Fifth International
Conference on
the Protection of
the North Sea

Intermediate
Ministerial Meeting
1997

Assessment Report

on Fisheries and
Fisheries related
Species and
Habitats Issues

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Ministerial Meeting
on the Integration
of Fisheries and
Environmental Issues
13 - 14 March 1997
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Summary and Conclusions

1.1 Introduction

The North Sea is important to the countries which border it, both as a source of food and for many other activities. In the past, concerns about the environment and concerns about fisheries have been addressed as largely independent features in managing human activities in the area. The First International Conference on the Protection of the North Sea took place against a background of increasing concern about the inputs of harmful substances to the North Sea. In subsequent years, there has been increasing concern about the effect of fisheries not only on the fish stocks themselves but also on the North Sea ecosystems as a whole. At the Fourth North Sea Conference, it was therefore decided to hold an intermediate ministerial meeting to consider ways in which management policies for fisheries and for protection of the environment might be integrated. The present report has been written as a reference document for the Ministers' discussions at the Intermediate Ministerial Meeting.

1.2 Development and Status of North Sea Fish Stocks

Long-term knowledge of the abundance of the different species in the North Sea is an important basis for the interpretation of the impact of human activities on the ecosystems. Changes in abundance of commercially important fish stocks in the North Sea are, in general, well known. However, for other groups of species such as non-commercially exploited fish, marine mammals and benthic organisms, similar knowledge is in general rather limited.

The capacity of the fleet involved in the human consumption fisheries increased steadily after the turn of this century, because the efficiency and range of operation of the vessels increased. Despite recent regulatory efforts, the total capacity of the North Sea fleet is still at a level which exceeds the available resources.

From the 1950s a fleet of bottom trawlers started an industrial fishery for small species like sandeel, Norway pout and sprat, and at present about half of the total landings are used for production of fish meal and oil. Around 1960 a fleet of purse seiners began intensive exploitation of the pelagic species, herring and mackerel, and there has also been a steady increase in beam trawlers targeting flatfish and roundfish.

The total annual landings from the North Sea increased gradually from 1 million tonnes around 1900 to about 2 million tonnes around 1960. During the 1960s the landings increased steeply to about 3.5 million tonnes, followed by a gradual decline to around 2.5 million tonnes in recent years from an estimated average total biomass of approximately 10 million tonnes.

Since 1945 there has been a generally increasing trend in the mortality on all commercial species. During the same period there has also been a change in the species composition of the landings.

The present exploitation rate on many fish stocks is high and cannot be regarded as sustainable. The differences between the current fishing mortalities and those corresponding to theoretical optimum rates are also very large. The yield from many stocks, in particular roundfish, could be significantly higher with a lower fishing mortality and different exploitation pattern.

Fishing has a major impact on the North Sea ecosystems. Herring, North Sea mackerel and cod stocks are at present depleted and could be in danger of collapse, while other commercially important stocks are at or close to their lowest recorded levels. Some stocks like the industrial species, sandeel and Norway pout, are considered to be within Safe Biological Limits. Since the turn of the century the size composition of North Sea fish has changed. The proportion of larger fish has decreased, while that of small fish has increased. This restructuring of the North Sea ecosystems is related to high fishing mortality.

1.3 Development of Management Systems

The concept of Safe Biological Limits (SBL) was introduced to identify those stocks which are at levels at which their productive capacity is impaired or which may become so at current levels of exploitation. For some stocks it has been possible to define a Minimum Biologically Acceptable Level of spawning stock size (MBAL): i.e. the level of spawning stock below which the probability of poor recruitment (the replenishment of young fish by the population) increases as spawning stock size decreases. MBAL is not a target for stock management but rather an indicator of a critical situation below which recruitment may be adversely affected, thereby threatening the future sustainability of the stock.

There is a need to establish medium and long-term objectives for the management of North Sea fisheries.

At present, managers apply a system of catch quotas and Total Allowable Catches (TACs) as the primary instrument used to control fishing mortality rates, as well as other measures like restricting the number of vessels, their fishing capacity, fishing time and area of operation at sea. The fisheries are monitored by a control and enforcement system which involves surveillance of fishing activities at sea, as well as control of catches upon landing. It is recognized that the present control system has limited effect and does not prevent misreporting.

Improvement of fishing gear selectivity to protect juveniles has been an active topic of research for several years.

The current management system in the North Sea permits discarding of fish, although this is prohibited for the main species in Norwegian fisheries.

1.4 Environmental Management

The reduction of pollution has so far been the main issue in the environmental management of the North Sea. Over the last decade, however, there has been an increasing awareness that the impacts of other human activities on the North Sea ecosystems are also very important and that the combined effects could be detrimental to biological diversity. The protection of species and habitats is one important tool for the conservation of biological diversity in the North Sea. Currently, there are no protected offshore areas.

1.5 Direct and Indirect Impact of Fisheries

Considerable changes have been observed in the size and species composition of the fish community during the course of this century. Some species which grow to a large size are much scarcer than they were at the beginning of the century and there has been a shift in favour of short-lived species that only grow to a small size.

Demersal gear causes physical disturbance to the bottom and has a major impact on benthic habitats and communities. The demersal fisheries are believed to have caused local decreases in the populations and in the average size of certain long-lived benthic species, and a shift from long-lived to short-lived benthic species due to repeated disturbance by demersal gear has been observed. There are indications from studies of long time-series of trawl data that changes of species composition and diversity have occurred.

Another impact of fisheries activities is the high by-catches of many non-commercially exploited species of fish, shellfish and some benthic species, as well as by-catches of marine mammals and seabirds.

Several seabird populations breeding in the North Sea have increased in size during the last 25 years. The increase in numbers of some scavenging seabird species may be connected to discards and discharge of offal, whereas other species may suffer from a decline in prey species and/or a change in competition for breeding areas.

