ICES prefers to give precedence to an analysis based on stocks for which limit reference points have been defined as the main indicator of fishing impacts on commercial stocks, because it is not straightforward to define stock status when limit reference points have not been defined. For demersal stocks, significant fishing impacts on assessed species are often indicative of significant fishing impacts on larger, more vulnerable species that are not assessed, but are taken as bycatch.

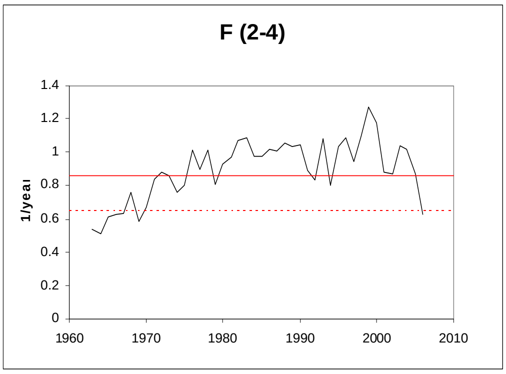
To determine the status of assessed stocks in relation to reference points we used 2005 rather than 2007 estimates of F and SSB. This is because the 2007 estimates are less precise in the most recent time-series due to the so-called “convergence” feature of the methods used in fish stock assessment. The overall status of assessed stocks for which all reference points have been defined is shown in Figure 1.5.5.9.3.8. Thus in 2005, the reference year, five of the nine stocks were harvested unsustainably and/or suffering reduced reproductive capacity.

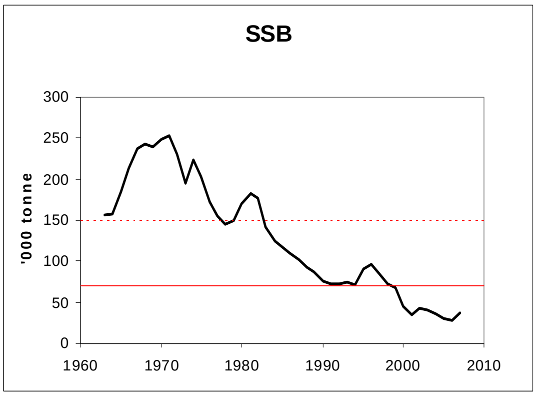
When considering the historical state of fish stocks and their management, F_{pa} and B_{pa} are not as relevant as F_{lim} and B_{lim}. For this reason the analyses focused only on the limit reference points. This means that no distinction was made between stocks that are harvested sustainably and those at risk of being harvested unsustainably (since in both cases $F > F_{lim}$), and no distinction was made between stocks at risk of suffering reduced reproductive capacity and those at full reproductive capacity (in both cases $B < B_{lim}$). This is unfortunate, but is also consistent with the focus of current ICES advice on the avoidance of limits rather than the achievement of targets.

Fishing mortality is generally high for several demersal stocks in the North Sea, but there are indications that fishing mortality on some stocks has been decreasing in recent years (Figure 1.5.5.9.3.7). This is consistent with the observed decrease in fishing effort due to days-at-sea regulations and decommissioning in the major fleets. Assessments of cod *Gadus morhua*, in the North Sea, Skagerrak, and eastern English Channel (North Sea cod), show trends in spawning-stock biomass (SSB), the mature component of the stock, declining from a peak of 250 000 t in the early 1970s to around 40 000 t. The stock is below the limit reference point of 70 000 t, indicative of a stock that is suffering reduced reproductive capacity

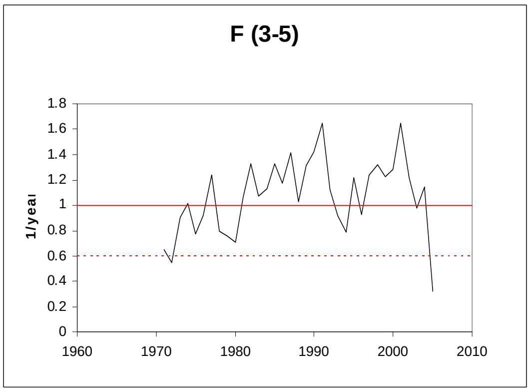
The centre of the distribution of cod in the North Sea has moved north, associated with the different sub-population responses to both warming and differing spatial fishing pressures. Although cod remain widely dispersed, survey data have shown a contraction of distribution within the range so that most young cod are now found in just 40–50% of the North Sea, compared with 90% when cod were at their most abundant. There appears to have been a particular reduction in the spawning intensity in the Southern Bight, but other spawning locations have remained unchanged.

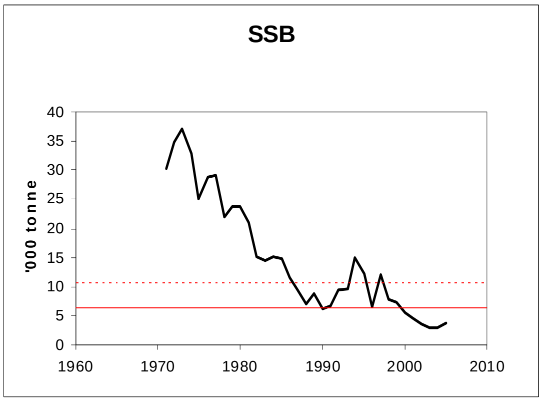
OSPAR II



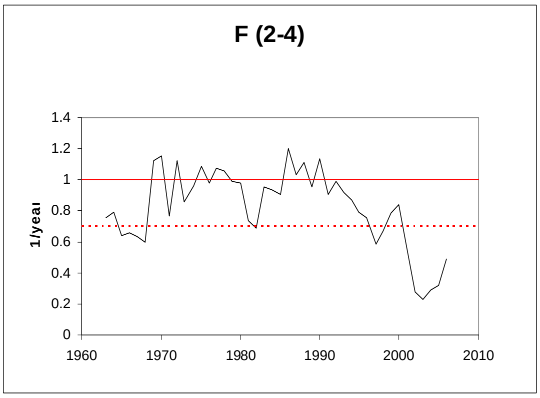


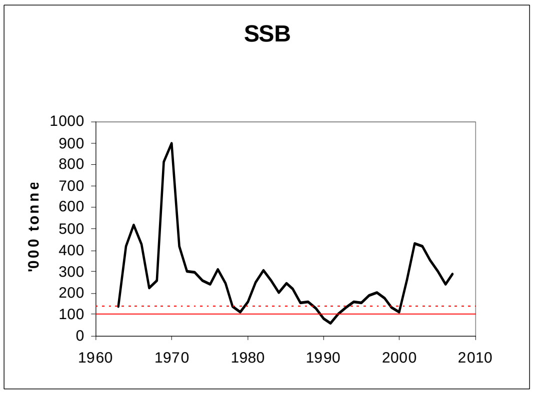
Cod in Sub-area IV, Divison VIId & Division IIIa (Skagerrak)



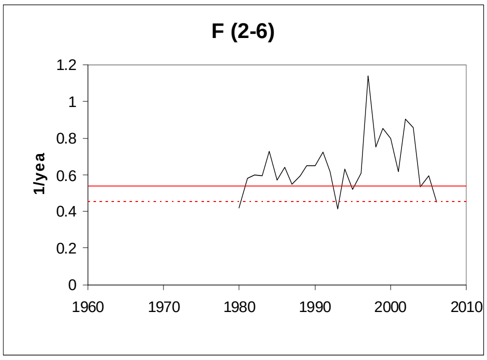


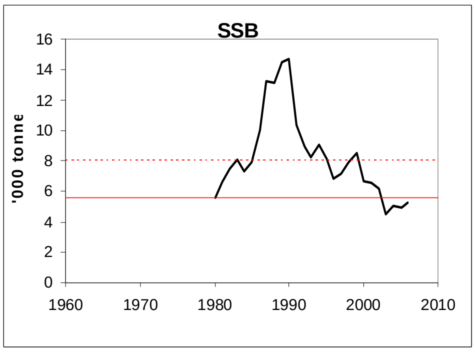
Cod in the Kattegat (part of Division IIIa). Data from the 2006 assessment



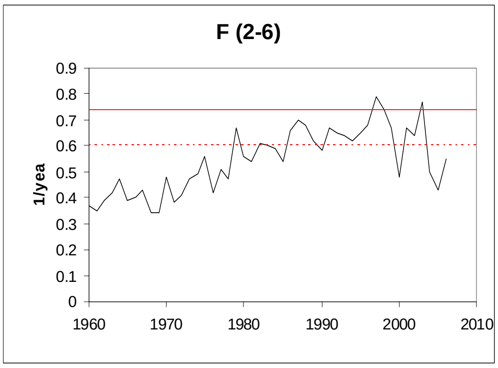


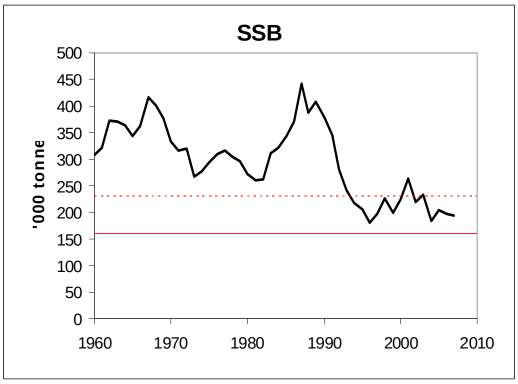
Haddock in Sub-area IV (North Sea) and Division IIIa



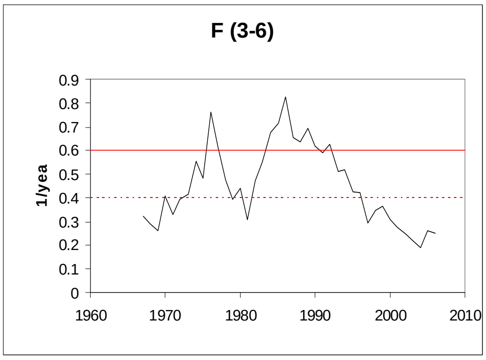


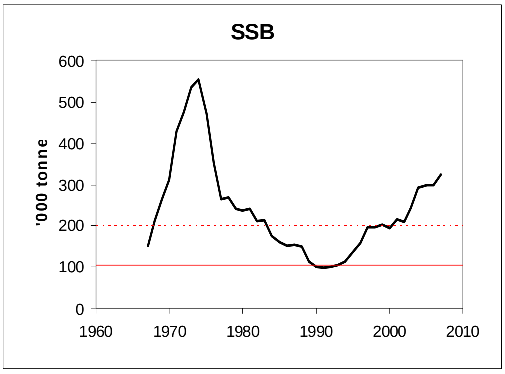
Plaice in Division VIId (Eastern Channel)



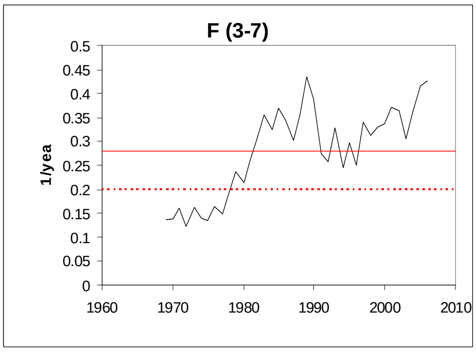


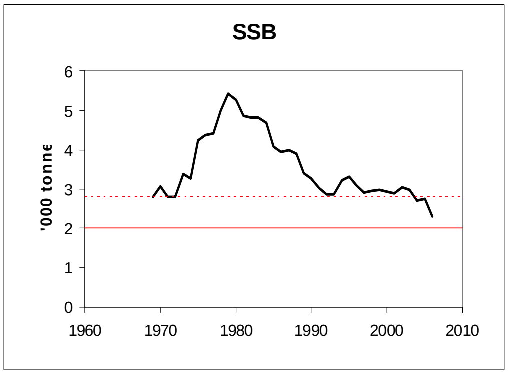
Plaice Sub-area IV (North Sea)



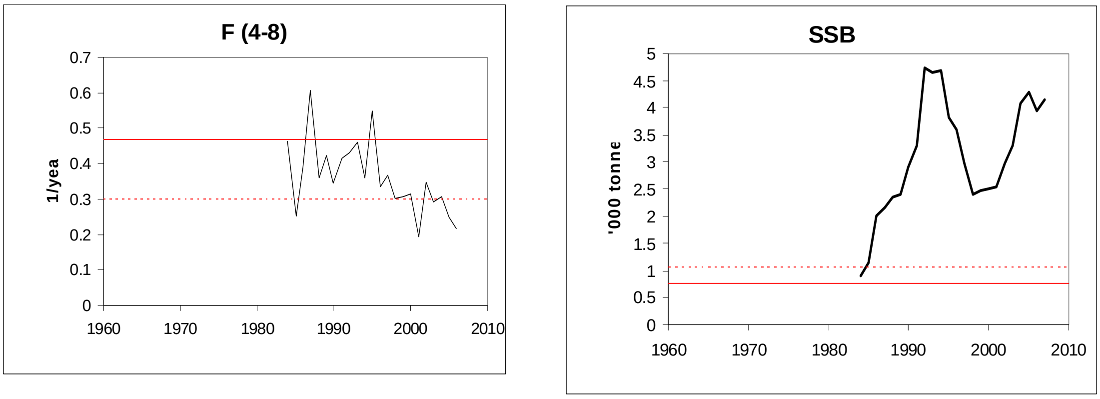


Saithe in Sub-area IV, Division IIIa (Skagerrak) & Sub-area VI

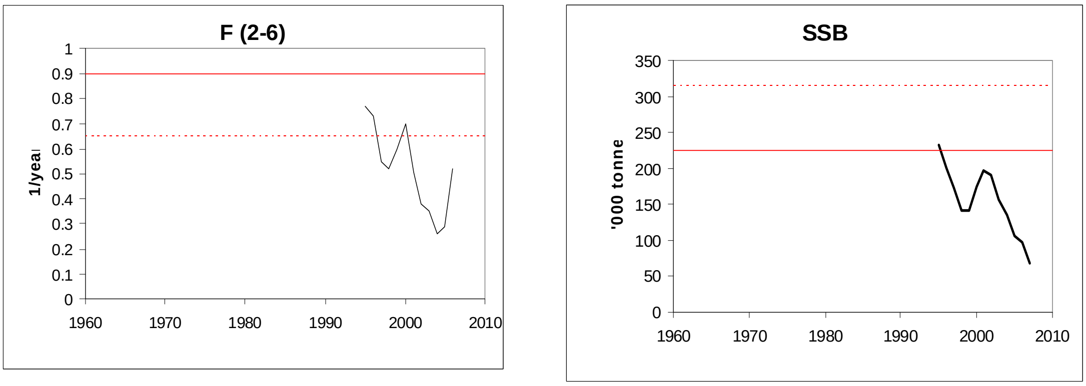




Sole in Division VIIe (Western Channel)



Sole in Division IIIa



Whiting Sub-area IV (North Sea) & Division VIId (Eastern Channel)

Figure 1.5.5.9.3.7 Trends in fishing mortality (F) and spawning-stock biomass (SSB) of assessed stocks allocated to OSPAR Region II and for which fishing mortality and biomass reference points have been defined. Continuous red horizontal lines show the limit reference points (F_{lim} and B_{lim}, respectively) while broken red horizontal lines show the precautionary reference points (F_{pa} and B_{pa}, respectively, when defined). The age classes for which values of F were calculated are shown in parentheses.

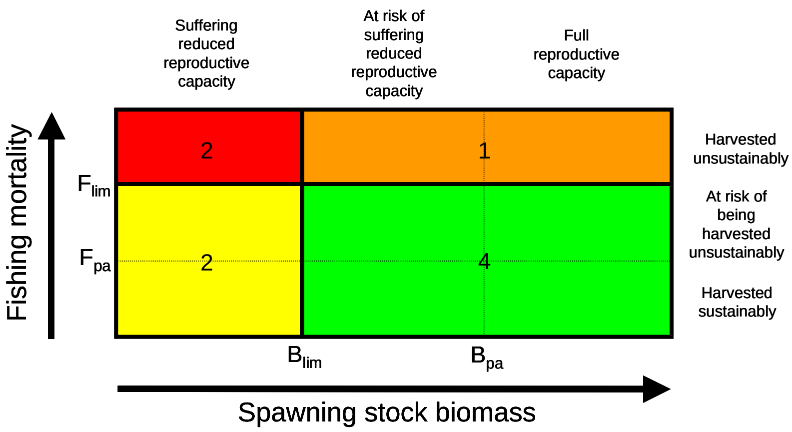


Figure 1.5.5.9.3.8 Summary of the status of assessed fish stocks in OSPAR Region II in 2005. Only those stocks for which F_{lim} and B_{lim} have been defined are included. Numbers in boxes refer to numbers of assessed stocks in each category.

Advice on status in relation to limit reference points is available for a relatively small proportion of the fish stocks that are fished in the North Sea, and for none of the invertebrate stocks. This reflects the considerable data demands necessary to support the assessment methods used by ICES.

Effects on non-target species, including birds, marine mammals, and discarded fish

Extensive discarding occurs in most fisheries on roundfish, flatfish, and *Nephrops* in the North Sea. These discards consist of predominantly small and juvenile fish below or close to the minimum landing size and of larger individuals of species without a reliable market.

The exploitation of sole and plaice are closely connected as they are caught together in fisheries mainly targeting sole, which are more valuable. This means that the minimum mesh size is decided on the basis of the more valuable species, resulting in substantial discards of undersized plaice. The mixed fisheries for flatfish are dominated by a mixed beam trawl fishery in the southern North Sea where up to 80% in number of all plaice caught are being discarded.

Based on the estimates of STECF (2007) the range of mean discard rates in the North Sea and eastern Channel flatfish fisheries by number by trip for drift netters is 29–63% for plaice (France and Germany), 61–100% for whiting (UK and Germany), 65–99% for dab, and 5–16% for sole (UK, France, and Germany). For the demersal trawlers, the range of mean discard rates (by trip and by number) for UK, France, Germany, and Denmark was 13–61% for plaice, 36–75% for whiting, and 65–94% for dab. For beam trawlers mean discard rates ranged from 13–81% for plaice, 78–98% for whiting, 65–98% for dab, and 11–27% for sole. In general, large numbers of whiting and dab above the Minimum Landing Size were discarded; this may have been due to the absence of a market for these fish.

The discard rate (by weight) in the English *Nephrops* fishery off the northeast coast of England was estimated at 4890 tonnes in the 2001/2002 season, equating to a discard rate of 57%. Discards in this fishery are dominated by whiting; other significant components of the discards include haddock, *Nephrops,* and commercial flatfish species. In 2001/2002 whiting discards from this fishery were thought to account for 16% of the estimated whiting discards for the entire North Sea. The weight of discarded whiting was estimated at six times that of the landed weight of whiting. Effort in the *Nephrops* fishery increased and then decreased in the period 1998 to 2006, and regulations have changed, so the discard rate reported in 2001/2 may not be representative of rates in other years.

The insertion of a square-mesh panel into the topsheet of single-rigged trawls used in the *Nephrops* fishery has been mandatory since 1991/92 and an additional 140 mm diamond mesh panel inserted behind the headline since January 2002. Furthermore, prior to 2002 the minimum legal codend mesh size was 70 mm for single-rigged trawls, but since January 2002, this has been increased to 80 mm. The threat of severe restrictions to fishing opportunities or closure of the English *Nephrops* fishery in 2002, in conjunction with the new regulations imposed on other fisheries provided the incentive to implement these gear changes.

The composition of catches has been monitored before and after these regulatory changes. The trawl modifications led to a reduction in discard rate for whiting of 11%. A second more recent study, utilising observer data to compare a longer period before and after the introduction of these changes, has also shown that whiting selectivity has improved.

The discard mortality on small commercial fish in the North Sea has contributed to the decline of stocks and consequent reduction in yields. Moreover, changes in community structure through discarding, either directly through discard mortality or indirectly, modify the energy flow through food webs.

Effects on the seabed and associated benthic communities and habitats

International beam and otter trawl effort, expressed as hours fished, declined by 31% and 44% respectively from 1997 to 2004Greenstreet *et al.*, 2007; however, otter trawl effort directed at *Nephrops* increased by 65%. Given that *Nephrops* are restricted to a narrow range of seabeds the total spatial footprint of bottom fishing activity in the North Sea is expected to have declined since 1997, although this cannot be tested explicitly because satellite Vessel Monitoring System coverage was not available throughout this period. However, the spatial distribution of effort has increased in some areas as a result of the relocation of bottom fishing activity and thus previously lightly impacted areas may now be subjected to high intensities of physical disturbance. Such changes are inevitable when fishing fleets can operate on large spatial scales and drivers such as regulation and oil prices affect their behaviour. For example, the cod box closure of 2001 led to the beam trawl vessels fishing in previously unimpacted areas and the increased physical disturbance may have led to a greater reduction in the total productivity of benthic communities (Rijnsdorp *et al.*, 2001; Dinmore *et al.*, 2003). Changes in effort distribution can have significant effects on the overall impact of disturbance in the North Sea since there are considerable local variations in the sensitivity of seabed habitats to trawling disturbance (Figure 1.5.5.9.3.9).

Analysis of beam trawling impacts in the southern and central North Sea has shown that the impacts of trawling were greatest in areas with low levels of natural disturbance, while the impact of trawling was relatively small in areas with high rates of natural disturbance. Over the entire area, beam trawl fishing is reported to have reduced total benthic biomass and production by 56% and 21%, respectively, compared with an unfished situation. In 2003, the biomass of benthic invertebrates was less than 90% of the predicted biomass in the absence of fishing over 56% of the area of the southern and central North Sea and production was less than 90% of the predicted production in the absence of fishing over 27% of the area. Despite these changes in biomass and production, the spatial distribution of the macrofaunal communities as described using multivariate methods that focus on species identity and distribution was largely unchanged between 1986 and 2000.

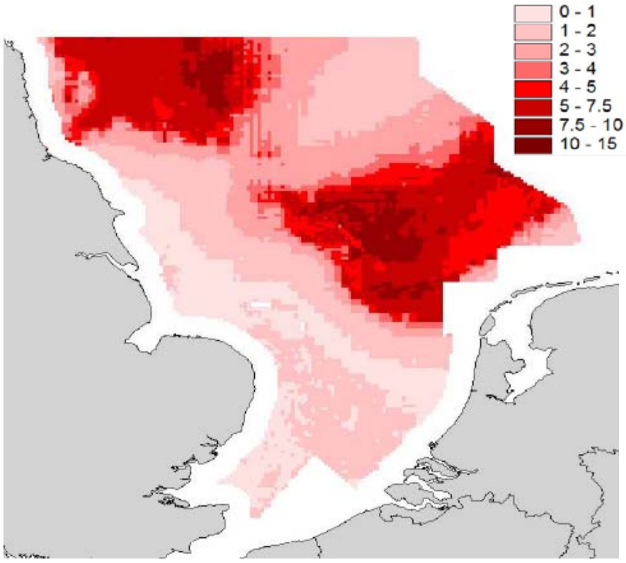


Figure 1.5.5.9.3.9 Estimated recovery time (years) for southern North Sea benthic communities following one pass of a beam trawl. Recovery is a measure of the time required for benthic production to return to 90% of the production in the absence of trawling disturbance. Hiddink *et al.* (2006).

Effects on community structure and food webs

In addition to the changes in benthic communities that result from physical impacts on the seabed described in the previous section, fishing has led to changes in fish community structure. These are manifest as reductions in the relative abundance of larger individuals and species and the effective loss of species such as common skate *Dipturus batis* from Region II (ICES, 2008b). Mortality rates on thornback ray, cuckoo ray, and spotted ray were thought to exceed sustainable levels in the early part of the period (Walker and Hislop, 1998), but it is unclear whether the reductions in average F on demersal species have been sufficient to change this situation.

Analyses of data from national and international fish surveys in the North Sea show that the mean size of individuals in the demersal fish community has decreased, as well as the proportion of species with larger body sizes (Figure 1.5.5.9.3.10). Since larger individuals generally feed at higher trophic levels, the decreases in the abundance of larger individuals has paralleled a decline in the trophic level of the community. The declining trend in larger species and individuals is less pronounced from 1998 to 2007, with some data sources indicating a slowing and even some reversal of the long-term trend. This may be indicative of recent reductions in fishing effort which have led to reductions in the average mortality on demersal species (Figure 1.5.5.9.3.11), but given the expected interannual variability in these size-based metrics an assessment of the longer-term significance of these trends will be contingent on evidence for the persistence of the recent changes.

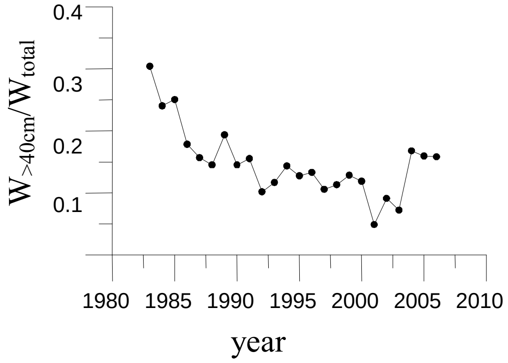


Figure 1.5.5.9.3.10 Trend in the proportion of large fish (the ratio between the weight of fish larger than 40 cm relative to the weight of fish larger than 10 cm). The metric is calculated for the North Sea demersal fish assemblage as sampled by the International Bottom Trawl Survey in the first quarter. From ICES (2008c).

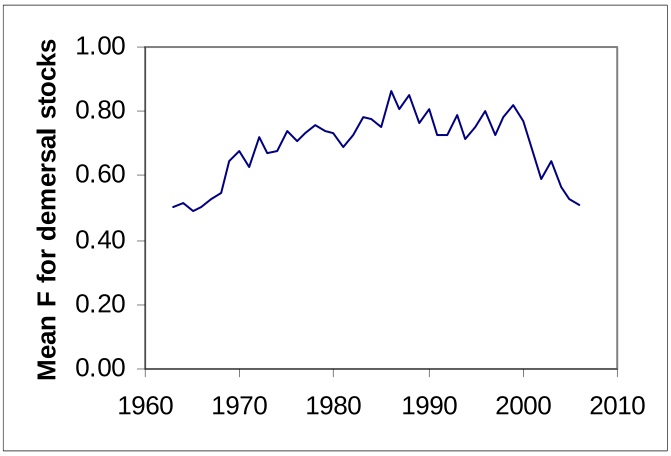


Figure 1.5.5.9.3.11 Trends in average fishing mortality on North Sea demersal species. Source: ICES (2007).

Fishing-induced depletions in the abundance of large predatory fish species have had an indirect effect on community structure (ICES 2008b, c). Absolute numbers of both small fish belonging to all species and of demersal species with a low maximum length have steadily and significantly increased over large parts of the area during the last 30 years, while the abundance of large fish has decreased. These changes in the size composition of the demersal fish community sampled during fish surveys are reflected in the steeper slopes of size spectra (relationships between the abundance of fish in body-size classes and body size), which are driven both by decreases in the abundance of large individuals and absolute increases in the abundance of small individuals. The best available explanation for this shift is the reduction of the predation pressure on juveniles of large species and small species. This is an indirect effect of overexploitation of the larger predators. Changes in the size-composition of the community are expected to be more closely linked to fishing impacts than climate changes since climate has a greater influence on species composition than size composition.

The overall decline in fishing activity and in fish discards in particular may have impacted seabird communities directly through food subsidies and indirectly through the food web. Over the past decade, 12 out of 28 seabird species in the Region show an increasing trend, 4 others including the northern fulmar and black-legged kittiwake show a decreasing trend, while another 4 appeared stable. Effects on the food web have been suggested due to removal of sandeels by the industrial fishery. Sandeels are an essential component of the diet of many fish species as well as seabirds and marine mammals and their low abundance is therefore expected to have severe implications for the whole North Sea ecosystem. Low breeding success for some seabird species in some areas has been attributed to sandeel removals by fishing, or the effects of fishing on sandeel recruitment. However, it is difficult to establish causality and to distinguish between fishing and environmental effects.

Conclusions

Fishing effort and mortality rates have started to fall in the period 1998 to 2007 and there are tentative signs of increases in the abundance of some fish stocks and the proportion of larger individuals and species in the fish community. The species that are most vulnerable to fishing in Region II, especially skates and rays, continue to be impacted by unsustainable rates of fishing. Despite recent reductions in effort and smaller reductions in mortality, Region II is still heavily modified by fishing and both fish stock abundance and the state of some other components of the marine environment are not consistent with management objectives. Even for a 'data-rich' region, a relatively small proportion of species impacted by fishing are quantitatively assessed and reference points have only been determined for a small number of these. Further, for those stocks with reference points, the assessments still focus on advice relating to the avoidance of limits rather than the attainment of targets that are more consistent with commitments to achieving MSY.

References

Dinmore, T. A., Duplisea, D. E., Rackham, B. D., Maxwell, D. L., and Jennings, S. 2003. Impact of a large-scale area closure on patterns of fishing disturbance and the consequences for benthic production. ICES Journal of Marine Science, 60, 371–80.

Greenstreet, S. P. R., Robinson, L. A., Piet, G. J., Craeymeersch, J., Callaway, R., Reiss, H., Ehrich, S., *et al.* 2007. The ecological disturbance caused by fishing in the North Sea. FRS Collaborative Report, 04/07. 169 pp.

Hiddink, J. G., Jennings, S., and Kaiser, M. J. 2006. Indicators of the ecological impact of bottom-trawl disturbance on seabed communities. Ecosystems, 9, 1190–1199.

ICES. 2007. ICES Advice 2007. Book 6, p. 31.

ICES. 2007a. Report of the Working Group on Fish Ecology, 5–9 March 2007, Nantes, France. ICES CM 2007/LRC:03.

ICES. 2008a. Report of the Study Group on Bycatch of Protected Species, 29–31 January 2008, ICES Headquarters. ICES CM 2008/ACOM:48.

ICES. 2008b. Report of the Working Group on Regional Ecosystem Description, 25–29 February 2008, ICES Headquarters. ICES CM 2008/ACOM:47.

ICES. 2008c. Report of the Working Group on Fish Ecology, 2008.

Rijnsdorp, A. D., Piet, G. J., and Poos, J. J. 2001. Effort allocation of the Dutch beam trawl fleet in response to a temporarily closed area in the North Sea. ICES CM 2001/N:01.

STECF. 2007. Commission Staff Working Paper. Scientific, Technical and Economic Committee of Fisheries STECF Sub-group SGRST on Fishing Effort Management. Barza d'Ispra, Italy, 5–9 June. Lisbon, Portugal, 9–13 October 2006.

STECF. 2008. Evaluation of the STECF/SGMOS 07-04 Working Group on Discards. STECF opinion expressed during the Plenary Meeting of 14–18 April 2008 in Hamburg – discards.

Walker, P. A., and Hislop, J. R. G. 1998. Sensitive skates or resilient rays? Spatial and temporal shifts in ray species composition in the central and northwestern North Sea between 1930 and the present day. ICES Journal of Marine Science, 55, 392–402.

1.5.5.9.4 Regional QSR III: Celtic Seas

Introduction

Traditionally the coastal shelf seas to the west of the UK and France and surrounding Ireland have supported demersal fisheries for whitefish and flatfish, and in some locations for *Nephrops* and scallops. There were also large seasonal pelagic fisheries for mackerel, horse mackerel, and herring while the inshore grounds have supported crab, lobster, and other shellfish fisheries. The main fishing nations operating in Region III are Ireland and Scotland (UK) along with France and Spain.

The development of fisheries management and policy since 1998, and an assessment of their effectiveness

Major changes in the management of the fisheries are described in the QSR NE Atlantic Overview section. In this section, we consider those measures from a regional (OSPAR Region III – Celtic Seas) perspective.

In the Celtic Sea since 1998, there have been changes in the gear types being used, the introduction of new techniques or new fisheries, evidence of technological creep, and new legislation which has either shifted fishing effort into other fisheries or encouraged fishers to adopt new gears. For example, over this period economics, and in particular with low fuel prices in the late 1990s followed by a sharp increase in recent years, as well as the introduction of considerable regulation have been the main drivers for the changes observed. As a consequence, some beam trawlers have switched to otter trawl gear. This has led to increased catches of skates and rays and seasonally increased catches of other species such as bass. In addition, beam trawlers have changed over to scallop fishing which is highly unregulated. Accordingly, scallops are coming under increasing pressure due to the displacement of effort from other fisheries. In the west of Scotland TAC availability is a major driver of effort switching between areas – largely driven by the significant increase in fishing opportunities in adjacent areas.

In the demersal trawl fisheries there was widespread use of twin-rig trawls for species such as *Nephrops* and monkfish. The primary motivation for the adoption of this gear has been better ground contact that can be generated with this gear compared to standard single rigs. The move to twin rigging has been accompanied by an improvement in available gear monitoring equipment, which allows fishers to control the spread and symmetry of their trawls. Demersal trawl design has also concentrated on increased spreads and vertical opening to increase catching efficiency. Double bosom trawls with two mouths and double bag trawls with extra wide mouths to accommodate the two codends are now being used. However, recent increases in fuel prices has halted this trend and, as apparent in Ireland, Scotland, and France, fishers have begun to return to single rig trawls, using trawls constructed in low diameter, high tenacity materials. There is also a move towards more fuel-efficient methods such as Scottish seining or gillnetting. Also of note is the change in use of beam trawls with steel heads to those with rubber wheels, which promotes fuel efficiency. These shifts seem likely to continue as fuel prices continue to rise.

In the pelagic trawl fisheries in the Celtic Sea prosecuted mainly by Irish, UK, and Dutch vessels there have been some changes in trawl design over the last 10 years. Fishers have managed to master the art of “aimed trawling” assisted by the developments in pelagic net design and sophisticated fish finding equipment. Trawls are now constructed with very large meshes in their fore parts (anything up to 128 mm meshes) and constructed using low drag materials. There has also been a shift to using hexagonal meshes in the front section to increase vertical and horizontal opening, while pelagic codends are now commonly constructed with the mesh orientated at 90° to that in the body of the net and with the inclusion of square mesh netting to improve water flow and reduce meshing. One of the latest developments in pelagic trawl design is the manufacture of so-called “self-spreading” trawls, which utilises the force of the water current through the net to spread the trawl without increasing towing resistance. Such trawls have been found to give the same effective horizontal and vertical openings for approximately 20% the twine surface area.

In static net fisheries there has been less development. Gear design has remained fairly similar with the only significant changes being a general increase in the amount of gear being used per vessel and lengthy soak times adopted in some fisheries, with subsequent increased discarding.

In the past decade, legislation in conjunction with the necessity for increased efficiency of gear (in order to reduce operating costs) and also lately, market pressures for fishers to act responsibly, has driven the development of gear technology to deliver better performance. In demersal fisheries this has including the testing of square mesh panels, selective codends, trawls with reduced top sheet sections, grids, and separator trawls (Section 4.4.4.2). Some of these modifications have found their way into legislation while others have seen limited voluntary adoption. Formal assessment of these measures remains incomplete with only limited data being available on the benefit to stocks of commercial fish species.

In order to reduce bycatch of harbour porpoises, the use of acoustic devices or ‘pingers’, was made mandatory for gillnet fisheries from January 2006 in the Celtic Sea and the western Channel and in 2007 in the eastern Channel for all vessels over 12 m. Since its inception a number of practical, technical, and economic issues have arisen that have largely negated effectiveness of this regulation and it is doubtful whether any meaningful reduction in harbour porpoise bycatch has been achieved by these measures in the Celtic Sea area.

Recovery plans exist within the ‘Celtic Seas’ area for cod and hake. The EC regulation for cod has recently been amended (*amending Regulation (EC) No. 423/2004 as regards the recovery of cod stocks and amending Regulation (EEC) No. 2847/93*) in an attempt to speed the recovery of cod in community waters. Celtic Sea (VIIg) cod was previously excluded from the 2004 cod recovery plan on the basis of its better conservation status. Seasonal restrictions also exist on the fishing of herring off the south coast of Ireland, in parts of the Irish Sea, and north and east of the outer Hebrides. In an area surrounding Cornwall (ICES Division VIIf in its entirety and part of the adjoining VIIg,h,e), no directed fishing on mackerel is allowed, except with gillnets and handlines. The fishery for Celtic Sea sole (ICES Division VIIf,g) is concentrated on the north Cornish coast and an average landing of 1000 tonnes is taken mainly by beam trawlers. Since 2003, fishing mortality has dropped substantially so that current fishing mortality is considered sustainable. Council Regulation (EC) No. 41/2007, Annex III, part A 7.2 prohibited fishing between the Cornish and the Welsh coasts (ICES rectangles 30E4, 31E4, and 32E3) during February and March 2007 with some gear-specific derogations. Lobster v-notching is a technical conservation measure, applied to the Irish lobster stock, which ensures that marked female lobsters have an opportunity to breed at least once before they are harvested. While stocks in Ireland appear to be depleted there is some evidence to suggest that, in some areas, v-notching in conjunction with reduced fishing effort has resulted in a positive response in terms of lobster stocks (BIM, 2008).