It is important to note that other anthropogenic factors, as well as variation in natural factors such as climate, can have a major influence on the ecosystems. Fisheries should be managed with reference to these variations in order to minimize any adverse effects on the ecosystems.

1.6 Impact on Fisheries from other Human Activities

Human activities other than fishing may also have an impact on fisheries resources and fisheries. Not only individual fish but also fish stocks, in particular in spawning and nursery areas, may be negatively affected by activities such as pollution by hazardous substances, oil and radioactive substances, excessive inputs of nutrients leading to eutrophication, the introduction of alien species, and changes in the physical environment, e.g. aggregate extraction.

Many of the contaminants introduced into the marine environment via various pathways are very slowly degraded. Several of these substances have the ability to accumulate in marine food chains (which may lower the quality of marine food for human consumption) and may have an adverse effect on the development and survival of eggs, larvae and juveniles of marine organisms.

A number of non-indigenous species have been introduced into the North Sea over the centuries, mainly through shipping and aquaculture activities. Such organisms may seriously affect the environment and other biota: for example, they can replace species of the natural flora and fauna, or directly or indirectly affect their growth, reproduction and survival.

Finfish aquaculture is often accompanied by the escape of individuals. This can have significant consequences for local populations through the spread of diseases, ecological competition and genetic change.

1.7 Towards a New Management

Until recently, ecosystem considerations have played a minor role in the setting of management objectives and decisions of the relevant authorities. Neither are biological interactions between species usually incorporated into annual scientific recommendations on catch levels. One way forward could be the further development of an ecosystem approach in the management of the North Sea.

One of the fundamental problems in fisheries management is to obtain an appropriate balance between fishing effort and the available fish resources. Many of the management measures employed have only been partially successful. It is recognized that the present system of control and enforcement has limited effect and could be improved.

There is a need to implement the precautionary approach in the future fisheries and environmental management of the North Sea.

Scientific advice forms an important basis for the management of North Sea fisheries. However, the scientific justification for measures is in many cases challenged, often by reference to lack of data. Reference to socio-economic conditions is frequently given as another reason for not implementing necessary management measures.

The EU and Norway have agreed that there is a case for broadening the scope of the system of exchange of information on catches and landings, in order to reduce the risk of overshooting quotas and in order to improve the basis for future scientific advice.

An important part of integrated fisheries and environmental management for the North Sea could be the development of medium and long-term management objectives, in order to conserve the biodiversity and the fish resources for the future. The establishment of target and limit reference points for fish stocks, as well as the establishment of TACs, are important management tools in this respect.

One of the possible future management actions could be the development of pre-agreed measures as a means of reacting quickly when a stock is approaching biological limit reference points. A further development and implementation of selective techniques in order to reduce the unwanted by-catch of juvenile target species and other organisms should also be encouraged.

Support from the fishery sector is essential for integrated fisheries management to be successful. Co-management could be used as an instrument to achieve this support. This implies in the first place involvement of the interested parties (including environmental organizations) in the decision-making process. The application of the instrument of co-management could be further elaborated, taking into account the differences between the North Sea states.

2

Introduction

2.1 Background

The North Sea[1] is a very important and rich sea for fisheries, and fishing has long since been an important activity in all countries bordering the North Sea. At the same time there are many pressures on the North Sea: a number of large towns and long-established industries have, over a long period, emptied their waste into the North Sea via rivers and direct discharges; the offshore oil and gas industry has become a major economic activity in the North Sea since the late 1960s; and the North Sea contains some of the busiest shipping routes in the world. The coastal zone is also used intensively for recreation, such as bathing, sailing and fishing.

In the early 1980s there was growing concern among North Sea states that the large inputs of various harmful substances could cause adverse effects, including long-term and perhaps irreversible damage to the North Sea ecosystems. This was part of the background which led to the First International Conference on the Protection of the North Sea in Bremen in 1984 and to the subsequent Conferences which have addressed most of the environmental problems in the North Sea.

1 For the purpose of this report the North Sea comprises the body of water:

a) southwards of latitude 62° N, and eastwards of longitude 5° W at the northwest side;

b) northwards of latitude 57° 44.8' N from the northernmost point of Denmark to the coast of Sweden; and

c) eastwards of longitude 5° W and northwards of latitude 48° 30' N, at the south side.

Over the last years there has been increasing concern about the development and status of the North Sea fish stocks, as well as the impacts of fisheries on the ecosystem. Several commercially important fish stocks are subject to high levels of fishing mortality and are, or recently have been, outside Safe Biological Limits. The further integration of environmental and fisheries policies was an important issue at the Fourth International Conference on the Protection of the North Sea in Esbjerg in 1995.

The Ministers at Esbjerg therefore welcomed the proposal that Norway would organize an Intermediate Ministerial Meeting on the Integration of Fisheries and Environmental Issues in 1997 (IMM 97), in which Ministers responsible for environmental protection and Ministers responsible for fisheries would participate. The Ministers furthermore agreed to establish the Committee of North Sea Senior Officials (CONSSO), which *inter alia* would be responsible for the preparation of IMM 97.

The Assessment Report on Fisheries and Fisheries related Species and Habitats Issues is the report from CONSSO to the Intermediate Ministerial Meeting.

2.2 Role and Influence of the North Sea Conferences

Whilst the pertinent Conventions and their executive bodies are rather specialized in their scope, the International Conferences on the Protection of the North Sea have the advantage of providing a political framework for a broad and comprehensive assessment of the measures needed to protect the North Sea environment. This enables Ministers to deal with a broad range of North Sea issues, and allows them to respond swiftly and to focus on key issues at each Conference.

Apart from the decisions for agreed action to protect the North Sea recorded in the Conference Declarations, the Conferences have played an important role in influencing environmental management decisions on a much wider level. The adoption of the precautionary principle constitutes one example of important agreements emanating from the Conferences.