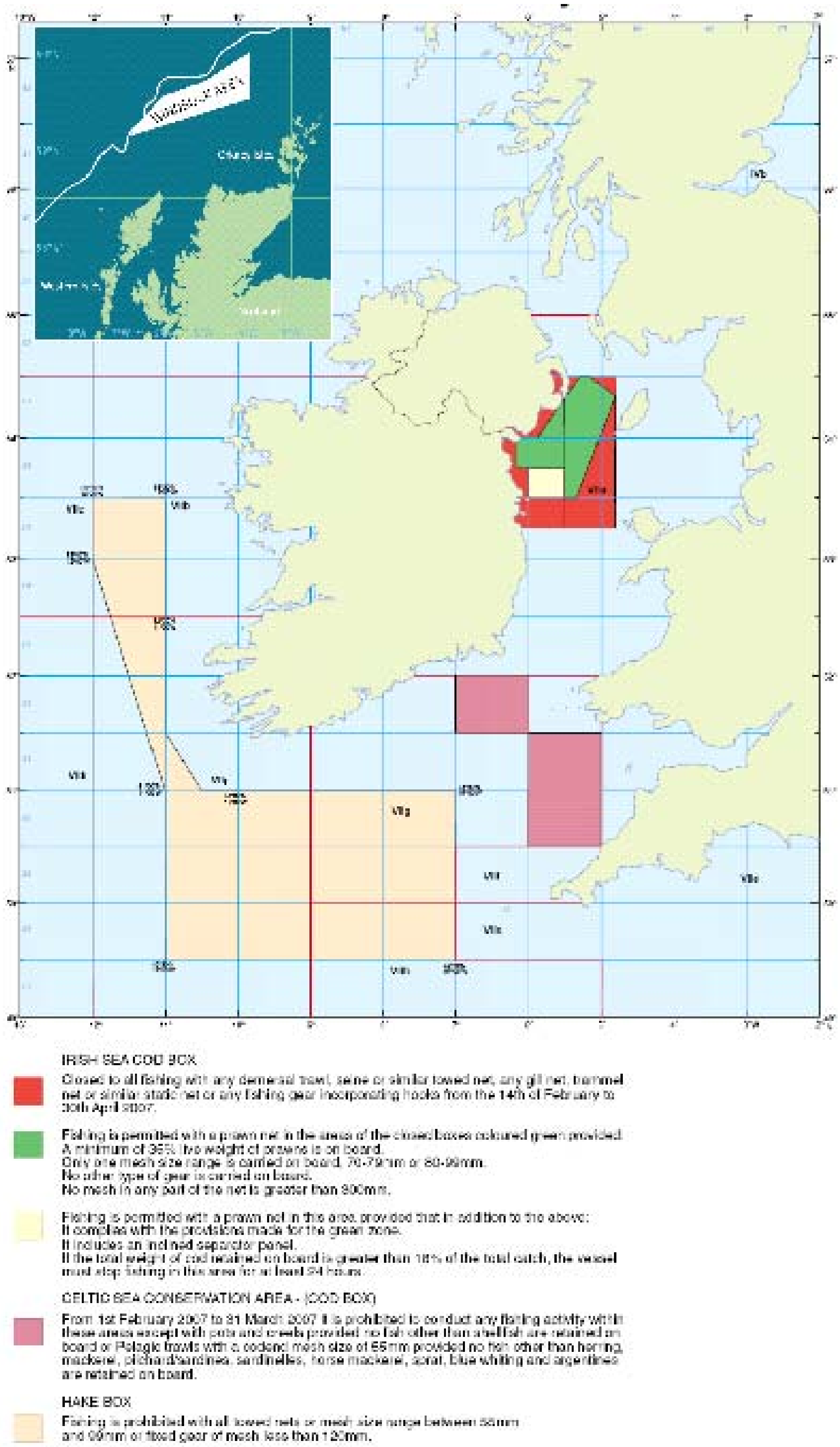
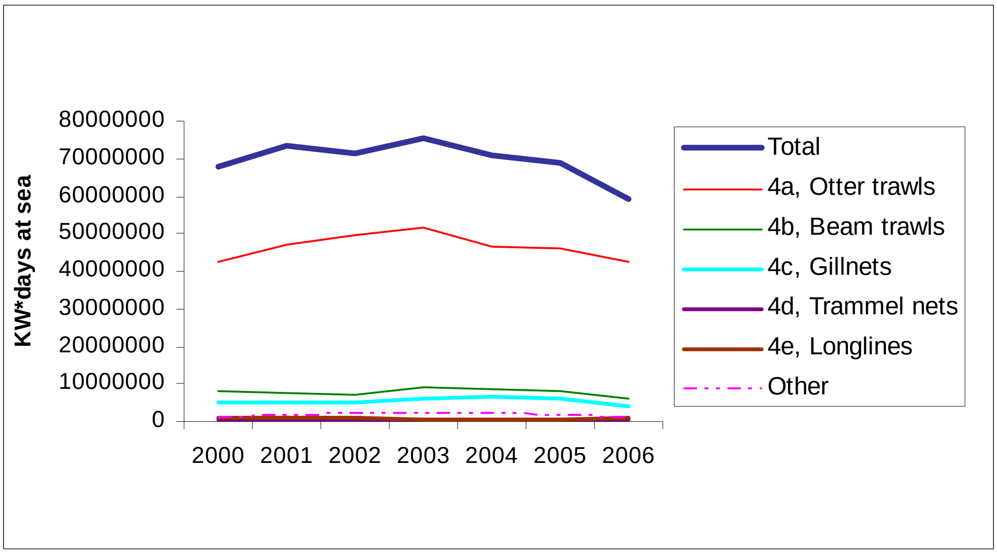


Figure 1.5.5.9.4.1 Areas closed to fishing for cod and hake in 2007 with insert showing the 'windsock area' north of Scotland which is included in the 'cod recovery plan'.

Fishing activities in the OSPAR Region III (Celtic Seas)

Landings of the main species exploited for human consumption in the Celtic Seas Region have declined in recent years. In contrast, the industrial fishery for blue whiting, most of which occurs in Region V, has developed in recent years and showed an increase in landings since the late 1990s (Figure 1.5.5.9.4.4).

Overall, the fishing effort employed in the Celtic Seas, excluding the Irish Sea had an increasing tendency up to 2002 and subsequently declined (Figure 1.5.5.9.4.2a), with little difference in effort between the start and end of the decade. In contrast in the Irish Sea effort has generally been declining, slightly, each year. The apparent increases in both otter and beam trawling in this area between 2002 and 2003 and the mostly downward trend in 'other' is a reflection of the 'other' category including fishing for which the details of the gear were not known. As data capture has improved so has the other category been resolved into either otter or beam trawling. Although spatially the general decrease is apparent in this area, there is some evidence of an increase in effort off the coast of Brittany (Figure 1.5.5.9.4.3).



a)

b)

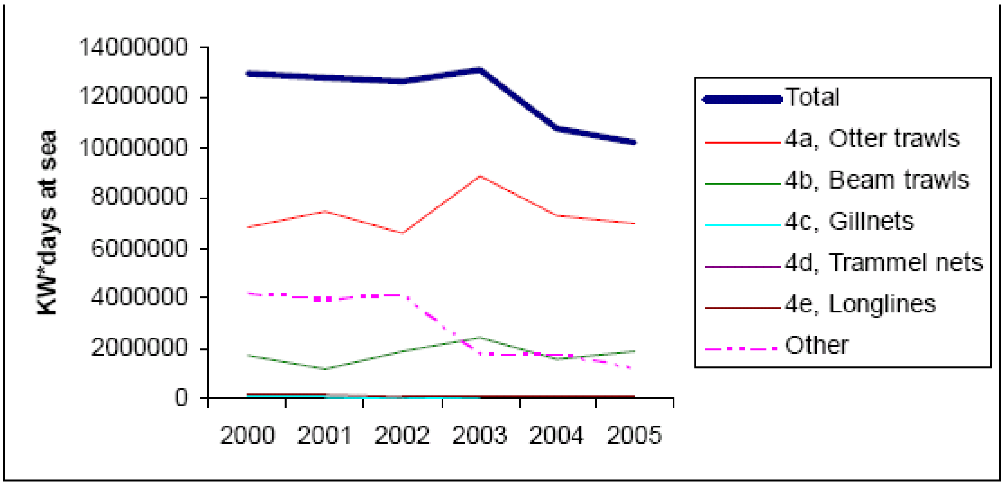


Figure 1.5.5.9.4.2 Trends in nominal fishing effort (kW*days at sea) in (a) the Celtic Seas excluding the Irish Sea and (b) the Irish Sea by major gear type (from STECF, 2006).

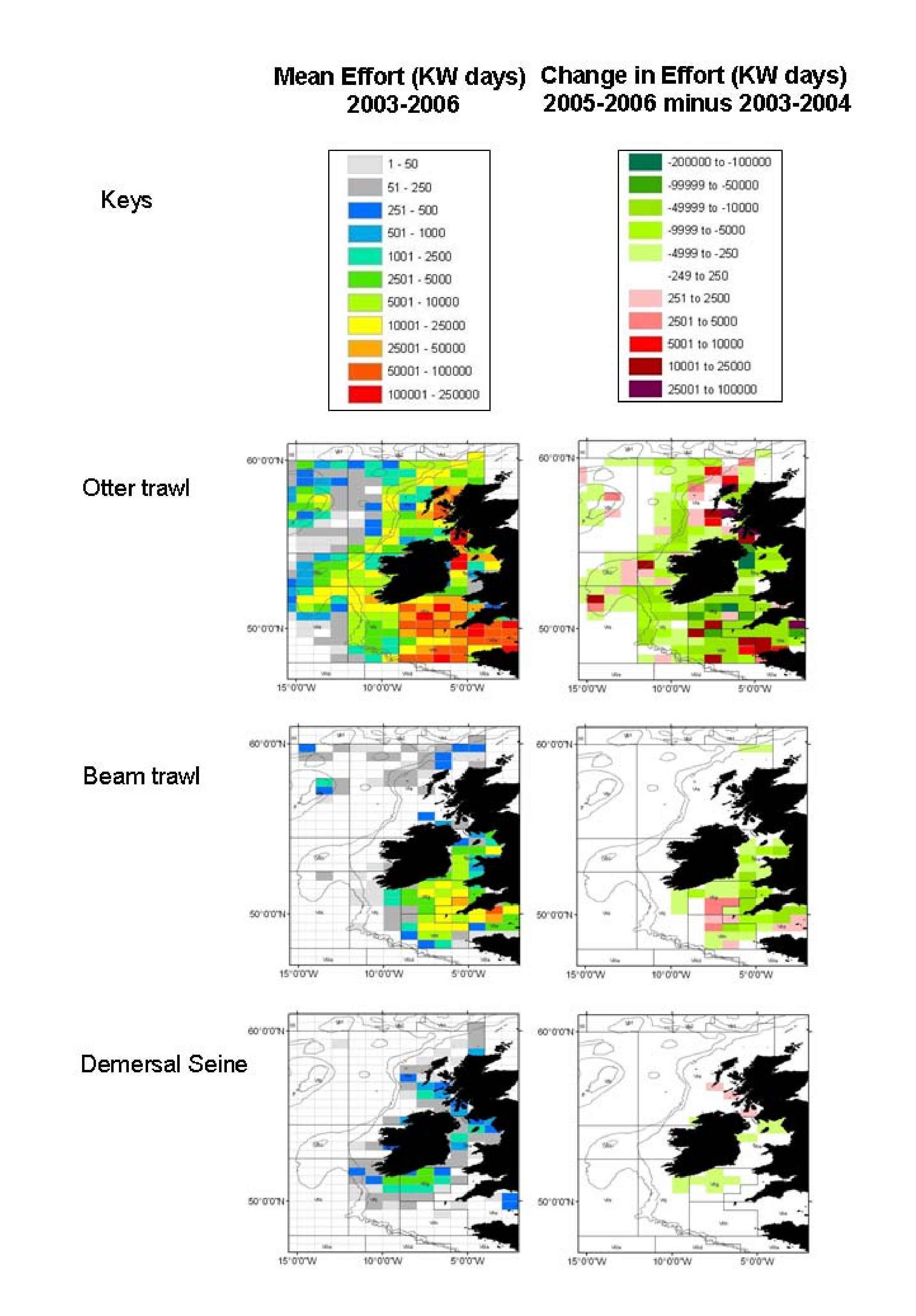


Figure 1.5.5.9.4.3 Demersal effort (kW*days) by three main gear types (otter trawl, beam trawl, and demersal seine) and by ICES statistical rectangle. Left column: mean effort 2003–2006 and Right column: recent change in effort (2005–2006 effort minus 2003–2004 effort) (note: no Spanish effort data supplied).

Mackerel range from north of the Arctic Circle to Portugal and Spain in the south and is mainly exploited in a directed fishery for human consumption. This fishery tends to target bigger fish and there is evidence that this does cause the discarding of smaller, yet marketable, fish. Mackerel are generally caught near the shelf edge, particularly in the central area of the fishes range. In recent years (2005–2006) there has been an overall reduction in catches, but on a smaller scale there appears to have been a relative increase in catches near the shelf edge, with other areas showing only minor variation (Figure 1.5.5.9.4.4).

Western horse mackerel is taken in a variety of fisheries exploiting juvenile fish for the human consumption market (with mid-aged fish mostly for the Japanese market), and older fish either for human consumption purposes (mostly for the African market) or for industrial purposes. From about 1994 onwards the fishery on juveniles expanded, resulting in a change in exploitation pattern for the stock. This may be due to the lack of older fish (decline of the 1982 year class) and the development of a market for juveniles. The percentage of catch (in weight) in the juvenile areas increased gradually from about 40% in 1997 to about 65% in 2003, dropping again to 40% in 2005 and 2006. Landings have generally been declining. Spatially the picture is mixed with the greatest reductions appearing at the entrance to the western English Channel and to the southwest of Ireland, with some suggestion that catches have increased further into the English Channel and also to the south of the Celtic Sea (Figure 1.5.5.9.4.4).

High landings of blue whiting from Region III over the last decade, which peaked in 2003–2004, were supported by enhanced recruitments. Spatially there appears to have been an increase in catches in deeper waters just west of the shelf edge (Figure 1.5.5.9.4.4), probably due to movement in fishing effort between these areas. The blue whiting stock is vulnerable to overexploitation because fishing mortality has remained high while recruitment has been consistently falling since 2003. The knowledge of the factors which drive blue whiting recruitment is very limited. It is not known if the poor 2005 and 2006 year classes are an anomaly or if it is a shift towards the low recruitment regime, as observed in the period before the mid-1990s.

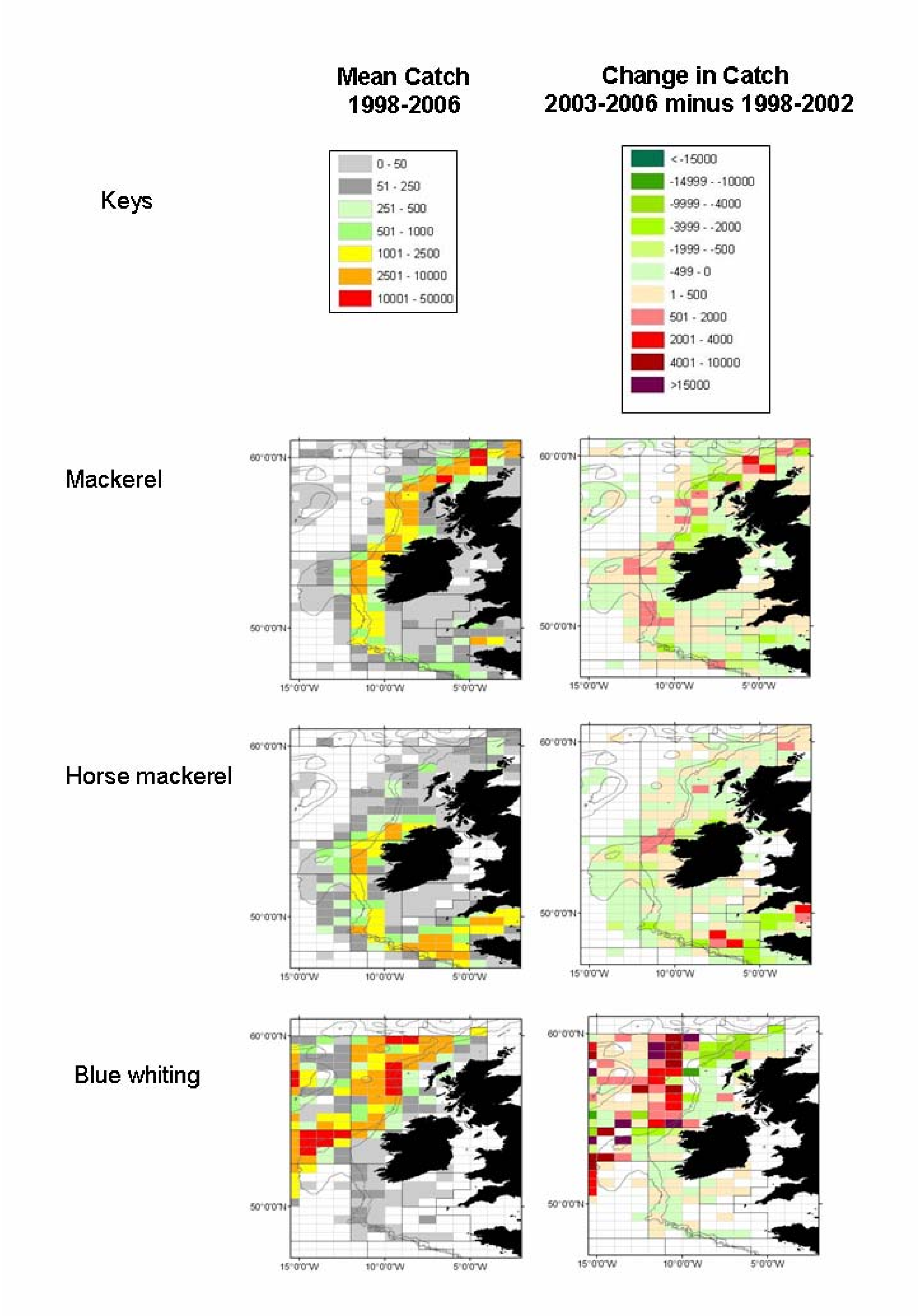


Figure 1.5.5.9.4.4 Commercial catch of three major pelagic species (mackerel, horse mackerel, and blue whiting) by ICES statistical rectangle. Left column: mean catch 1998–2006 and Right column: recent change in catch (2003–2006 minus 1998–2002) (data from WGMHSA (mackerel and horse mackerel), WGNPEL (blue whiting)).