2.3 Main Issues of the Esbjerg Conference

In the Esbjerg Declaration, the Ministers responsible for the environment gave high priority to the further integration of fisheries and environmental policies. They recommended that the precautionary principle should be applied in fisheries management policies and that there was a need to establish exploitation rates for fish stocks within Safe Biological Limits, so as to promote the rebuilding of depleted stocks and the maintenance of stocks above their Minimum Biologically Acceptable Levels. Furthermore, the Ministers recommended that policies should be such as to minimize by-catches and other negative impacts on marine mammals, seabirds and benthic organisms, and to minimize discarding of fish and benthic organisms. They also asked competent authorities to facilitate research on a number of issues (involving the International Council for the Exploration of the Sea (ICES) where appropriate). They called for awareness by fishermen of the ecological impact of fishing activities to be improved, and the implementation of fisheries management policies to be supported by more effective control and enforcement mechanisms.

2.4 Aim of the Report

This report addresses the main challenges with regard to further integration of fisheries and environmental policies, and is thus an important reference document for the Ministers' discussion on how to make progress on this issue. This will include improving the management of the North Sea fisheries, thereby ensuring the sustainability of the North Sea fish stocks and reducing the negative impact from fisheries on the North Sea ecosystems, as well as reducing the adverse impacts on fisheries and ecosystems from other human activities.

Substantial information has been collected from the North Sea states, the European Commission, the observers to CONSSO and ICES. This information is contained in the Basis Report prepared from responses to a Reporting Format on Fisheries and Fisheries related Species and Habitats Issues. Both the extent of research into the different issues that are covered in the report and the extent to which results have been reported to the North Sea Secretariat vary between the North Sea countries. This is evident in some chapters, and it should be emphasized that areas for which there is information are not necessarily those with the most severe problems.

2.5 Regional Implementation of Global Conventions and Agreements

Many of the general principles and agreements that form the basis for the management of fisheries and the environment are laid down in global and regional conventions and agreements, as well as other international instruments and guidelines, such as:

- UNCLOS, in particular Part V and XII thereof;
- The Convention on Biological Diversity;
- The OSPAR Convention and relevant river conventions;
- The UN Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks;
- Agenda 21, Chapter 17, Commission of Sustainable Development and the outcome of the review of Chapter 17 as agreed by the General Assembly resolution;
- The FAO International Code of Conduct of Responsible Fisheries;
- The Jakarta Mandate;
- The Washington Declaration on the UN Global Programme of Action for the Protection of the Marine Environment from Land-based Activities; and
- The Kyoto Declaration.

One of the aims of the process of further integration of fisheries and environmental policies is the implementation of such international commitments on a North Sea scale, including the application of the precautionary approach.

2.6 Guide to the Report

When reading the Report it should be noted that in the waters of the Member States of the European Union, legal competence for the establishment of fisheries management policies belongs to the European Community and is implemented within its Common Fisheries Policy and, within Norwegian waters, legal competence for management of fisheries lies with Norwegian authorities. The bilateral fisheries agreement between EU and Norway is therefore the appropriate arrangement for all joint fisheries management issues.

The chapters of the Report are as follows:

Chapter 3, «Status of Marine Species», sets the scene by describing the development and status of the different commercially and non-commercially exploited fish stocks, ecological communities, seabirds, marine mammals and benthic organisms in the North Sea.

Chapter 4, «North Sea Fisheries and their Management», links the development and status of the stocks to man's impact by looking into the development of fishing fleet capacity and fishing effort, the development of catches of the key species and the socio-economic aspects of fisheries.

Chapter 5, «Present Environmental Management», describes the present environmental management bodies for the North Sea, and the concepts of biological diversity and protected areas as one management tool for protection of diversity.

Chapter 6, «Ecological Impact of Fisheries», addresses the wider effects of fisheries on the ecosystems, including target and non-target species and their habitats.

Chapter 7, «Impact of other Human Activities on Fisheries Resources and Fisheries», describes the present knowledge of impacts from pollution on the ecology, mortality and recruitment of fish stocks, as well as the impact of physical disturbances and the introduction of non-indigenous species.

Chapter 8, «Towards a New Management», discusses the future integration of fisheries and environmental management, adaptation of the fishing fleet capacity to the available resources, improved technology, co-management, closed and protected areas, and socio-economic aspects.

Chapter 9, «Need for Enhanced Knowledge», summarizes the need for research and improvement of knowledge as identified in the previous chapters.

Two of the annexes could be of practical value to the reader throughout the report. These are Annex I which contains an explanation of the terminology used, and Annex II which includes a list of species mentioned in the report.

3

Status of Marine Species

> *The Ministers recommend that the North Sea fisheries management policies implemented by EU within the Common Fisheries Policy and by Norway by means of relevant national regulations, should aim at establishing, as soon as possible, exploitation rates for fish stocks within safe biological limits to promote, where required, the rebuilding of depleted stocks and, otherwise, to maintain stocks above their minimum biologically acceptable level.*
>
> *(The Esbjerg Declaration, Article 16.ii)*

3.1 Summary and Issues of Concern

The North Sea is a highly productive area supporting landings of about 2.5 million tonnes of fish and shellfish every year. The fisheries have a major impact on the ecosystem, especially with regard to the stock size of target species. Changes in stock size may, however, also be caused by other anthropogenic effects and by hydrographic or climatic factors, through interactions between species or by a combination of different factors.

The changes in the abundance of commercially important fish stocks in the North Sea since the

1950s are, in general, well known from assessments based on fishery statistics, the results of market sampling programmes and different types of surveys.

Most commercially important fish stocks are heavily exploited. The fisheries take a high proportion of the stocks of adult fish and, in addition, the catches include many fish in younger age groups. As a result of these fishing practices the stocks of several species, especially those landed for human consumption, are at present considered to be outside Safe Biological Limits.