Belgium, the Netherlands, and the United Kingdom (UK) are the main nations with beam trawl fisheries in Region III. These fleets target species such as flatfish, mainly sole (*Solea solea*) and plaice (*Pleuronectes platessa*), and groundfish species such as cod (*Gadus morhua*).

The following case-study focuses on the technical alterations to beam trawls that can reduce the direct ecosystem effects of this fishing method.

In the framework of the Council Regulation laying down certain technical measures for the conservation of fisheries resources (850/98), a general increase in mesh size and the use of square mesh panels in towed gears was suggested to improve the selectivity of towed fishing gears. On the 19th of October 2001, EU Regulation 2056/2001 was adopted, establishing additional technical measures for the recovery of the stocks of cod in the North Sea and to the west of Scotland. It included as a provision that the minimum codend mesh size of beam trawls in the North Sea must be 80 mm south of 56°N, and 120 mm north of 56°N (with a restricted area in the western part of the central North Sea, where codends of 100 mm mesh size were made compulsory). However, a general increase in mesh size as first suggested in earlier drafts of the regulations, was firmly rejected due to perceived losses of sole catches. These regulations also included the mandatory insertion of a panel of no less than 180 mm in the top panel of all beam trawls.

There are a number of other discard (fish and benthos) reduction devices such as benthic release panels that are not currently included in technical measures legislation; however, there is evidence of increasing voluntary use of some of them.

The use of more selective beam trawl gear is being driven by the market place as well. Public perception of beam trawl-caught fish has become increasingly negative, putting pressure on fishers to adopt more responsible fishing practices. More importantly, some multiple retailers have publically stated a desire to move away from sourcing beam trawl-captured fish, or have executed this policy already. This move has gained increasing momentum worldwide with the advent of certification schemes such as MSC and Seafish Responsible Fishing Scheme, and also through competitions such as the WWF Smart Gear competition or the Responsible Fishing Gear competition in the UK.

The effect of the existing regulations under 850/98 and the additional requirements included in 2056/2001 designed to improve species selectivity have not been properly evaluated. Enever *et al*. (submitted) has showed a significant reduction in fish discards by number by increasing mesh sizes from 80–89 mm to 90–110 mm and 110–120 mm

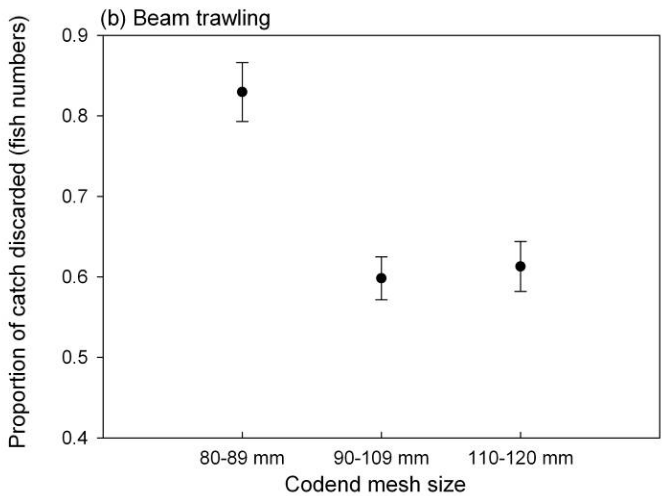


Figure 1.5.5.9.4.5 Proportion of catch discarded (all finfish numbers combined) by English and Welsh registered beam trawlers in the North Sea between 1999 and 2006, fitted for varying codend mesh size groups (Modified from Enever *et al.*, submitted).

Impacts of fisheries on the ecosystem

Commercial fishing has direct and indirect effects on the marine ecosystem, which can be summarized as effects on:

1. commercial fish stocks;
2. non-target species, including birds, marine mammals, and discarded fish;
3. the seabed and associated benthic communities and habitats;
4. community structure and food webs.

Effects on commercial fish stocks

Biomass and fishing mortality limit reference points have only been defined for four of the stocks assessed by ICES and allocated to Region III. Total landings from these stocks accounted for 1.8 million tonnes or 7.3% of the total reported landings of 24.7 million tonnes of fish and shellfish from this region in the period 1986 to 2006. Temporal trends in the spawning-stock biomass (SSB) and fishing mortality (F) of these stocks in relation to their limit reference points are shown in Figure 1.5.5.9.4.6.

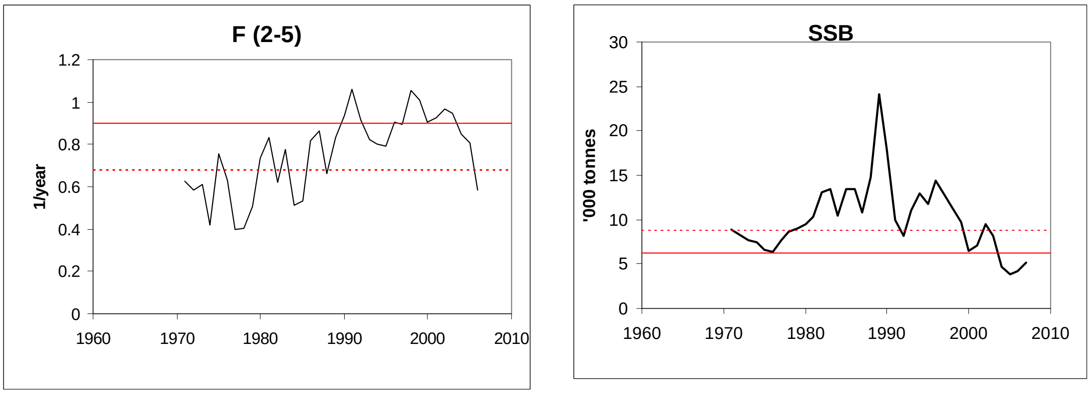
ICES prefers to give precedence to an analysis based on stocks for which reference points have been defined as the main indicator of fishing impacts on commercial stocks because it is not straightforward to define stock status in relation to a management objective when reference points have not been defined. For demersal stocks, significant fishing impacts on assessed species are often indicative of significant fishing impacts on larger, more vulnerable species that are not assessed but taken as bycatch.

The overall status of assessed stocks for which all reference points have been defined is shown in Figure 1.5.5.9.4.7. It must be pointed out that the coding used in the summary assessment presented in Figure 1.5.5.9.4.7 might give a misleading impression regarding the status of the stock. Consequently, the status of the stock must also be considered in light of the time-series graphs presented in Figure 1.5.5.9.4.6.

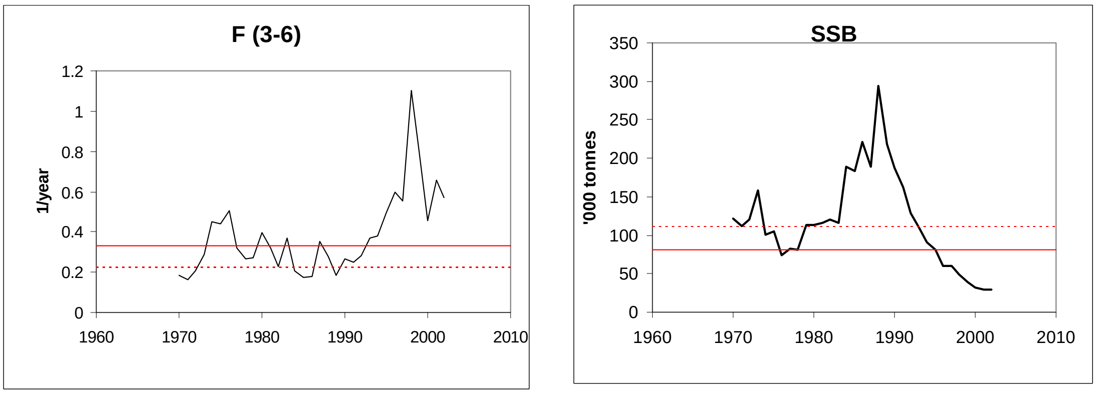
Overall, there were four stocks considered for inclusion in this analysis, one stock (herring) was assessed using 2003 data as there were no assessments conducted after this date. Three other stocks (cod, hake, and sole) were analysed using 2005 data. The herring 2003 and sole 2005 stocks were both considered to be harvested unsustainably and suffering from reduced reproductive capacity. While the sole biomass and mortality values appear to be relatively close to the precautionary reference points, the herring values are considerably removed from the precautionary points, indicating a highly stressed stock. Cod in 2005 was considered to be harvested sustainably, yet suffering reduced reproductive capacity. Hake in 2005 was considered to be harvested sustainably and at full reproductive capacity; however, the values for biomass and mortality are still relatively close to the precautionary limits. This stock should continue to be assessed to validate the observed trends, which seem to demonstrate a gradual improvement in status.

To determine the status of assessed stocks in relation to reference points the 2005 (or earlier) estimates of F and SSB were used rather than the 2007 ones. This is because the 2007 estimates are less precise in the most recent time-series due to the so-called “convergence” feature of the methods used in fish stock assessment.

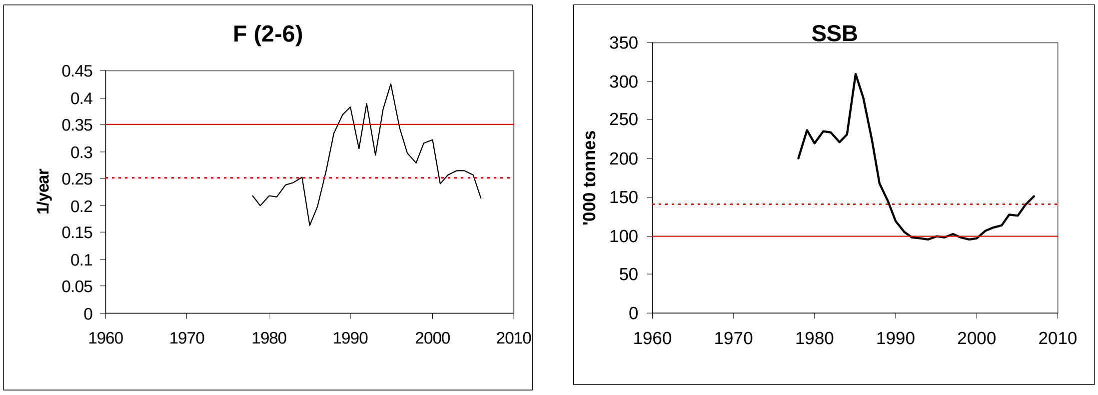
The biological reference points F_{pa} and B_{pa} are developed to take the imprecision in the most recent estimates F and SSB when developing fisheries management advice for fish quotas in the near future. Thus, when considering historical performance of fish stocks, F_{pa} and B_{pa} are not as relevant as F_{lim} and B_{lim} and focused only on the limit reference points. This means no distinction was made between the stocks that are harvested sustainably and those at risk of being harvested unsustainably (since in both cases $F > F_{lim}$), and no distinction was made between the stocks at risk of suffering reduced reproductive capacity and those at full reproductive capacity (in both cases $B < B_{lim}$). This is unfortunate, but does reflect the focus of current ICES advice on the avoidance of limits rather than the achievement of targets.



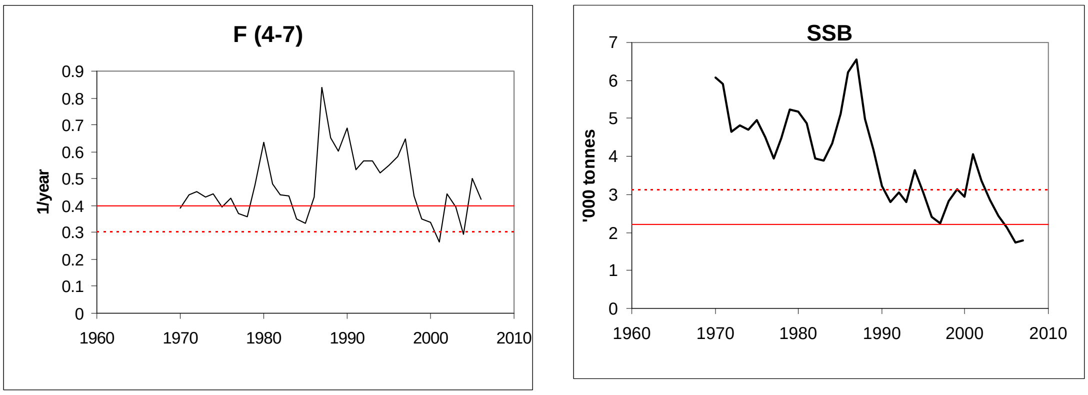
Cod in Divisions VIIe–k.



Herring in Divisions VIa (South) and VIIb,c. Data from 2003 assessment.



Hake – Northern stock (IIIa, IV, VI, VII, VIIIa,b). Note: this stock also covers OSPAR a reas II and IV.



Sole in Division VIIa (Irish Sea).

Figure 1.5.5.9.4.6 Trends in fishing mortality (F) and spawning stock-biomass (SSB) in assessed stocks allocated to OSPAR Region III and for which fishing mortality and biomass reference points have been defined. Continuous red horizontal lines show the limit reference points (F_{lim} and B_{lim}, respectively) while broken red horizontal lines show the precautionary reference points (F_{pa} and B_{pa}, respectively, where defined). The age classes for which values of F were calculated are shown in parentheses.

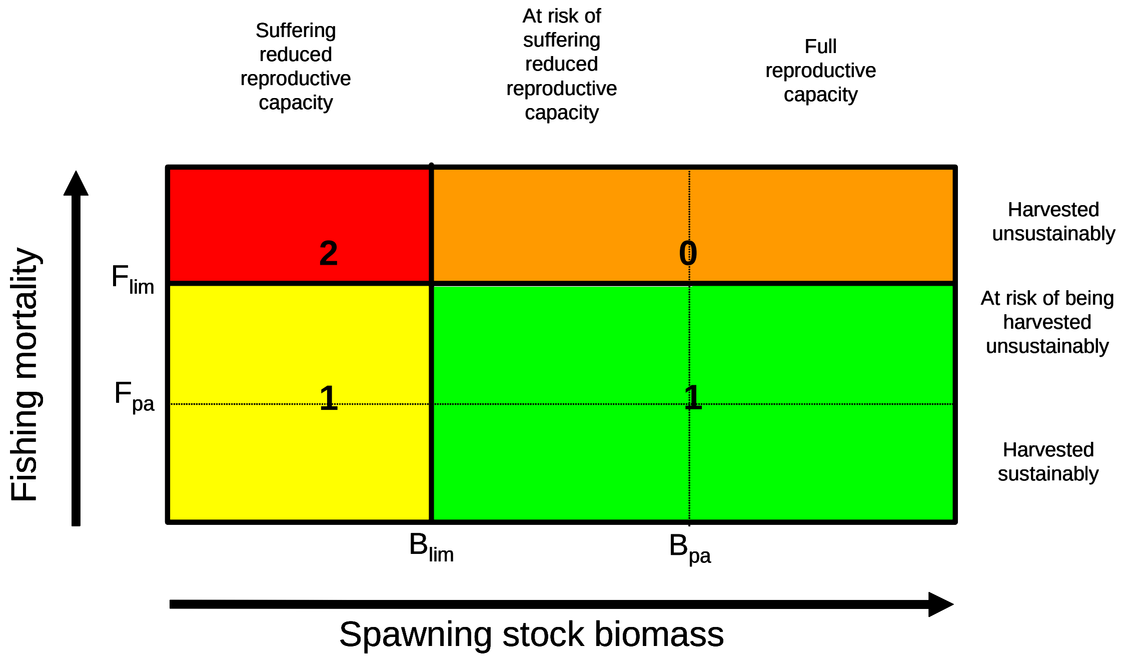


Figure 1.5.5.9.4.7 Summary of the status of assessed fish stocks in OSPAR Region 3 in 2005. Only those stocks for which F_{lim} and B_{lim} have been defined are included.

Landings of rays appear as a series of peaks and troughs, with lows of approximately 14 000 t in the mid-1970s and 1990s, and highs of just over 20 000 t in the early and late 1980s and late 1990s (Figure 1.5.5.9.4.8). While landings have fluctuated considerably over the time-series, they have been in a constant decline since 2003, and the 2006 landings of approximately 10 000 t are the lowest in the time-series. This decline in landings is thought to be due to a combination of increased regulation and changes in consumption. Fishery-independent data recording the landings of specimen rays by recreational anglers in the Irish Sea reported a linear decrease in the mean size of thornback rays landed between 1974 and 2002 (Richardson *et al.*, 2006). This highlights a major deficiency in the manner in which landings of skates and rays are currently reported. No distinction is made between landings of different species of skates and rays. These species have widely contrasting life histories that make them more or less vulnerable to over-exploitation.

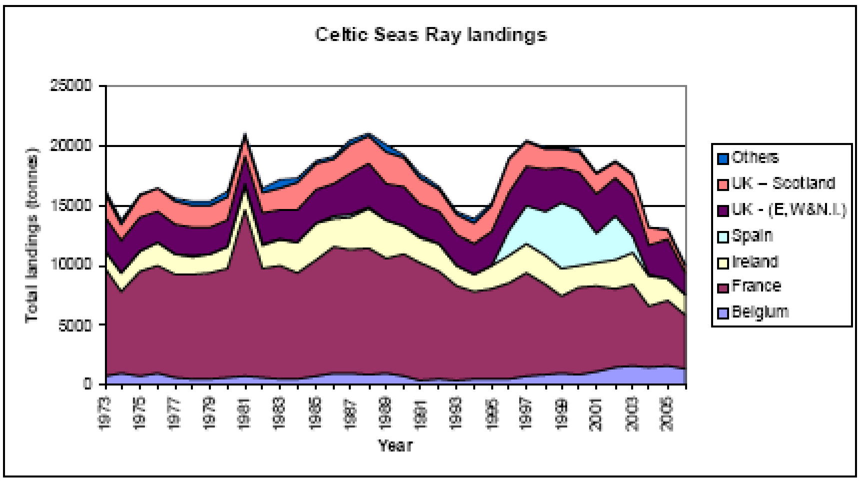


Figure 1.5.5.9.4.8 Total landings (tonnes) of Rajidae by nation in the Celtic Seas from 1973–2006 (Source: ICES).

Effects on non-target species, including birds, marine mammals, and discarded fish

The removal of the target fish and the incidental catch of small fish have had a widespread effect on the groundfish communities throughout the region. Scottish and Irish groundfish surveys (1997–2000 and 1993–2000, respectively) show declines in the biomass and abundance of cod, whiting, and hake, amongst others, which were more pronounced in the latter part of the time-series. In some cases these have translated to changes in the ecosystem structure. For example, in the Celtic Sea, the capture and discarding of large numbers of immature fish has significantly altered the size structure of a number of commercial species. Discarding levels differ between the different fleets but can be as high as two thirds of the total catch. In addition, increased discarding rates have also been attributed to the exhaustion of single-species quotas in multi-species fisheries. Celtic Sea cod and Irish Sea haddock are two cases in point.

Analysis of discarding levels of the demersal fleet around Ireland has shown that a significant proportion of the catch is discarded (Borges *et al.*, 2005). Discarding levels differ between the different fleets but have shown to be up to two thirds of the total catch. In this study, whiting, haddock, megrim, and dogfish are the main species discarded by otter trawlers, while the Scottish seiners discard mostly whiting, haddock, and grey gurnard and beam trawlers discard mostly dab and plaice. The majority of these discard species consist of immature fish and discarding appears to be increasing in recent years.

Cetacean bycatch occurs in this Region, mainly affecting small cetaceans – i.e. dolphins, porpoises, and the smaller toothed whales. Bycatch of common dolphins in fisheries in the northeast Atlantic have been reported for several decades, but only since the 1990s have large numbers of dead dolphins that had evidently died in fishing gear, washed ashore. Two types of fishery are considered to pose a particular threat to common dolphins, pelagic trawls and bottom-set nets. The pelagic trawl fisheries in the northeast Atlantic are complex and varied, with over twelve species targeted by vessels from six EU member states (with maybe further non-EU nations operating in international waters) using at least three major gear types. An even greater complexity applies to the bottom-set net fisheries. Some of these fisheries have relatively low or non-existent cetacean bycatches, others apparently have relatively high bycatches (e.g. the fishery for hake/pollock). For most fisheries, however, there is insufficient information to assess total cetacean bycatch at present.

Information from the Petracet Project (EU) and national programmes suggests that the total mortality of common dolphins in European pelagic trawl fisheries in the ICES area is currently probably around 800 animals per year, though large interannual variation in bycatch is known to occur in some fisheries, such as in the bass and tuna fisheries. Bycatches of common dolphins, though limited in numbers are also known to occur in other fisheries, including VHVO (Very High Vertical Opening) trawls, bottom trawls, and static nets (ICES, 2007). However, there is considerable variability in the estimated total bycatch in fisheries for which several years of data are available. This implies that there are dangers in taking (or not taking) measures based on only one or two years of bycatch data and that observation will need to continue in several fisheries where programmes appear to have finished (ICES, 2007).

Effects on the seabed and associated benthic communities and habitats

The effect of fisheries on habitat structure is not routinely monitored in this region. In addition, there have been no large-scale (1000s km^2) studies of the aggregate effects of bottom fishing activity in this region, but the known distribution of bottom fishing effort and knowledge of the local impacts of fishing suggests that there would be detectable decreases in benthic biomass and production at larger spatial scales. Locally, assessment of the impacts of scallop dredging in the Irish Sea has shown that scallop dredging causes a shift from communities dominated by relatively sessile, emergent, high biomass species to communities dominated by infaunal, smaller-bodied fauna. Removal of emergent fauna also reduced the topographic complexity of the habitat (Kaiser *et al*., 2000). Based on studies in other regions beam trawls are expected to have similar effects.

Inshore fisheries for mollusc species can have major effects on habitat structure and associated infaunal and epifaunal communities with an associated decrease in biomass and production similar to that which has been quantified for the North Sea. Hydraulic dredges for cockles, razor clams, and surf clams (*Spisula* sp.) are considered destructive to benthic habitats, but are relatively restricted in their overall extent.

Effects on community structure and food webs

The Celtic Sea groundfish community consists of over a hundred species and the most abundant 25 make up 99 percent of the total estimated biomass and around 93 percent of total estimated numbers (Trenkel and Rochet, 2003). Population and community analyses have shown that fishing has impacted a number of commercial species, primarily because individuals of too small a size have been caught and discarded in the past (Trenkel and Rochet, 2003; Rochet *et al.*, 2002).

The size and trophic structure of the fish community has changed over time, and a decrease in the relative abundance of larger (piscivorous) fish has been accompanied by an increase in smaller pelagic fish which feed at lower trophic levels (Blanchard *et al.*, 2005; Pinnegar *et al.*, 2003; Trenkel *et al.*, 2005). Temporal analyses of the effects of fishing and climate variation suggest that fishing has had a stronger effect on size-structure than changes in temperature. While the bulk of the blue whiting fishery is carried out in Region V, Heath (2005) contends that there is no foodweb connection between the blue whiting catch and the other landed species from the Celtic Sea and west of Scotland. However, both Pinnegar *et al.* (2003) and Trenkel *et al.* (2005) have both highlighted the importance of blue whiting as a prey for fish on the shelf-edge, within Region III, most notably for hake and megrim.

Interactions of the fishery with other parts of the marine community are patchily described. Zooplankton abundance (estimated by CPR) has declined in recent years and the overall substantial decline in *Calanus* abundance in this region, which is currently below the long-term mean, may have longer term consequences. There is some evidence suggesting that the decline in *Calanus* may be due to increased feeding pressure of these smaller fish and hence an indirect effect of fishing; however, climate change factors are also implicated (Nash and Geffen, 2004).

Conclusions and priorities for action

The fisheries of Region III are economically important to the large coastal population of the region. They continue to evolve taking on technical developments, exploiting new fishing opportunities, responding to regulation, and increasingly being constrained by economic forces such as the fuel price and consumer preferences, although the effect of the latter has yet to be fully evaluated. The fisheries resources in the region are heavily exploited and the level of fishing mortality remains high on most species. There is good evidence of impacts of the fishery extending across the ecosystem of the region and to date mitigation measures and regulations do not appear to have reduced the levels of fishing mortality.

From the review it is apparent that formal assessment of regulatory measures remains incomplete, with only limited data available on the benefit to stocks of commercial fish species. It would be useful to derive new measures (metrics) or continue to develop/apply existing ones (e.g. EcoQOs) in order to distinguish between different forces acting on the communities (i.e. partition effects between environmental, economic, and regulatory forces). Ultimately the goal would be to assess the effectiveness of existing management measures (through legislation and/or voluntary measures) to improve stocks and mitigate against detrimental environmental impacts. In addition, it would be informative, as new mitigation or conservation measures are implemented, to recommend or develop appropriate metrics (that can be easily monitored and reported) in order to measure the success of such measures.

Of particular note is that in the Celtic Seas Region III, there is increasing effort on non-quota species such as scallops, and that these are currently fully or over-exploited. As other fishing opportunities decline many fishers are turning to these fisheries. It would be prudent to introduce quotas or a limited license entry scheme for scallops to regulate this fishery before the situation deteriorates further.

References

BIM. 2008. Managing access to the Irish lobster fishery. http://www.bim.ie/templates/reports.asp?node_id=232.

Blanchard, J. L., Dulvy, N. K., Ellis, J. E., Jennings, S., Pinnegar, J. K., Tidd, A., and Kell, L. T. 2005. Do climate and fishing influence size-based indicators of Celtic Sea fish community structure? ICES Journal of Marine Science, 62: 405–411.

Borges, L., Rogan, E., and Officer, R. 2005. Discarding by the demersal fishery in the waters around Ireland. Fisheries Research 76: 1–13.

Heath, M. R. 2005. Regional variability in the trophic requirements of shelf sea fisheries in the northeast Atlantic, 1973–2000. ICES Journal of Marine Science, 62: 1233–1244.

ICES. 2007. Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems, 2007. ICES Advice. Books 1–10. 1333 pp.

Kaiser, M. J., Ramsay, K., Richardson, C. A., Spence, F. E., and Brand, A. R. 2000. Chronic fishing disturbance has changed shelf sea benthic community structure. Journal of Animal Ecology, 69, 494–503.

Nash, R. D. M., and Geffen, A. J. 2004. Seasonal and interannual variation in abundance of *Calanus finmarchicus* (Gunnerus) and *Calanus helgolandicus* (Claus) in inshore waters (west coast of the Isle of Man) in the central Irish Sea. Journal of Plankton Research 26:265–273.

Pinnegar, J. K., Jennings, S., O'Brien, C. M., and Polunin N. V. C. 2002. Long-term changes in the trophic level of the Celtic Sea fish community and fish market price distribution. Journal of Applied Ecology, 39: 377–390.

Pinnegar, J. K.., Trenkel, V. M., Tidd, A. N., Dawson, W. A., and Du Buit, M. H. 2003. Does diet in Celtic Sea fishes reflect prey availability? Journal of Fish Biology, 63 (Supplement A): 197–212.

Rochet, M-J., Péronnet, I., and Trenkel, V. M. 2002. An analysis of discards from the French trawler fleet in the Celtic sea. ICES Journal of Marine Science 59: 538–552.

Richardson, E. A., Kaiser M. J., Edwards-Jones, G., and Ramsay, K. 2006. Trends in sea anglers' catches of trophy fish in relation to stock size. Fisheries Research, 82: 253–262.

STECF. 2006. Report of the Subgroup on review of stocks (SGRST): Fishing Effort Management, June 2006, Ispra, Italy and October 2006, Lisbon, Portugal.

Trenkel, V. M., Pinnegar, J. K., Dawson, W. A., Du Buit, M. H., and Tidd, A. N. 2005. Spatial and temporal predation patterns in the Celtic Sea. Marine Ecology-Progress Series, 299: 257–268.

Trenkel, V. M., and Rochet, M-J. 2003. Performance of indicators derived from abundance estimates for detecting the impact of fishing on a fish community. Canadian Journal of Fisheries and Aquatic Sciences, 60: 67–85.

1.5.5.9.5 Regional QSR IV: Bay of Biscay and Iberia

Introduction

The region extends from west of Brittany (48°N) to the Gibraltar Straight (36°N). A large shelf extends west of France. The southern part of the Bay of Biscay, along the northern Spanish coast is known as the Cantabrian Sea and is characterized by a narrow shelf. Further south a narrow shelf continues west off Portugal. Lastly, to the south, the Gulf of Cadiz has a wider shelf strongly influenced by the Mediterranean Sea. Within these zones the topographic diversity and the wide range of substrates result in many different types of coastal habitat.

In addition, typical temperate-water species occur together with both sub-tropical and more boreal species. Consequently, species diversity is high. The exploited living resources consist of more than 100 species, including fish, cephalopods, and crustaceans. Many of these resources are exploited by a large variety of fleets from France, Portugal, and Spain, and also from other nations (e.g. Belgium and the Netherlands); however, the data presented are largely based on French sources and consequently do not cover the whole region.

In coastal areas, demersal and benthic resources are exploited using a wide range of fishing gears, including trawls and dredges, gillnets and trammel nets, seines, lines, traps, etc. In the offshore zone, trawling is the major activity, and fixed gears are also extensively and increasingly used. Most fisheries are multi-species.

With the exception of local stocks exploited in coastal areas (i.e. large crustaceans, scallops, small bivalve clams), few of the resources exploited are confined to the Bay of Biscay. Sole, anchovy, sea bass, *Nephrops*, and cuttlefish stocks are considered to be geographically limited to the Bay of Biscay. Most of the other resources are widely distributed and therefore part of the stock is exploited outside the Bay of Biscay. In contrast, the megrim, anglerfish, anchovy, and *Nephrops* stocks belong to the southernmost area.

The development of fisheries management and policy since 1998, and an assessment of their effectiveness

As a consequence of the depleted status of the stocks in Region IV, several recovery plans have been adopted since 2004. All aim at restoring spawning-stock biomass to a precautionary level by gradually reducing fishing mortality (TAC variations between years are to be kept below 15%). These plans involve various technical measures in addition to TAC reduction, including seasonal closures, protected areas, minimum landing size, and mesh size regulations (Table 1.5.5.9.5.1).

Although there is no recovery plan for *Nephrops* in the Bay of Biscay, a diversity of measures have been adopted either by the French administration or by the Producers' organizations (POs) themselves. A 9 cm minimum landing size regulation was established in December 2005, together with a 70 mm codend mesh size since 2000. A license system was adopted in 2004 resulting in a cap on the number of *Nephrops* trawlers operating in this area; in addition, trawling is prohibited during week-ends, and individual quotas have been imposed by the French POs since 2006. Since April 2008 selective devices have been introduced into the *Nephrops* fishery.

The major management measure taken in this area, however, is the closure of the anchovy fishery in the Bay of Biscay in June 2005 following a recruitment failure. Although slight signs of improvement were seen in 2006 and 2007, the fishery will not be reopened until the end of 2008. The only fishing allowed in 2007 has been experimental fishing with scientific observers on board, representing 20% of French and Spanish effort.

Table 1.5.5.9.5.1 Ongoing recovery plans for the stocks in the Biscay and Iberia region. All plans aim at restoring SSB at a precautionary level by a gradual decrease in fishing mortality, and also include technical measures.

STOCK	YEAR ADOPTED	TECHNICAL MEASURES
Northern hake	2004	100 mm minimum mesh size for large trawlers. 100 mm minimum mesh size OR square mesh panel for all trawlers in specified areas. Seasonal closures (2 months 2001–3, 1 month 2004–6).
Southern hake	2006	Minimum landing size. Protected areas. Minimum mesh size.
Bay of Biscay sole	2006	Minimum landing size; Minimum mesh size in the directed fishery.
Cantabrian Sea *Nephrops*	2006 2008	Minimum landing size. Selective device.
West of Portugal and Gulf of Cadiz *Nephrops*	2006	Minimum landing size. Minimum mesh size. Closed areas (3 months Galicia West; 4 months SW Portugal). Seasonal closure (1 month, Portuguese waters).

Drivers of fishing activities in OSPAR Region IV

The main economic forces acting on the fishers are the price of fish and the fuel prices, which have increased. The number of French vessels fishing in the Bay of Biscay decreased from 2000 to 2006 (Figure 1.5.5.9.5.1), except for liners and gillnetters. However, fishing effort in power × days fished increased or remained stable for each sector, except for the small pelagic fishery as the anchovy fishery was closed in 2005 (Figure 1.5.5.9.5.2). The paradoxical discrepancy between increasing fishing effort and decreasing fishing mortality on most stocks in the Bay of Biscay might be explained by i) effort targeting other stocks not presented here (e.g. cuttlefish and squid, sardine, sea bass) or ii) loss in fishing power owing to implementation of more selective fishing gears, e.g. in the *Nephrops* fishery. There has been no marked change in the spatial distribution of fishing activities of the French fleet between 2000 and 2005.

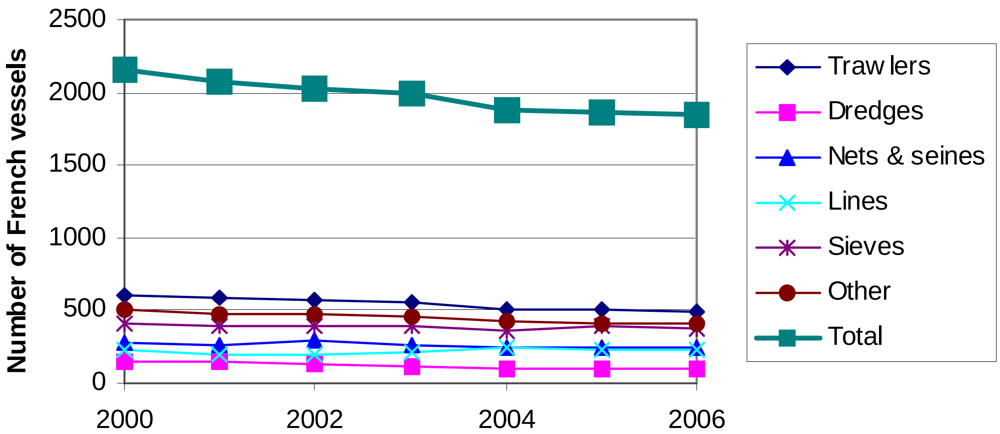


Figure 1.5.5.9.5.1 Number of French vessels fishing in the Bay of Biscay 2000–2006.

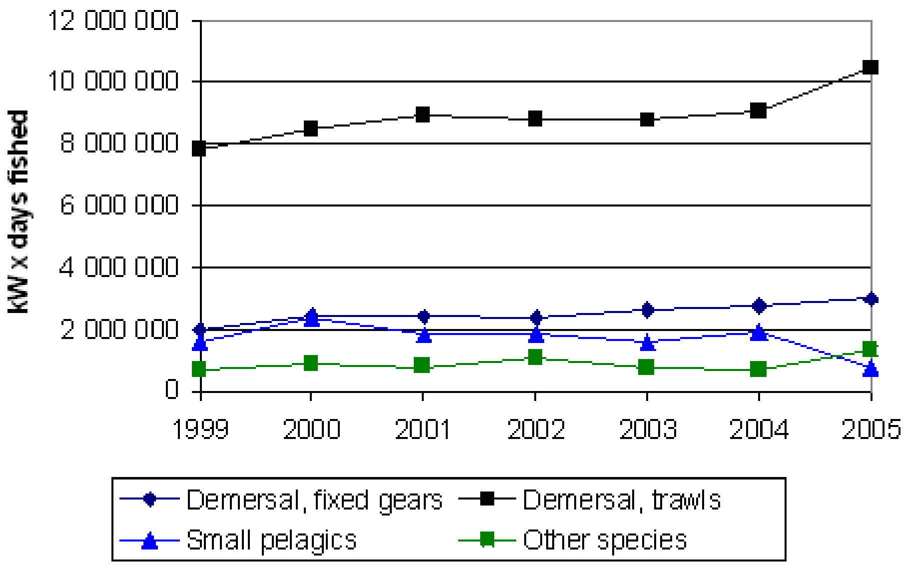


Figure 1.5.5.9.5.2 Effort in horse power × days fished by French vessels in the Bay of Biscay. Source: IFREMER aggregated VMS, market, and logbook data.