The North Sea herring stock and the component of mackerel spawning in the North Sea both collapsed in the mid-1970s. The herring recovered in the 1980s during and after closure of the fishery. The fishing pressure, however, has subsequently increased to such a level that the stock is again outside Safe Biological Limits. The North Sea mackerel stock has not recovered and remains depleted.

All major roundfish stocks (cod, haddock, whiting and saithe) are heavily exploited. In the case of cod, the spawning stock biomass is so low that future recruitment is endangered. In the other species, the spawning stock biomass has either remained stable or increased in the most recent years.

Fishing pressure is also close to its highest recorded level for North Sea plaice and sole. The North Sea plaice stock is outside Safe Biological Limits, and there is a reasonable probability that the stock of sole will fall outside Safe Biological Limits in the medium term unless there is a good year class, an event which occurs at only infrequent intervals.

The stocks of the three major industrial species, sandeel, Norway pout and sprat, are considered to be within Safe Biological Limits.

For those fish species that are not the main object of specific fisheries (often termed «by-catch species») less information is available, even though some of them have considerable commercial value. Analysis suggest that these fish species are subject to fishing mortality rates similar to the main species caught in the commercial fisheries.

Survey data indicate a change in the size composition of North Sea fish. The quantity of larger fish has decreased, while the numbers of small fish have increased.

Most populations of seabirds breeding in the North Sea as a whole have increased over the past 25 years. Of the 23 species for which there is sufficient information, 15 have increased over this period and the populations of three species have decreased. These generalizations disguise much detail, and some areas show opposite trends to those observed in the North Sea as a whole (e.g. the Channel and Norwegian waters). There is limited knowledge of the causes behind the changes. It is likely that the increase in some scavenging species is connected to discarding of fish and offal. In the case of species that capture live prey, the increases are more probably due to an increase in the abundance of small prey fish species. Some of these seabird species, however, demonstrate a close dependency on the abundance of prey species, especially when their foraging range is limited during the breeding season.

There is no information on trends in the abundance of porpoises, dolphins and small whales in the North Sea, although some species that once occurred in the Channel (e.g. bottlenose dolphin) are no longer found there. In the case of seals there has been a steady growth in North Sea populations during recent decades except during an epidemic in the late 1980s, when the numbers of common seals temporarily decreased.

Knowledge of bottom-living organisms (benthos) is poor. The most extensive data exist for Norway lobster and deep sea shrimp, the stocks of which are currently considered to be within Safe Biological Limits. There is also a considerable amount of information at a local level about populations of other commercially exploited shellfish species, such as cockles, mussels, brown shrimps and lobsters, but very little about non-exploited species of benthos except on a very small scale.

Issues of Concern

The state of the fish stocks in the North Sea and the high level of exploitation give rise to the following concerns:

- The stocks of a number of species are in a serious condition:
  - The greatest concerns are being expressed about the **herring** and **cod** stocks which could be in danger of collapse;
  - The **plaice** stock is also currently at a low level and is considered to be outside Safe Biological Limits;
  - The population component of **mackerel** that spawns in the North Sea has been at a very low level for many years; and
  - Other stocks such as **haddock**, **saithe**, and **sole** are also exploited at high levels and the continued stability of the stocks depends critically on good recruitment;
- High exploitation rates allow relatively few individuals to survive to spawning age;
- The decrease in population size of a number of species of fish and shellfish that are not at present the primary object of commercial fisheries (*inter alia* oysters, halibut, sharks, rays and skates);
- Poor knowledge of the local effects of intensive sandeel fisheries;
- The low size of some populations of some seabird species and the local extinction of certain marine mammal species; and
- The decrease in abundance of fish and benthic species that grow to a large size, the shift from long-lived species to short-lived species, and in certain areas the decrease in species diversity.

3.2 Introduction

In this chapter, an overview is presented of the status of fish, seabirds, marine mammals and benthos of the North Sea. Available information varies considerably between groups. In some cases, time series of population sizes are available as far back as the 1880s; for other groups/species the first data were only collected in recent years. For some species, population trends may be known on a limited local scale, whereas very little may be known for the North Sea as a whole.

3.2.1 The North Sea

The North Sea is a rather shallow semi-enclosed basin (see Figure 3.1). Its depth ranges from about 30 m on average in the southeast to 200 m in the northwest. The northwestern boundary lies along the edge of the continental shelf, west of Orkney and Shetland. The northeastern margin is formed by a trough, the Norwegian Deep, which has a maximum depth of 700 m in the Skagerrak. The Channel is relatively shallow and the depth ranges from about 30 m in the Straits of Dover to about 100 m in the western part.

The North Sea ecosystems are strongly influenced by the Atlantic Ocean. To the west and northwest of the British Isles, the Atlantic current flows north along the edge of the

Figure 3.1. Map of the North Sea and the catchment area.

continental shelf. Several currents bring Atlantic water into the northern North Sea around the north of Scotland. The input of Atlantic water via the Channel is much less. The importance of this inflow of water from the Atlantic is that it brings into the North Sea the replenishment of nutrients necessary for the growth of plankton, which ultimately supports the productive fisheries and provides the resources for many other types of organisms. Many stocks of fish spawn in the North Sea, and in most of them the water circulation distributes the young from the spawning to the nursery grounds. In a number of commercially important species of fish (e.g. herring and plaice), the spawning grounds tend to be in the northern and western parts of the area, whereas the nursery grounds are in the more shallow parts of the southeastern North Sea. Some stocks of other species, notably mackerel and horse mackerel, spawn outside the North Sea and make seasonal migrations into the North Sea to feed.

The North Sea, which came into being after the last major period of glaciation, is one of the largest semi-enclosed areas of continental shelf waters in the world ocean. Although it is small in global ocean terms, it is by no means homogeneous as regards temperature, water type, and the nature of the substrate. On the basis of hydrographic and biological conditions, the North Sea can be divided into different areas, with marked seasonal and regional differences in the vertical structure of the water column. In large parts of the northern and central North Sea the water becomes stratified in summer, with relatively warm water near the surface and a sudden drop in temperature at a depth of around 30-40 m. Temperatures in the deeper parts of the North Sea show relatively little seasonal variation compared with the more shallow parts.

The variation in the physical environment is reflected in the flora and fauna. The different substrate types support very different communities of bottom-living animals and, similarly, each water mass influences the benthos and the different assemblage of planktonic organisms.

The North Sea is a highly productive system compared to the surrounding Atlantic. The total biomass of all fish in the North Sea is estimated at approximately 10 million tonnes. Total annual landings of fish fluctuate around 2.5 million tonnes, and approximately the same amount of fish is eaten annually by the main predatory fish species: cod, haddock, whiting, saithe and mackerel. The amount of fish eaten by birds and marine mammals amounts to approximately 3/4 million tonnes. This does, however, not include the amount eaten by birds and marine mammals in the Channel or the Skagerrak.

The North Sea ecosystems do not fluctuate wildly in terms of the main species; neither are they entirely stable and, even in the absence of human influence, there will be continuous changes in the abundance of all species. Long-term changes may be caused by gradual changes in climate, or in hydrography. Superimposed on these trends are annual fluctuations caused, for example, by cold winters or warm summers or by short-term changes in current flow.

3.3 Biological Reference Points

The state of the main commercially exploited stocks of fish and shellfish in the North Sea is assessed on an annual basis by scientists of the coastal states under the coordination of the International Council for the Exploration of the Sea (ICES). To provide bench marks for the interpretation of the state of each stock, a number of biological reference points have been identified.

A biological reference point is a level of fishing mortality (a measure of the proportion of a stock taken by a fishery) or stock size estimated through agreed scientific procedures. The values correspond to states of the fishery or the stock and are increasingly being used in fishery management advice. An example of a biological reference point used to indicate the state of a stock is MBAL (Minimum Biologically Acceptable Level), representing a level of spawning stock size below which the stock may be in danger of severe depletion if it is not allowed to rebuild as quickly as possible. This and other biological reference points are described in more detail in Annex I.

The reason why MBAL represents a danger point is that it is the spawning stock size below which the probability of poor recruitment (the annual replenishment of young fish to the stock) increases as spawning stock size decreases. The implications of a stock going below MBAL are potentially serious, because any sustained decrease in recruitment can lead to a progressive decrease in the stock with the possibility of eventual collapse. In the sense used here, a stock collapse is a decrease to a very small percentage of the range of stock sizes normally observed.

While MBAL is used by ICES as an indicator of those stocks for which prompt restorative action is needed, it is not the only criterion of the state of a stock. It is recognized, for example, that some stocks that are not currently in danger may be expected to fall below a safe level if the current fishing pressure on them is maintained. Such stocks, and of course those already recognized to be below MBAL, are said to be outside Safe Biological Limits. A number of different criteria indicate when a stock is outside Safe Biological Limits. Among them are the size of the spawning stock in relation to the historical trends, the fishing pressure on the stock, the age structure and exploitation pattern of the stock, and its distribution (a decrease in stock size is often accompanied by a decrease in the area occupied by the stock). The scientists responsible for giving advice use all available indicators available to them to decide whether they consider that a stock is within or outside Safe Biological Limits. In the next section of this chapter a summary is given of the state of the most important commercially exploited fish stocks in the North Sea in relation to Safe Biological Limits.

3.4 Status and Development of the Individual Fish Stocks

A total of 224 species of fish have been recorded in the North Sea. A high proportion of the total biomass of fish, however, is made up of a small number of species most of which are commercially exploited. Most information on the status of the different species is available for the most abundant commercially exploited species. Figure 3.2 illustrates the fish landings of various species from the North Sea, compared to total landings in neighbouring areas in 1990.

When describing the status of fish stocks a distinction can be made between species that have a commercial value, and those that are of no commercial interest to fishermen. The greatest fraction of the commercial component of the catch usually consists of species at which the fishery is specifically aimed; these are often spoken of as the «target» species. Fisheries can be «targeted» at a single species, but very often they catch a mixture of species in what are called the «mixed fisheries». In addition to the «target» species, catches often contain a by-catch of other species some of which may be landed. Part of the catch of either commercially or non-commercially exploited species may be discarded for one or more of several reasons, including quota limitations, minimum landing size regulations, regulations on by-catch percentages, high-grading (sorting of fish to maximize the value of the catch retained for the market, with associated discarding of legal-sized but lower value species or sizes), or because species have no commercial value. Discarding of the most important commercially exploited species in the Norwegian zone is prohibited.

Fisheries in the North Sea are either aimed at human consumption markets or to provide fish for reduction to meal and oil (industrial fisheries). The species caught for human consumption can be divided into pelagic species that live mostly off