The last decade has also seen the introduction of a number of gear modification programmes aimed at reducing environmental impact, including the use of pingers in the set net fishery, modifications to demersal *Nephrops* trawls, and changes in the beam trawl fishery.

Impacts of fisheries on the ecosystem

Commercial fishing has direct and indirect effects on the marine ecosystem, which can be summarized as:

1. trends in commercial fish stocks;
2. bycatch of target and non-target species, including birds and marine mammals;
3. physical disturbance of the sea bottom and related impacts on benthic communities and habitats;
4. shifts in community structure; and
5. indirect effects on the food web.

Effects on commercial fish stocks

Landings of most species in the Iberian region have declined in recent decades. In the Bay of Biscay landings from most stocks have been maintained, with fluctuations of varying amplitudes; the exceptions to this being landings of sole which have decreased markedly since 1995, and landings of anchovy which declined severely from 2001 until the fishery was closed in 2005. In contrast, landings of the northern stock of hake started to recover in 2002 after a long period of decline.

In most cases, declines in landings were accompanied by declines in fishing mortality; southern hake and Biscay sole are the two stocks undergoing increasing fishing mortality.

Up to 90% of French landings from the Bay of Biscay are composed of 34 stocks (Forest, 2001; Forest, 2005). Reliable assessments are only available for a limited number of stocks. However, evidence of impacts of fishing on fish populations is provided by ICES (2007). Stocks which are harvested unsustainably and for which reduction in exploitation is required are Northeast Atlantic (NEA) mackerel, NEA blue whiting, southern hake, and sole on the Bay of Biscay continental shelf (ICES Divisions VIIIab). As the status of these stocks has not improved since 1998, and the status of the Bay of Biscay anchovy deteriorated, the fishery has been closed since July 2005. Some other stocks are in a better shape owing to decreasing fishing mortality and/or good recent recruitments, namely northern hake, anglerfish in Celtic Sea and Bay of Biscay, megrim in Celtic Sea and Bay of Biscay, and *Nephrops* in the Bay of Biscay. Northern hake has experienced a long period of overexploitation, and a recovery plan is currently implemented. The main concerns about the success of the recovery plan are high discarding rates of juvenile hake, in particular in the *Nephrops* fishery, and TAC overshooting (ICES, 2007). The *Nephrops* stock in Divisions VIIIab seems to be stable. However, the gear selectivity implies a high mortality of small *Nephrops* and consequently large amounts of discards. Various regulation systems are expected to reduce fishing pressure on *Nephrops*.

The largest catch of albacore tuna in the North Atlantic is taken in Area IV. Since the 1960s stock sizes in the North Atlantic have varied around the target that provides the maximum sustainable yield level. Catches have been around 30 000 tonnes per year over the past decade (Figure 1.5.5.9.5.3) (ICCAT, 2007).

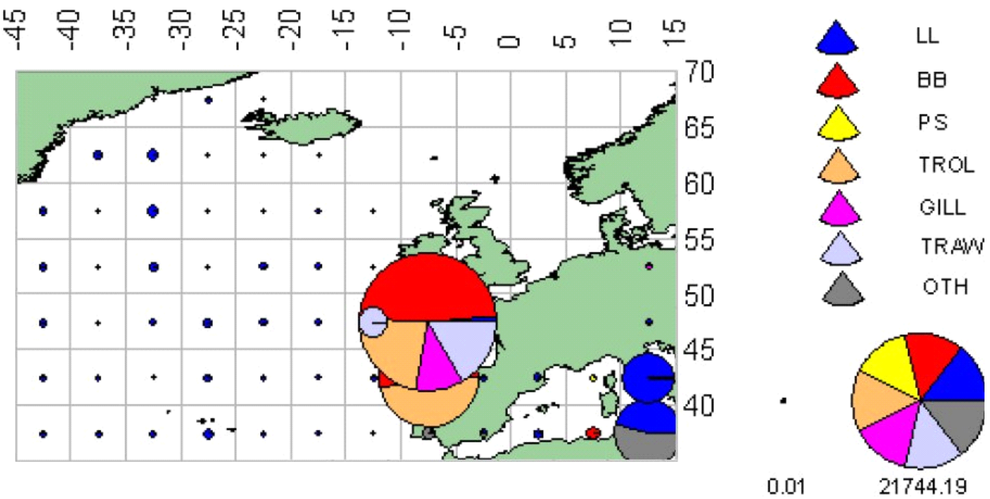
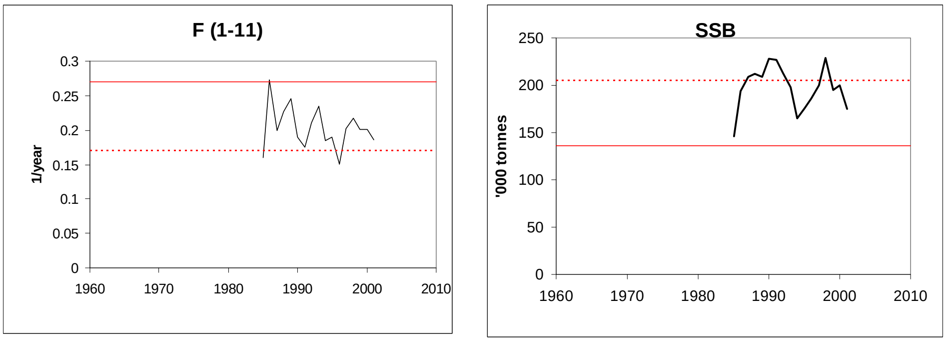


Figure 1.5.5.9.5.3 Landings in tonnes of albacore tuna in the OSPAR region by gear type in 2000–2005. LL – longline; BB – bait-boat; PS – purse seine; TROL – Troll line; GILL – Gillnets; TRAW – Trawling; OTH – other (ICCAT, 2007).

Biomass and fishing mortality limit reference points have only been defined for three of the ICES assessed stocks allocated to Region IV, i.e. southern hake (VIIIc and IXa), sole (VIII), and anchovy (VIII). Prior to 2004, southern horse mackerel had also biomass and fishing limit reference points. These data were used to plot Figure 1.5.5.9.5.4 for the state of this stock in 2002. Temporal trends in the spawning-stock biomass (SSB) and fishing mortality (F) of this stock in relation to its limit reference points are shown in Figure 1.5.5.9.5.4. In 2002, the horse mackerel stock was at risk of being harvested unsustainably and at risk of suffering reduced reproductive capacity. In 2004 this stock was redefined as covering only Division IXa and the Division VIIIc stock was included in the western horse mackerel stock, based on new scientific evidence, with no limit reference points having been set so far (ICES, 2007a).

ICES prefers to give precedence to an analysis based on stocks for which reference points have been defined as the main indicator of fishing impacts on commercial stocks because it is not straightforward to define stock status in relation to a management objective when reference points have not been defined. For demersal stocks, significant fishing impacts on assessed species are often indicative of significant fishing impacts on larger, more vulnerable species that are not assessed, but taken as bycatch. This summary excludes the ICCAT assessments. We have presented the results of those separately above.

The biological reference points F_{pa} and B_{pa} are developed to take the imprecision in the most recent estimates of F and SSB when developing fisheries management advice for fish quotas in the near future. Thus, when considering historical performance of fish stocks, F_{pa} and B_{pa} are not as relevant as F_{lim} and B_{lim} and are focused only on the limit reference points. This means that no distinction was made between stocks that are harvested sustainably and those at risk of being harvested unsustainably (since in both cases $F > F_{lim}$), and no distinction was made between stocks at risk of suffering reduced reproductive capacity and those at full reproductive capacity (in both cases $B < B_{lim}$). While this is unfortunate, it does reflect the focus of current ICES advice on the avoidance of limits rather than on the achievement of targets.



Southern horse mackerel (Divisions VIIIc and IXa). Data from 2002 assessment year.

Figure 1.5.5.9.5.4 Trends in fishing mortality (F) and spawning-stock biomass (SSB) in assessed stocks allocated to OSPAR Region IV and for which fishing mortality and biomass reference points have been defined. Continuous red horizontal lines show the limit reference points (F_{lim} and B_{lim}, respectively) while broken red horizontal lines show the precautionary reference points (F_{pa} and B_{pa}, respectively, where defined). The age classes for which values of F were calculated are shown in parentheses.

Effects on non-target species, including birds, marine mammals, and discarded fish

In the trawl fishery, trawls with small mesh sizes have long been used, catching large amounts of small fish. Even if this exploitation pattern improved over the years, large amounts of undersized catch and non-target fish species are currently being discarded in the *Nephrops* fishery and in the other French trawl fisheries in the Bay of Biscay (unpublished on-board observer data, 2002–2006). In the southern Bay of Biscay, the Spanish mixed-species fishery has increased its level of discards to the highest yet reported (ICES, 2008). The main fish species discarded are the small-sized snipe-fish *Macrorramphosus scolopax* and silver pout *Gadiculus argenteus* and the medium-sized blue whiting *Micromesistius poutassou*. None of these species survive (Pérez *et al.*, 1996).

Effects on the seabed and associated benthic communities and habitats

As a consequence of heavy trawling in the Bay of Biscay, especially in the *Nephrops* fishery, the benthic community structure is significantly altered in terms of species composition and size structure. In heavily exploited stations, the benthic community is dominated by opportunistic carnivorous species of minor or no commercial interest (Blanchard *et al*., 2004).

The Great Mud Bank (Grande Vasière), stretching from north to south in the center of the Bay of Biscay is heavily trawled, especially by the *Nephrops* trawler fleet. On average, the northern part is swept six times a year and this is suspected to have changed the sediment grain size through resuspension of fine materials, causing a decrease in the proportion of muds found on the “Grande Vasiere” grounds (Bourillet *et al*., 2004).

Effects on community structure and food webs

The Bay of Biscay fish community is recognised to have been strongly affected by fishing for a long time. A number of top predator species have been depleted in the early to mid-20th century. Red seabream, for example, used to be one of the dominant large fish species, and its collapse in the mid-1980s generated a major change in the community structure. The fish community in the Bay of Biscay is therefore dominated by small-sized species. Over the last ten years few changes have occurred at the community level. There are, however, recent signs of increase in total biomass of both small and large species after a year of sharp declines (Figure 1.5.5.9.5.5).

An analysis of demersal trawl survey-based indicators for the whole community of 51 target and non-target populations off the French coast demonstrated no overall changes in community structure in the period 1987–2002 (Rochet *et al*., 2005).

In the Cantabrian Sea, the mean trophic level of the demersal and benthic fisheries has declined. Most of this change occurred from 1983 through to 1993 and has since varied without a clear trend (Sánchez and Olaso, 2004). The fish communities are now largely dominated by lower trophic level planktivorous fish (blue whiting, horse mackerel).

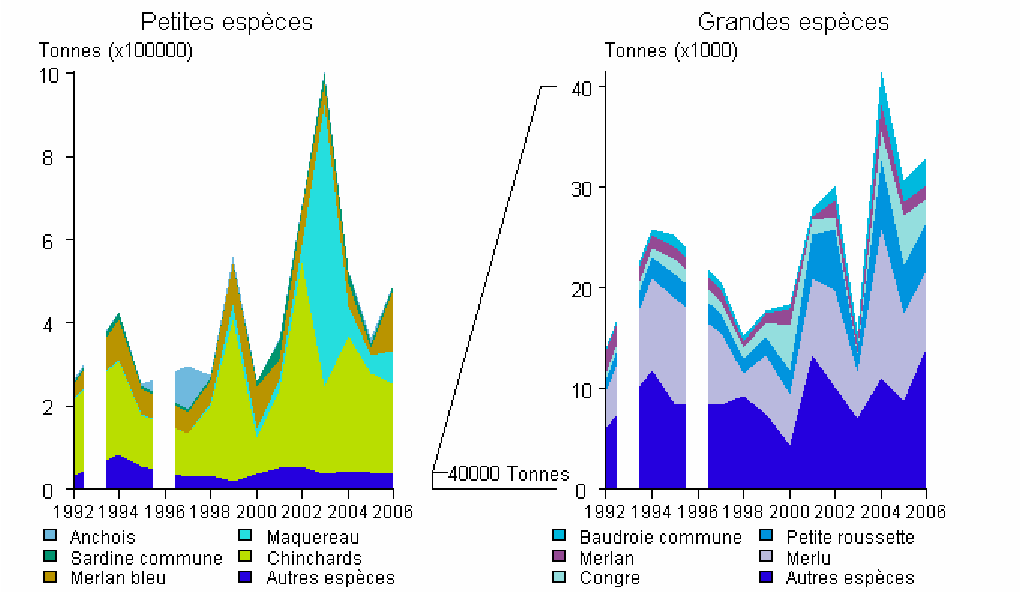


Figure 1.5.5.9.5.5 Biomass of the main large (right panel) and small (left panel) species in the Bay of Biscay.

Fisheries have a considerable influence on the distribution of seabirds at sea due to the supply of discard that serve as food for scavenging species. Studies of offshore seabirds in the Gulf of Cadiz, Galicia, and the Cantabrian Sea report a strong correlation between the spatial distribution of the scavengers and that of the demersal trawl fleet (Valeiras *et al.*, 2007).

Conclusions and priorities for action

Despite a decrease in the number of fishing vessels in the French fleet, fishing effort has increased and, under this continuing pressure, the impact of fishing cannot be said to have decreased over the last ten years. Although some management measures have proven efficient like the northern hake recovery plan, in general there has been low or no improvement in the status of target species and in the impact of fishing on the community, and the anchovy fishery had to be closed in 2005. Moreover, undersized individuals and bycatch species continue to be caught and discarded in large amounts. Recent changes in fishing gears for example, in the *Nephrops* fishery, have not yet proven efficient.

References

Blanchard, F., LeLoc'h, F., Hily, C., and Boucher, J. 2004. Fishing effects on diversity, size and community structure of the benthic invertebrate and fish megafauna on the Bay of Biscay coast of France. Marine Ecology Progress Series, 280: 249–260.

Bourillet, J-F., Folliot, B., Lesueur, P., and Goubert, E. 2004. Architecture des sédiments holocènes de la plate forme armoricaine et lien avec l'eustatisme. *In*: Les incisions et dépôts de la marge atlantique française depuis le néogène: états de lieux (Ed SGF-ASF), Paris, 25–26 novembre 2004, p. 7.

Forest, A. 2001. Ressources halieutiques hors quotas du Nord Est Atlantique: bilan des connaissances et analyse de scénarios d'évolution de la gestion. Contrat Ifremer/MAPA, Réf. 99-11-03-01. 390 pp.

Forest, A. 2005. L'état des ressources halieutiques et des pêcheries dans le golfe de Gascogne (divisions VIIIab du CIEM), Colloque golfe de Gascogne, Brest, 22–24 mars 2005.

ICCAT. 2007. Report of the 2007 ICCAT albacore stock assessment session. Madrid, Spain – July 5 to 12, 2007. 84 pp.

ICES. 2007. Report of the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine, and Anchovy (WGMHSA). ICES CM 2007/ACFM:31.

ICES. 2007a. Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment, and Advisory Committee on Ecosystems, 2007. ICES Advice. Book 7: 94 pp.

ICES. 2008. Report of the Working Group for Ecosystem Regional Description (WGRED). ICES CM 2008/ACOM:47, 203 pp.

Pérez, N., Pereda, P., Uriarte, A., Trujillo, V., Olaso, I., and Lens, S. 1996. Descartes de la flota española en el área del ICES. Datos y Resúm. Inst. Esp. Oceanography, 2: 142 pp.

Rochet, M-J., Trenkel, V., Bellail, R., Coppin, F., Le Pape, O., Mahé, J-C., Morin , J., Poulard, J. C., Schlaich, I., Souplet, A., Vérin, Y., and Bertrand, J. A. 2005. Combining indicator trends to assess ongoing changes in exploited fish communities: diagnostic of communities off the coasts of France. ICES Journal of Marine Science, 62: 1647–1664.

Sánchez, F., and Olaso, I. 2004. Effects of fisheries on the Cantabrian Sea shelf ecosystem. Ecological Modelling, 172: 151–174.

Valeiras, X., Abad, E., Serrano, A., Preciado, I., and Sánchez, F. 2007. Distribution and abundance of seabirds at fishing boats in Galician and Cantabrian waters in relation to environmental and fisheries factors and discards. Journal of Marine Systems (accepted).

1.5.5.9.6 Regional QSR V: Wider Atlantic

Introduction

The majority of Region V is deep water, greater than 3000 m in depth. The exceptions are the continental slope, some banks to the west of Scotland and Ireland and southwest of the Faroes, and the narrow areas of shallow water around the Azores. The major topographic feature is the northern part of the mid-Atlantic Ridge, located between Iceland and the Azores. Numerous seamounts of variable heights occur all long this ridge along with isolated seamounts in other areas such as Altair and Antialtair. The physical structure of seamounts often amplify water currents and create unique hard substrata environments that are densely populated by filter-feeding epifauna such as sponges, bivalves, brittle stars, sea lilies, and a variety of corals.

The fisheries on the shallower banks (e.g. Rockall) are similar to those in the more offshore parts of Region III, targeting for instance haddock. On the continental slopes and deeper banks, there are bottom trawl and set-net fisheries for species such as monkfish *Lophius* spp., hake *Merluccius merluccius*, and deep-water species such as blue ling, roundnose grenadier, black scabbard fish and deep-water sharks. Bottom-fisheries for deep-water species such as redfish *Sebastes* spp., orange roughy *Hoplostethus atlanticus*, and roundnose grenadier *Coryphaenoides rupestris* also occur along the mid-Atlantic Ridge and over seamounts using trawls, set nets, and longlines.

There are two fisheries for small pelagic species in the area: the large pelagic fishery for blue whiting *Micromesistius poutassou* on the western European continental margin extends into parts of Regions I, III, and IV, while the greater silver smelt *Argentina silus* fishery is more localised. Fisheries for large pelagic species, tuna, billfish, and some sharks extend across much of the region.

Management of fisheries for large pelagic species in Region V is carried out through the International Commission for the Conservation of Atlantic Tuna (ICCAT). Management of demersal fishing in the high seas of Area V is through the North-East Atlantic Fisheries Commission or the relevant authority for areas inside exclusive fishing zones (European Union, Faroe Islands, Iceland).

The development of fisheries management and policy since 1998, and an assessment of their effectiveness

Major changes in the management of fisheries in the northeast Atlantic are described in the Quality Status Report (QSR) NE Atlantic Overview volume. In this section we consider only measures with a purely regional basis.