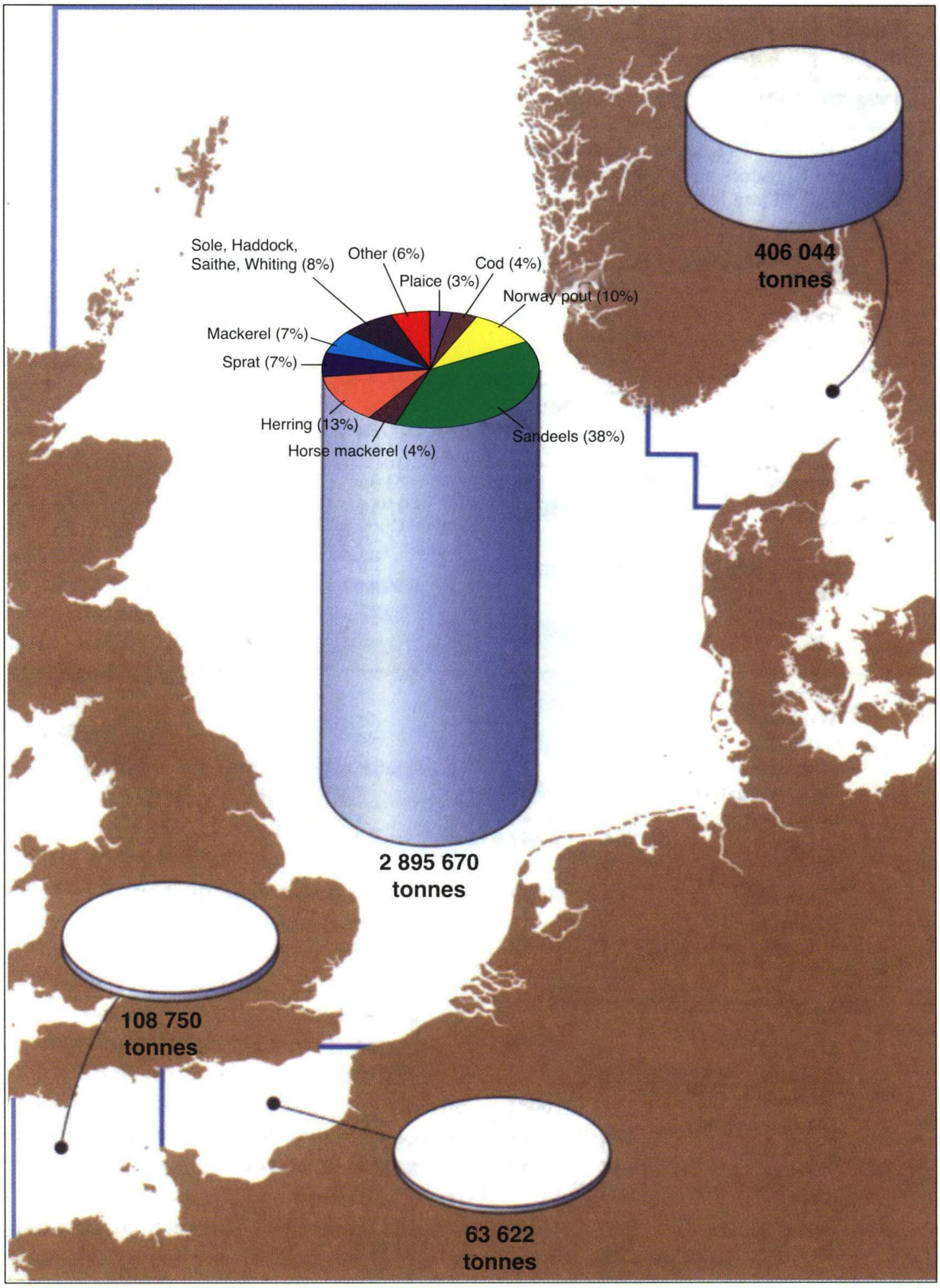


Figure 3.2. Fish landings from the North Sea in 1995. (ICES)

the bottom, and demersal species that live on or close to the sea bed. The main pelagic species are herring (*Clupea harengus*), mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*). In the demersal component, roundfish and flatfish can be distinguished. The most important roundfish species are cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*) and saithe (*Pollachius virens*), while the most important flatfish species are plaice (*Pleuronectes platessa*) and sole (*Solea vulgaris*). In addition to these species, the demersal fisheries also take variable quantities of other species.

The landings from the industrial fishery mainly consist of sandeels (different species of Ammodytidae of which one species *Ammodytes marinus* accounts for a very high proportion of the catch), Norway pout (*Trisopterus esmarkii*) and sprat (*Sprattus sprattus*), a small pelagic species which may also be landed for human consumption. In some industrial fisheries there is a variable by-catch of, mostly, juveniles of human consumption species, of which haddock and whiting (in the Norway pout fishery) and herring (in the sprat fishery) are the most important. Table 3.1 summarizes the text above and lists the major fish species caught in the North Sea fisheries.

Table 3.1. List of the major fish species caught in the North Sea fisheries.

Pelagic species	Demersal species		Industrial species (reduction purposes)
	Roundfish	Flatfish	
herring mackerel horse mackerel	cod haddock whiting saithe	plaice sole	sandeels Norway pout sprat

The amount of information available for each of the fish species varies substantially. Most is known about the species of commercial importance, partly from the records of landings compiled by national statistical offices and partly from market sampling of the landings of these species, schemes which have in some cases been in operation for several decades. Sampling consists of the collection of information on length- and agecompositions. For some of the species it has been possible to reconstruct the main population dynamics parameters back to the late 1880s (e.g. plaice) or the early 1900s (e.g. cod, haddock and whiting). For the industrial fish species, sampling commenced in the 1970s. For a variety of other species only landings data are available. Nevertheless, these data clearly show that some species which used to be common in the early part of this century (e.g. halibut) are now rare.

Other sources of information are the results of surveys by fishery research vessels, such as the ICES co-ordinated International Bottom Trawl Survey, which started in the mid-1960s and which has covered the total North Sea, Skagerrak and Kattegat annually since 1974. Several other national or international surveys exist in which different gear are used, targeting different species or combinations of species. Some recent studies have compared survey results from the first half of this century with those from recent years.

Based on all available information, quantitative stock assessments are carried out for stocks of 12 fish species that occur in the area: herring, mackerel, horse mackerel, cod, haddock, whiting, saithe, sole, plaice, sandeel, Norway pout and sprat. For present purposes, stock assessment is a process in which estimates are made of current stock size and exploitation rates, and these are compared with a historical series. For a number of stock/sub-area combinations, sampling levels are considered to be too low to carry out reliable assessments, although in some cases there may be indications of the state of the stock concerned, for example, from catch rates in the fisheries.

In the next section the status and development of the stocks of the species mentioned above are briefly described. Some information is also given for the commercially most important by-catch species and for some of the non-commercially exploited species.

3.4.1 The Main Commercial Fish Species

For each of the species and for each management unit, Annex IV summarizes the most important parameters used to characterize the state of the stock: the landings, fishing mortality rate of the most heavily exploited age groups, the size of the adult population or spawning stock biomass, and the number of individuals that each year recruit to the fishery. The minimum and maximum values are given for the time period for which data are available, and the average over the recent 5-year period 1990-1994.

Herring

The herring in the North Sea consist of a mixture of populations, most of which spawn in the autumn or winter. In the eastern North Sea and in the Skagerrak and Kattegat there is a component of spring-spawning herring which spawn in the Baltic and seasonally migrate as far as the North Sea to feed. In the northeastern North Sea there is also a component of spring-spawners that spawn along the Norwegian coast. North Sea autumn-spawning herring also occur as juveniles in the Skagerrak and Kattegat.

North Sea herring are caught in directed fisheries for human consumption in the North Sea and eastern Channel and in the Skagerrak/Kattegat. Juvenile herring are also taken in small-mesh industrial trawl fisheries, often together with sprat, both in the North Sea and in the Skagerrak/Kattegat («mixed clupeoid» fishery). Landings peaked in 1965 at 1.2 million tonnes when purse seining was introduced into the North Sea (Figure 3.3). After 1965, landings and stock size decreased rapidly and in 1977 a total ban was imposed on herring fishing in the North Sea. After a number of extremely weak year classes (fish spawned in a particular year), recruitment increased and the stock started to recover (Figure 3.3). In 1981 the fishery was reopened. The landings again increased and peaked at 875 000 tonnes in 1988, since when they have decreased.

The level of fishing mortality was extremely high from the late 1960s until the closure of the fishery. Levels of fishing mortality in the 1980s and 1990s have also been higher than during the 1950s and early 1960s.

The spawning stock biomass declined from an estimated 4-5 million tonnes after World War II to approximately 50 000 tonnes in 1977. The MBAL for North Sea herring is considered to be 800 000 tonnes. Despite the recovery after the closure of the fishery, the spawning stock biomass has declined since 1989 and was estimated to be 500 000 tonnes in 1995 (Figure 3.3). The stock is thus outside Safe Biological Limits and a continuation of the fishery at the recent levels of fishing mortality would have a high probability of leading to a collapse of the stock. During 1996 it was therefore decided to reduce the current TAC mid-year, to minimize the need for a total closure of the fishery in 1997.

The herring spawning in the southern North Sea and eastern Channel belong to a separate stock that spawns in the winter. As it mixes with other North Sea herring during the summer, no separate assessment has been possible. Although no precise estimates of the size of the stock are available, it appears to be at its lowest level since 1980. For this reason, the scientific advice is that no directed fishing for herring should be allowed in the southern North Sea and eastern Channel in 1996 and 1997.

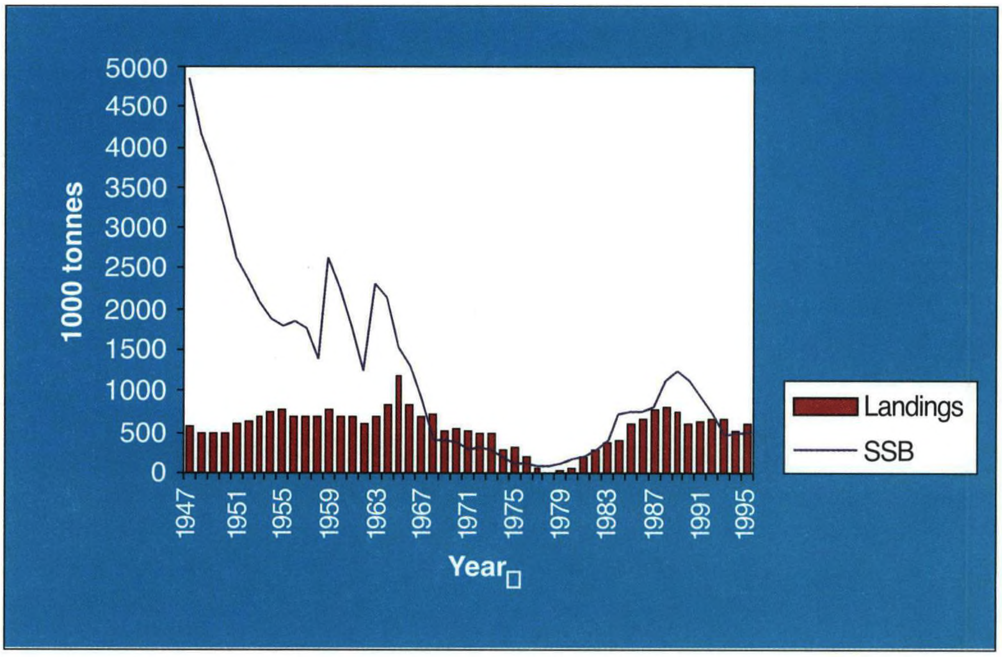


Figure 3.3. Landings and spawning stock biomass for herring in the period 1947-1995. (ICES 1997)

Mackerel

This species is known for its extensive migrations and changing distribution. In winter, mackerel are almost absent from the North Sea. In spring, mackerel enter the North Sea both via the Channel and from the northwest. In summer, adults are found throughout the area, whereas juveniles mainly occur in the southeastern North Sea and Channel. Mackerel are mainly caught in directed fisheries with pelagic trawls and purse seines, sometimes together with horse mackerel, or as by-catch in demersal fisheries. This species is used for human consumption and for reduction to fish meal and oil.