Deep-water fisheries in the European waters of Region V are regulated under the Common Fisheries Policy (CFP). Under Council Regulation (European Commission (EC) No. 2347/2002), member states must ensure that fishing activities which lead to catches and retention on board of more than 10 tonnes each calendar year of deep-sea species by vessels flying their flag and registered in their territory are subject to a deep-sea fishing permit. Member states are obliged to calculate the aggregate power and the aggregate volume of their vessels which, in any one of the years 1998, 1999, or 2000, landed more than 10 tonnes of any mixture of the deep-sea species. The aggregate volume of vessels holding deep-sea fishing permits may not exceed this figure.

Council Regulation (EC) No. 27/2005 obliged member states to ensure that, for 2005, the fishing effort levels, measured in kilowatt days absent from port, by vessels holding deep-sea fishing permits did not exceed 90% of the average annual fishing effort deployed by that member state's vessels in 2003 on trips when deep-sea fishing permits were held and deep-sea species were caught. For 2006 this limit was further reduced to 80% of 2003 levels.

Council Regulation (EC) No. 51/2006 banned the use of gillnets by Community vessels at depths greater than 200 m in ICES Divisions VIa, b and VII b, c, j, k. This was intended as an emergency measure for a duration of one year, and it was replaced in 2006 with a ban on gillnetting at depths greater than 600 m. In 2008, this measure is still a "*transitional measure(s) to allow these fisheries to take place under certain conditions* [...] *until more permanent measures are adopted*" included in the general TAC regulation (Council regulation (EC) No. 40/2008 of the Council of 16/01/2008).

Since 2003, black scabbardfish *Aphanopus carbo*, blue ling *Molva dypterygia*, greater silver smelt *Argentina silus*, ling *Molva molva*, orange roughy *Hoplostethus atlanticus*, red seabream *Pagellus bogaraveo*, roundnose grenadier *Coryphaenoides rupestris*, and tusk *Brosme brosme* have been subject to TACs and quotas in EC waters and for Community vessels fishing elsewhere. In 2005, the list of species managed by quota was increased by the addition of deep-water sharks.

Closed areas have been established in ICES Subarea VII to protect aggregations of orange roughy and in Division VIa to protect cold-water corals.

The only deep-water fisheries in ICES Subarea Xa are those from the Azores. Fisheries management is based on regulations issued by the European Community, by the Portuguese government, and by the Azores regional government. Fishing with trawl gears is forbidden in the Azores region. A box of 100 miles limiting the deep-water fishing to vessels registered in the Azores was created in 2003 under the management of fishing effort of the common fishery policy for deep-water species (EC Reg. 1954/2003). Some technical measures were also introduced by the Azores regional government in 1998 (including fishing restrictions by area, vessel type and gear, fishing licence based on landing threshold and minimum lengths). In order to reduce effort on traditional stocks, fishers are encouraged by local authorities to exploit the deeper strata (>700m), but the poor response of the market has been limiting the expansion of the fishery.

The Northeast Atlantic Fisheries Council (NEAFC) regulates effort in the fisheries for deep-water species in the NEAFC Regulatory area and has introduced some closed areas to protect vulnerable habitats and cold-water coral. These closures are on the Hecate, Faraday, Altair, and Antialtair seamounts, a section of the Reykjanes Ridge, Hatton Bank, and Rockall Bank.

Gillnets, entangling nets, and trammelnets have been banned from use in the NEAFC Regulatory Area since early 2006 in waters deeper than 200 m.

NEAFC introduced a system in 2007 to list vessels caught fishing illegally. This effectively bans such vessels from operating in ports of NEAFC Contracting Parties and thus helps curtail illegal, unreported, and unregulated (IUU) fishing.

Measures were introduced by ICCAT in 2004 to ban the "finning" of sharks caught in ICCAT waters. This measure was designed to reduce the incentive to target sharks for their fins alone (the remainder of the shark being discarded).

In 2007, ICCAT introduced measures to reduce seabird bycatch in tuna fisheries. The measures apply to vessels fishing south of 20°S. All vessels are required to carry and use bird-scaring lines (tori poles) to specified design. Vessels are encouraged to use a second tori pole and bird-scaring line at times of high bird abundance or activity. Longline vessels targeting swordfish using monofilament longline gear may be exempted on condition that these vessels set their longlines during the night, with night being defined as the period between nautical dusk/dawn as referenced in the nautical dusk/dawn almanac for the geographical position fished. In addition, these vessels are required to use a minimum swivel weight of 60 g placed not more than 3 m from the hook to achieve optimum sink rates.

There is no evidence of any gear-based mitigation measures being introduced into deep-water fisheries and given the species composition it is unlikely that any such measures would have much effect as most of the species are vulnerable deep-water species. A closure has been introduced on Rockall Bank to protect juvenile haddock, but there has been no formal assessment of the effectiveness of this closure. Vinnichenko and Khlivnoy (2008) indicated that at least part of the closed area contained few juvenile haddock.

The largest fishery in the northeast Atlantic is for blue whiting. This stock is present in waters of Regions I, III, and IV and straddles various fishery management zones, including portions of the high seas managed by NEAFC. Negotiations among coastal states failed to set a TAC in this fishery for many years, with coastal states subsequently setting quotas for themselves that totalled substantially more than was recommended in scientific advice. For example, in 2003, catches of blue whiting reached a peak of 2.3 million tonnes whereas the advice from ICES was not to exceed 600 thousand tonnes. In 2005, coastal states finally agreed a TAC, but this was set considerably in excess of the TAC recommended by ICES, with an agreement to reduce the TAC annually by 100 000 tonnes until a target fishing mortality rate was reached. ICES found that these management decisions were not consistent with the precautionary approach.

Reducing bycatch in the pelagic trawl fishery for blue whiting around the Faroe Islands

As noted above, blue whiting is one of the major pelagic fish resources in the northeast Atlantic. The total blue whiting catch in the Faroese exclusive economic zone (EEZ) in 2004 was 426 000 t (http://www.neafc.org/fisheries/docs/final_catch_2004.pdf).

The last decade has seen huge technical developments in pelagic fishing, both in vessel size and design, as well as in development of trawl design. Today pelagic trawls used for blue whiting have horizontal openings 200 m wide, with vertical openings of 100 m encompassing meshes of 64 mm in the mouth of the trawl gradually tapering back to 32 mm in the codend. These trawls have the ability to catch several 100 tonnes in a few minutes towing time with a towing speed of 3–4 knots.

In recent years an increasing bycatch of demersal species, mainly saithe *Pollachius virens* and to a lesser degree cod *Gadus morhua*, have been observed in the blue whiting fishery, particularly in the Faroese area. The Faroese Fisheries Inspection estimated an average bycatch in Faroese waters to be approximately 1%, with similar estimates being made for the fishery in Icelandic waters. Given the catch sizes in this fishery, these bycatches have the potential to impact on saithe and cod stocks.

For the Faroese pelagic fishers this bycatch was valueless as it could not be sorted from the blue whiting catch. As the main problems were seen in Faroese waters there was a strong motivation for them to find ways to reduce saithe and cod catches, thus benefiting the Faroese demersal fleets. On the 1st of January 2007 it became mandatory for the Faroese blue whiting fishery to use a sorting grid in Faroese waters where bycatch is an issue. The type of sorting grid is not specified, but the bar spacing has to be 55 mm. Acceptance of this gear measure is reportedly high for the Faroese fishing industry and has received a strong helping hand through an education campaign initiated by the Faroese fisheries laboratory to assist fishers with the installation and use of the grid. Grants for purchase and installation costs have also been instigated. This strong collaboration between the Faroese fisheries laboratory and the Faroese fishing industry, in parallel with the technical assistance provided has led to this high level of acceptance of adopting the sorting grid.

Monitoring of the use of the grid has been intense and, as part of the introduction of the regulation the Faroese authorities have sought to assess the effectiveness of this measure through monitoring catches at sea and landings ashore. The monitoring of the landings reflects whether bycatch levels have been reduced effectively and reports suggest this is the case.

The introduction of the flexible grid into the blue whiting fishery shows how gear measures properly researched with full industry support can work, and what is really interesting about this gear measure is that it took only a year or so from inception to regulation. The Faroese experience shows the importance of industry collaboration, but also the need for back-up technical support and education of fishers to encourage acceptance. The adoption of this grid is perhaps paralleled to the introduction of Turtle Excluder Devices in the US, southeast Asia, and Australia where education programmes have accompanied their introduction to advise fishers on correct installation and handling, as well as provision of back-up technical assistance to solve any rigging and handling problems that may have arisen.

Fishing activities in OSPAR Region V; Wider Atlantic

The Wider Atlantic region encompasses high seas fisheries and some fisheries in Exclusive Fisheries Zones from south of Iceland and the Faroe Islands to the Azores. The deep-water fisheries are relatively poorly described and the developments in gear and introduction of gear-based technical measures identified are fairly limited.

A demersal trawl fishery, primarily for haddock *Melanogrammus aeglefinus* occurs on Rockall Bank (primarily EU vessels) and in international waters to the west of Rockall (primarily Russian vessels). The fishery in international waters began in 1999. It uses rockhopper trawls with small mesh codends and has a high bycatch of blue whiting and grey gurnard *Eutrigla gurnardus*. Catches of undersize haddock in this fishery are high in some areas of waters less than 200 m in depth (Vinnichenko and Khlivnoy, 2008).

Bottom trawl fisheries in deep waters are mainly concentrated around the continental slope and offshore banks west of the British Isles, the mid-Atlantic Ridge, and to the west of the Azores. They target species such as redfish, orange roughy, roundnose grenadier, deep-water sharks, alfonsino *Beryx decadactylus*, and black scabbardfish. The gears used in these fisheries tend to be high opening rockhopper trawls with heavy groundgears made up of a combination of steel bobbins and rubber discs of 500 mm or more in diameter. The net designs used are broadly similar across fleets, generally quite simple 2-panel “Alfredo” trawls that are relatively cheap to construct and easy to repair given gear damage in many of these fisheries can be high.

The pelagic fishery for blue whiting off the west coast of Ireland and the UK extends into the wider Atlantic region. Large vessels from EU, Norway, Faroe Islands, and Iceland participate in this fishery using single-boat pelagic trawls. Trawl design in this fishery as with other pelagic fisheries has seen dramatic changes as net manufacturers have strived to improve the hydrodynamics of the trawls to reduce drag and improve water flow. This has included using self-spreading technology, which utilises the force of the water current through the net to spread the trawl without increasing towing resistance and also the use of hexagonal meshes at the mouth of the trawl, as well as using low drag materials such as dynex. Trawl door designs in this fishery have also developed in the last decade. Doors have become smaller and lighter but with the same spreading force, allowing vessels to tow faster without increasing fuel consumption.

Since the introduction of a ban on deep-water gillnets at depths greater than 600 m in EU waters of Subareas VI and VII, the directed gillnet fishery for deep-water sharks and deep-water red crab *Geryon affinins* that formerly took place in these subareas has now been displaced to Subareas IV, VIII, and IX. This fishery is very poorly documented, but there is a bycatch of mora *Mora moro* and greater forkbeard *Phycis blennoides*. There are also directed gillnet fisheries for monkfish and hake at depths less than 600 m. Since 2005, vessels operating in the NEAFC Regulatory Area are not permitted to deploy gillnets, entangling nets, or trammelnets at any position where the charted depth is greater than 200 metres. In recent years a directed fishery for deep-water red crab, using pots, has also taken place in this area. Effort levels in this fishery are not known, but vessels are reportedly fishing upwards of 1000 pots per vessel. A similar pot fishery exists off the Azores.

As in the OSPAR Regions III and IV a major development within the static net fisheries was the development and subsequent banning of a driftnet fishery for albacore tuna *Thunnus alalunga*. This fishery straddled the wider Atlantic region. This fishery developed in the early 1990s and at its peak involved around 120 Irish and French vessels working 5–10 km of gear in line with the UN resolution 44/225 of 22 December 1989, which called for a moratorium on the use of large-scale driftnets to protect cetacean species. Following protracted negotiations this fishery was closed in 2002 on the basis of reported marine mammal bycatches. Following these measures, Irish and French fishers converted to other forms of fishing, including the use of pair pelagic trawls. Research trials with this method showed that bycatch of marine mammals was as high as in the driftnet fisheries, although in later years this bycatch has reduced considerably. Anecdotally this has been put down to the fact that fishers have tended to drop the headline of these trawls to well below the surface to target bigger tuna.

The Norwegian longline fleet described in Region I also fishes in Region V for blue ling *Molva dypterygia*, tusk *Brosme brosme*, and deep-water sharks. These vessels all fish with automatic longline systems and in the deeper waters in this region can work around 20 000–25 000 hooks a day. A directed fishery for Greenland halibut *Reinhardtius hippoglossoides* with a bycatch of deep-water shark species, mora, and blue ling was developed in 2000/2001 at Hatton Bank, yielding very high catch rates. However, this fishery has declined in recent years with only limited catches reported, and effort has been reduced.

In the south of the OSPAR Region V, there are traditional handline and longline fisheries near the Azores, targeting red seabream, wreckfish *Polyprion americanus*, conger eel *Conger conger*, bluemouth *Helicolenus dactylopterus*, golden eye perch *Beryx splendens*, and alfonsino. The gear used in this fishery is artisanal with only 30–60 hooks shot per set. Hooks are attached to 1.1 m gangions spaced every 1.2 m along a monofilament leader which is connected to a steel wire that runs to the surface. The fishery predominantly targets red seabream. Since the mid-1990s, the landings of other deep-water species have decreased (Figure 1.5.5.9.6.1.). Since 2000, the use of bottom longline in the coastal areas has been significantly reduced, as a result of a ban on the use of longlines within 3 miles of the islands. As a consequence, the smaller boats operating in this area have changed their gears to several types of handlines, which may have increased the pressure on some species. The deep-water bottom longline is at present mostly a seamount fishery.

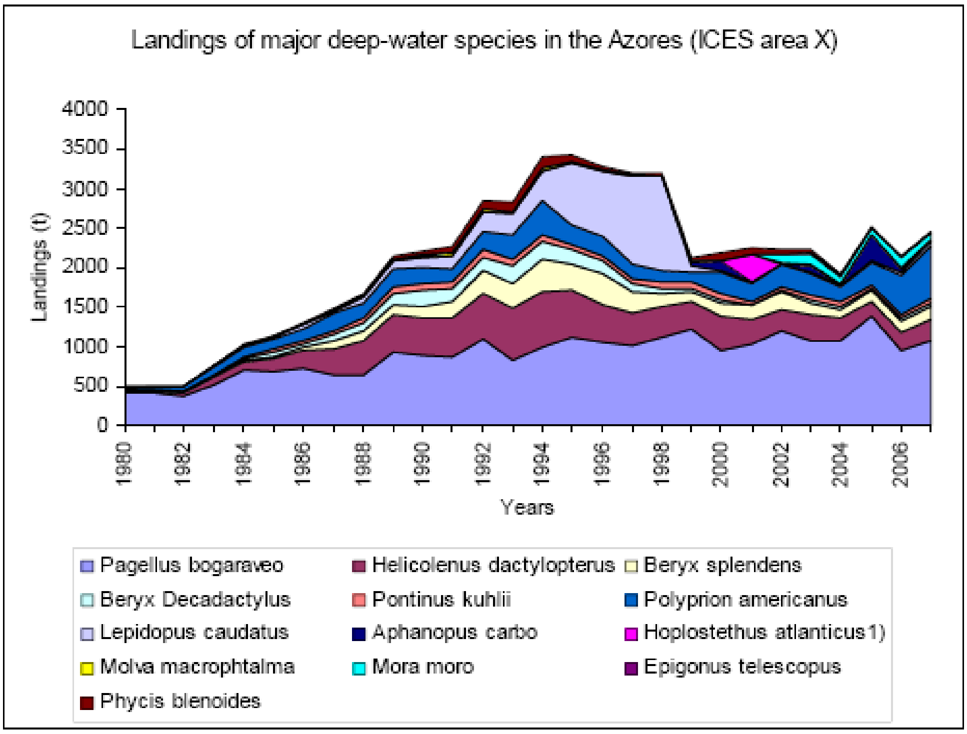


Figure 1.5.5.9.6.1 Annual landings of major deep-water species in Azores from the hook and line fishery (1980–2007).

A number of surface longline fisheries in this area target tuna and billfish species with high bycatches of pelagic sharks. Approximately 150 active Japanese pelagic longline vessels operating over the wider Atlantic Ocean target species such as bluefin tuna *Thunnus thynnus* and bigeye tuna *Thunnus obesus* in the remaining regions. The gear used has not changed recently and the longline systems used by these vessels are still labour intensive. Up to 50 km of 2500 hooks is shot and hauled per day.

The Spanish surface longline fishery in the North Atlantic primarily targets swordfish *Xiphias gladius*, sharks, and tuna over a variety of years, areas, and seasons (Mejuto and de la Serna, 2000). The gear used is the standard Spanish surface longline for swordfish (using a mean number of 1100–1500 hooks per set), although some technological improvements have been documented over time (e.g. the introduction of light sticks and changing from a multifilament to a monofilament line) (Mejuto and de la Serna, 1997; Mejuto *et al*., 2002). It can be considered a multi-species fishery because the gear can be modified (e.g. by switching configurations such as the depth of set or hook type) to target swordfish, tuna, or sharks. Blue shark *Prionace glauca* has become a target species in recent years for some sets, trips and areas due to the recent increase in price of this species on the international market (Mejuto and García-Cortés, 2004) and the ability of modern vessels to freeze their catch and therefore to retain sharks caught without any deterioration of the meat and cross-contamination of other more valuable species.

There are also Portuguese surface longline fisheries targeting swordfish around the Azorean EEZ. An artisanal fleet fishes 800–1200 hooks on a daily or weekly basis. This is still essentially manual fishery with little mechanization other than limited haulers. Larger sized longline vessels from the Azores and Portugal also target swordfish in waters outside the Azorean EEZ. These vessels have freezing capabilities and conduct trips lasting a month or more, working an average of 2500 hooks per set. These vessels are much more sophisticated, tending to work with line hauling and line setting equipment and using also chemical lightsticks to attract swordfish.

Another major development within static net fisheries was the development and subsequent banning of a driftnet fishery for albacore tuna. This fishery developed in the early 1990s and at its peak involved around 120 Irish and French vessels working 5–10 km of gear in waters to the west of France and Ireland. In line with the UN resolution 44/225 of 22 December 1989, which called for a moratorium on the use of large-scale driftnets to protect cetacean species, this fishery was closed in 2002 (see Section 4.6.4.2 for reported marine mammal bycatches). Following these measures, Irish and French fishers converted to other forms of fishing, including the use of pair pelagic trawls.

Another fishery that was developed during the period from 1998 and then subsequently declined is the orange roughy fishery on seamounts off the west and southwest coast of Ireland. French vessels had been exploiting this fishery on a limited basis since the early 1990s, although landings had declined markedly in Area VI by 1995. These vessels continued to land orange roughy from Area VII. Following a fleet renewal programme in Ireland, which saw the introduction of a number of new and efficient whitefish trawlers the fishery in Area VII expanded rapidly around 2000–2001. The vessels worked around a limited number of seamounts at depths up to 1200 m. In 2003 following concerns about the state of deep-water species, including orange roughy, the EU introduced TACs and quotas into these fisheries, thereby restricting fishing opportunities. Prompted by concerns over damage to sensitive habitats, further restrictions were introduced in 2005, preventing fishing on seamounts. This effectively curtailed the orange roughy fishery and has forced the vessels involved to divert effort to other areas, e.g., Rockall, or concentrate on species such as black scabbard, grenadier, and saithe.

Impacts of fisheries on the ecosystem

Commercial fishing has direct and indirect effects on the marine ecosystem, which can be summarized as effects on:

1. commercial fish stocks;
2. non-target species, including birds, marine mammals, and discarded fish;
3. the seabed and associated benthic communities and habitats; and
4. community structure and food webs.

Effects on commercial fish stocks

There is clear evidence that some deep-water fish (500–1800 m) have been severely depleted in Region V by the deep-water fisheries. Many of these species have attributes which make them particularly vulnerable to overfishing such as slow growth rates, late age of maturity, low or unpredictable recruitment, and long lifespans. Examples include the roundnose grenadier, orange roughy, and deep-sea sharks. Other deep-water species such as black scabbard fish and blue ling have higher productivity and are believed to be more similar to typical gadoids.

Populations of fish that aggregate on oceanic bathymetric features such as seamounts are particularly sensitive to overfishing, due to low productivity and high catchability. On the southern part of the mid-Atlantic Ridge and adjacent seamounts, populations of alfonsinos were depleted also in the 1970s. More recently, longline fisheries appear to have depleted seamount populations of "giant" redfish on seamounts of the northern mid-Atlantic Ridge (Hareide and Garnes, 2001).

Modern fishing fleets are capable of causing a very significant reduction in demersal deep-water fish biomass in just a few years; a consequence of this has been the collapse of several fisheries (Koslow *et al*., 2000). Exploitation of orange roughy on a single seamount in Subarea VI began in 1989. Catches peaked in 1991 at 3500 t, then dropped to less than 100 t by 1995. It is presumed that the aggregation was fished out and no subsequent recovery has been observed.

Landings are a particularly poor indicator of the state of deep-water species in Region V because sequential depletion of local stocks has occurred in this fishery (ICES, 2008). Moreover, increases in landings reflect increased effort in this fishery. In cases where landings data are known to apply to a single stock or location, they may provide a better proxy for the status of the resource. However, biological reference points have not been set for any of the assessed species in this region, and therefore only landings data are presented.

Landings of blue ling, tusk, and haddock have declined over the past decade, all continuing long-term declines (Figure 1.5.5.9.6.3). Fishing mortality on haddock at Rockall has declined (Figure 1.5.5.9.6.4). The blue whiting fishery grew greatly in the past decade and has since declined; fishing mortality paralleled this increase, but has remained high (Figure 1.5.5.9.6.4). Much of this growth of the fishery has occurred in OSPAR Region 1.

Bluefin tuna are caught throughout Region V (Figure 1.5.5.9.6.2). The stocks in the North Atlantic and Mediterranean are related. Spawning biomass fell in the 1950s and has remained at a relatively low level ever since. In 2004 the reported catch was about 32 500 tonnes for the east Atlantic and Mediterranean, of which about 25 000 t were reported for the Mediterranean. It is likely that catches of bluefin tuna from the eastern Atlantic and Mediterranean have been seriously under-reported in recent years. This indicates the probability that the volume of catch taken in recent years significantly exceeded TAC levels and is about 7000 tonnes in the east Atlantic (ICCAT, 2006). The ICCAT assessment results show that the spawning-stock biomass continues to decline while fishing mortality is increasing rapidly, especially for large fish. ICCAT (2006) mentioned the possibility of a collapse in the near future, given the estimation of the fishing capacity of all fleets combined and current fishing mortality rates, unless adequate management measures are implemented.

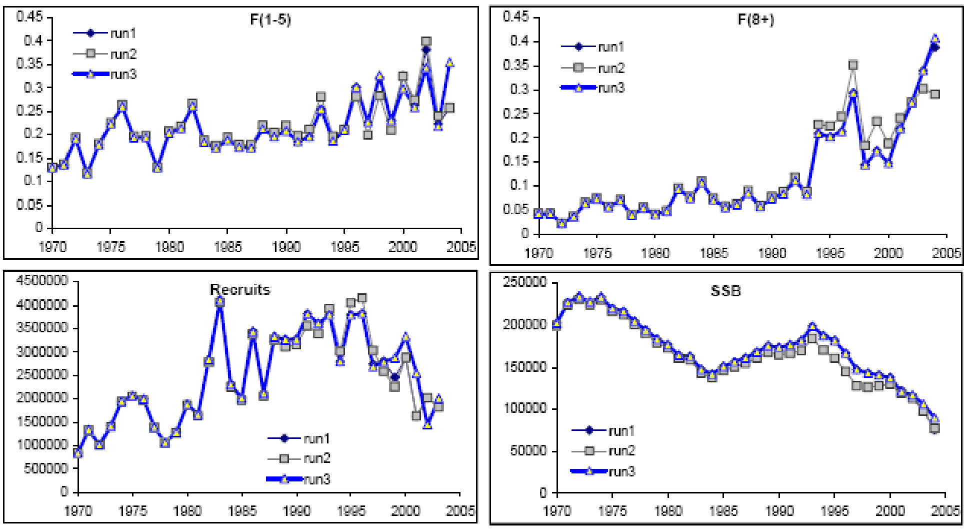
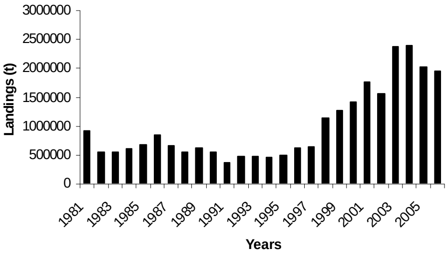
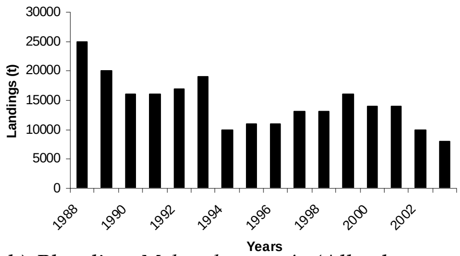


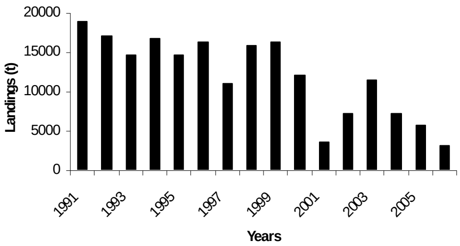
Figure 1.5.5.9.6.2 Results of three runs of VPA models of east Atlantic and Mediterranean bluefin tuna. Top figures show average fishing mortality for ages 1 to 5, and 8 and older. The bottom figures show trends in recruitment and spawning-stock biomass. These figures are based on analyses which assume there was no underreporting of catches (From ICCAT, 2006).



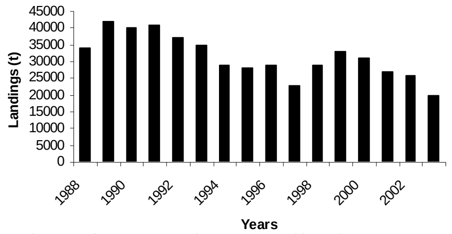
a) Blue whiting combined stock (Sub-areas I-IX, XII & XIV)



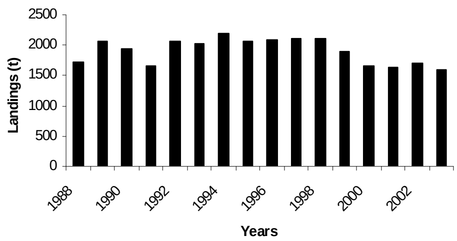
b) Blue ling *Molva dypterygia* (All relevant ICES sub-areas including some outside Region V)



c) Haddock in Division VIb (Rockall)

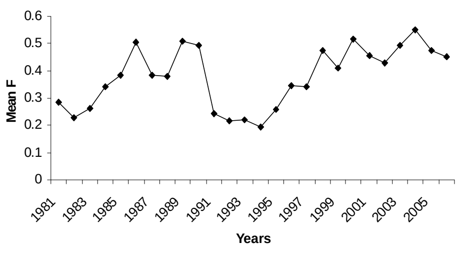


d) Tusk *Brosme brosme* (All relevant ICES sub-areas including some outside Region V)

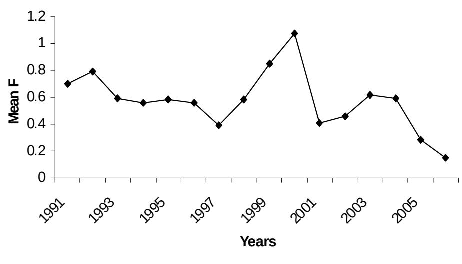


e) Red (=blackspot) seabream (All relevant ICES sub-areas including some outside Region V)

Figure 1.5.5.9.6.3 Landings of selected species of commercial importance from parts of OSPAR Region V. Data from ICES.

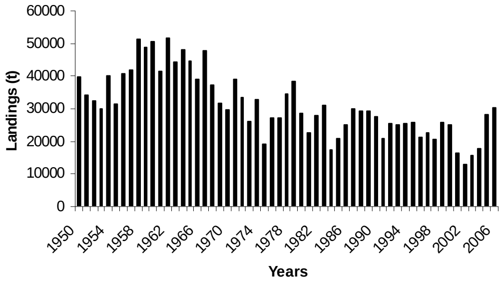


Blue whiting combined stock (Sub-areas I-IX, XII & XIV)

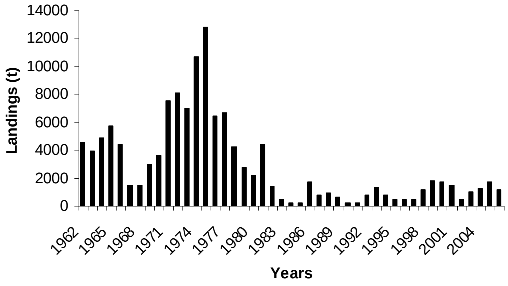


Haddock in Division VIb (Rockall)

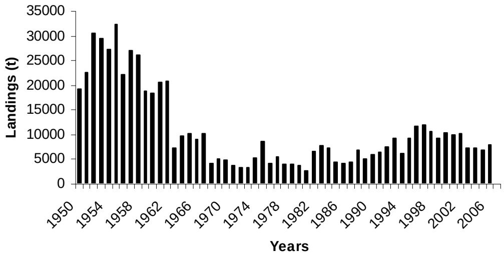
Figure 1.5.5.9.6.4 Fishing mortality on selected stocks of importance in Region V.



a) Albacore tuna



b) Bigeye tuna



c) Northern bluefin tuna

Figure 1.5.5.9.6.5 Landings of three species of tuna, 1950–2007 in the northeast Atlantic (Data from ICCAT).

Effects on non-target species, including birds, marine mammals, and discarded fish

The majority of fish and invertebrates living in the deep waters of OSPAR Region V are poorly known, and consequently the impacts of fishing on these communities have not been clearly demonstrated.

In order to reduce bycatch in lost and abandoned deep-water gillnet fisheries, Ireland and the UK have completed a number of net retrieval surveys and recovered substantial amounts of lost or abandoned gear in certain areas. These retrieval surveys are continuing in 2008.

An observer programme on an albacore tuna driftnet fishery in Region V has provided some data on bycatch. A minimum of seven fish species were caught and landed. Eleven fish species were discarded, of which blue shark *Prionace glauca* was the most frequently recorded representing 68% of all fish discarded by number. At least four species of seabird (northern gannet *Morus basanus*, northern fulmar *Fulmarus glacialis*, Manx shearwater *Puffinus puffinus*, Atlantic puffin *Fratercula arctica*) and two species of turtle, including the leatherback turtle *Dermochelys coriacea*, were also entangled. Eight species of cetacea were recorded as bycatch during these fishing operations, including common dolphins *Delphinus delphis* and striped dolphins *Stenella coeruleoalba*. Using landings of albacore tuna as an indicator of effort, the extrapolated decadal scale data from Irish and other driftnet fleets operating in this area suggest that during the period 1990–2000, a minimum of about 778 000 blue sharks were caught, with a substantial proportion discarded. An estimated 24 300 dolphins were killed during these years by these fleets, of which 11 700 were common dolphins and 12 600 were striped dolphins.

There are indications that the bycatch of marine mammals in the pelagic trawl fishery for albacore was as high as in the driftnet fishery it replaced, although in later years this bycatch appears to have reduced considerably.

There are some detailed data available for the fleet of about 20 Spanish demersal longliners targeting hake in the Gran Sol area (which straddles the boundary of OSPAR Regions III and V) off western Ireland. This information indicates a relatively large bycatch of northern fulmar and great shearwater *Puffinus gravis*.

A programme to monitor demersal longline fisheries around the Azores placed three observers on-board vessels in 2005–2007 over periods between 6 and 9 months, during which time no seabirds were recorded as bycatch.

Surface longline fisheries for tunas, swordfish, and others often have a bycatch of sea turtle, pelagic sharks, and seabirds. ICCAT is currently engaged in assessing all of the fisheries that it manages to determine the scale and significance of seabird bycatch.

In addition to catching target species, deep-water fisheries bycatch unwanted species that are either too small or unpalatable. Discarding rates are often high (in the order of 50%). The bulk of the discarded catch in deep-water trawl fisheries west of the British Isles consists of smoothheads (Alepocephalidae).

Effects on the seabed and associated benthic communities and habitats

Most attention has been directed towards the destruction of biogenic habitat by bottom tending gear. In particular, cold-water coral and sponge species have been recognized as vulnerable marine ecosystems warranting international protection. The main reef building species is *Lophelia pertusa*. This species forms large bioherms or reefs along the continental slope and on the offshore banks (Rockall and Hatton). Many areas remain to be surveyed for *Lophelia pertusa*. Some of these reefs are large, for instance, to the south and west of Ireland several reefs have built mounds at heights of 150–200 m and about 1 km wide.

Seamounts often have coral reefs, supporting aggregations of fish such as orange roughy and alfonsinos. Many seamounts have been targeted by commercial fleets. The habitats on seamounts are often highly susceptible to damage by mobile bottom fishing gear and the fish stocks can be rapidly depleted due to the life history traits of the species, which are slow-growing and longer-living than non-seamount species.

Effects on community structure and food webs

No available information directly describes changes in the community structure within Region V. Based on research elsewhere and given the depletion of some fish stocks, it is likely that such changes have occurred.

Conclusions and priorities for action

The effects of fishing in OSPAR Region V are relatively poorly studied. The high value of the large pelagic fish in the region has also led to depletion of their stocks. A number of the deep-water biogenic habitats in Region V are very susceptible to damage from seabed fisheries, particularly trawling, but also to the intense or prolonged use of other gears. Damage has been documented at a number of locations, but there is very likely to have been more damage than that documented. Fisheries managers have introduced closed areas to protect some of these habitats. Bycatch of birds, marine mammals, and sharks occurs, and in the case of sharks this is probably affecting stocks in an unsustainable manner.

Priorities in the region are primarily to continue to improve the management of fisheries. In general a reduction in fishing effort in deep-water trawl and pelagic long-lining (tuna) fleets will be effective, but other fisheries management tools are available. Further scientific surveys are required to identify habitats of particular importance, along with fisheries closures to protect vulnerable marine ecosystems. Bycatch can be reduced using technical measures, but these require dedicated development, usually best undertaken in association with relevant fishers.

References

Hareide, N-R., and Garnes, G. 2001. The distribution and abundance of deep-water fish along the Mid-Atlantic ridge from 43°N to 61°N. Fisheries Research, 51: 297–310.

ICCAT. 2006. Report of the 2006 Atlantic Bluefin Tuna Stock Assessment Session. Madrid, Spain – June 12 to 18, 2006. SCRS /2006/013. 137 pp.

ICES. 2008. Report of the Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP). ICES CM 2008/ACOM:14. 13 pp.

Koslow, J. A., Boehlert, G., Gordon, J. D. M., Haedrich, R. L., Lorance, P., and Parin, N. 2000. Continental slope and deep-sea fisheries: implications for a fragile ecosystem. ICES Journal of Marine Science, 57: 548–557.

Mejuto, J., and de la Serna, J. M. 1997. Updated standardized catch rates by age for the swordfish (*Xiphias gladius*) from the Spanish longline fleet in the Atlantic using commercial trips from the period 1983–1995, ICCAT Collective Volume of Science Papers, SCRS/96/141.

Mejuto, J., and de la Serna, J. M. 2000. Standardized catch rates by age and in biomass for the North Atlantic swordfish (*Xiphias gladius*) from the Spanish longline fleet for the period 1983–1998 and bias produced by changes in the fishing strategy. ICCAT Collective Volume of Science Papers, SCRS/99/056.

Mejuto, J., and García-Cortés, B. 2004 Preliminary relationships between the wet fin weight and the body weight of some large pelagic sharks caught by the Spanish surface longline fleet. ICCAT Collective Volume of Science Papers, SCRS/03/085.

Mejuto, J., García-Cortés, B., and de la Serna, J. M. 2002. Preliminary scientific estimations of bycatches landed by the Spanish surface longline fleet in 1999 in the Atlantic Ocean and Mediterranean Sea. ICCAT Collective Volume of Science Papers, SCRS/2001/049.

Vinnichenko, V. I., and Khlivnoy, V. N. 2008. Basis for boundaries of closed areas on the Rockall Bank. Working Documents for the Working Group on Deep-water Ecology (WGDEC) 2008. 11 pp.