Mackerel spawn in a number of areas. Whether the component spawning in the North Sea is a separate stock from that spawning to the west of the UK and Ireland or just a component of a much larger combined stock is not yet finally established. The western component, however, is currently the largest in terms of total biomass and has been so for at least 20 years.

The North Sea component was intensively exploited in the 1960s. Landings, mainly in the purse seine fishery in the northern North Sea, peaked at 930 000 tonnes in 1967 (Figure 3.4). Since then the North Sea component has collapsed. The last good year class was produced in 1969, since when recruitment to the North Sea spawning population has been at a very low level. Prior to the period of heavy exploitation in the 1960s the biomass of mackerel spawning in the North Sea was estimated to have been over 3 million tonnes. Currently the population spawning in the North Sea is believed to be between 50 000 and 100 000 tonnes. «North Sea mackerel» are therefore considered to be outside Safe Biological Limits, and require the maximum possible protection.

The western component inhabits a vast area to the south, west and north of the British Isles, along the continental shelf. After spawning southwest of the British Isles, the adults migrate to summer feeding grounds in the Norwegian Sea and the northern North Sea, where large catches are made in the second half of the year. The spawning stock biomass of the western component is estimated to have been 2 million tonnes in 1995. This is the lowest level in the time-series that began in 1972. The stock may be outside Safe Biological Limits, but the time-series is too short to evaluate this fully. To restore and maintain the spawning stock within the range previously observed, a significant reduction in fishing pressure on the western component has been recommended. In the western Channel, protection has been given to juveniles since 1983.

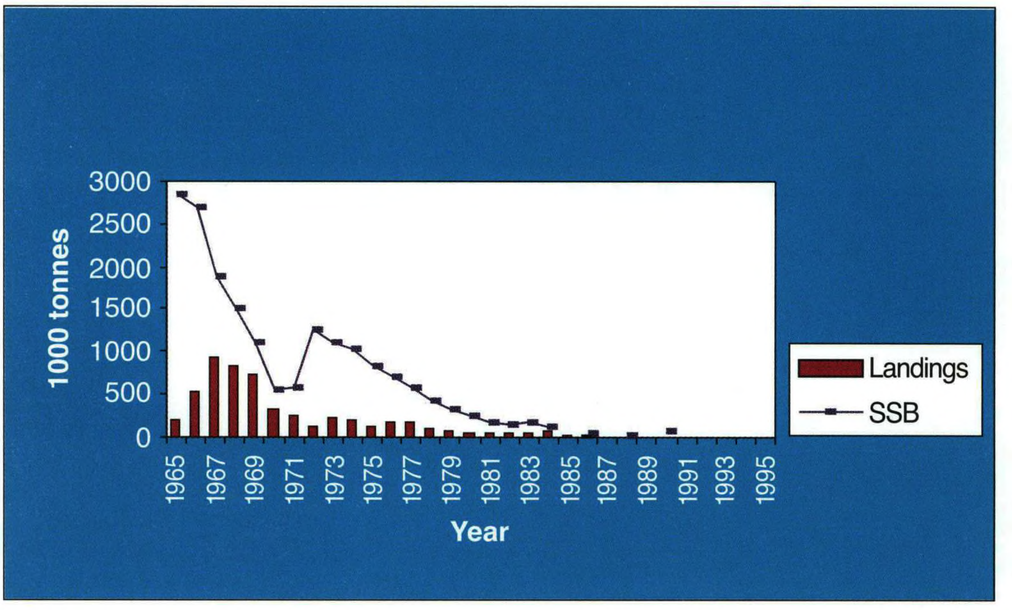


Figure 3.4. Landings and spawning stock biomass for the North Sea mackerel component in the period 1965-1995. (ICES 1997)

Horse mackerel

The horse mackerel is also a highly migratory species. Only few horse mackerel may be found in the North Sea in winter. Some juveniles overwinter in the Kattegat area, but most horse mackerel are found in winter to the west of the British Isles and in the Channel. In spring they migrate into the North Sea, via the Channel and from west of Scotland in the north. In summer, juveniles are especially abundant in the shallow southeastern North Sea, whereas adult fish are mainly found in the northernmost and southeastern parts of the North Sea.

A North Sea stock and a western stock are distinguished, but the data for the North Sea stock are considered to be insufficiently reliable to carry out an assessment. North Sea horse mackerel are predominantly caught in the Skagerrak/Kattegat, in the central and southern North Sea, and in the eastern Channel. Part of the catch is taken as by-catch in the small mesh industrial trawl fishery and part in a directed fishery for human consumption.

In the period 1989-1991, the spawning stock biomass of North Sea horse mackerel was estimated to be over 200 000 tonnes, as compared to over 3 million tonnes for western horse mackerel in the same period.

Landings of the North Sea stock of horse mackerel have fluctuated since 1987 between 6 000 and 33 000 tonnes.

Like western mackerel, the western horse mackerel also makes seasonal migrations into the North Sea. Since 1987 considerable catches (up to 130 000 tonnes) of western horse mackerel have been taken for reduction purposes by the Norwegian purse seine fleet in the northern North Sea. This stock consists mainly of a single year class, that of 1982. As recruitment since then has been at a much lower level, the spawning stock biomass of the western stock has declined steadily from 4.8 million tonnes in 1988 to 1.5 million tonnes in 1995, i.e. very close to the level that produced the strong 1982 year class. Unless recruitment improves, the spawning stock will continue to decline. To maintain the spawning stock biomass above 1.5 million tonnes, a substantial reduction in fishing pressure on the stock has been recommended.

Cod

Cod are found widely over the North Sea, Skagerrak and Kattegat and in the Channel. Cod in the eastern Channel and in the Skagerrak probably belong to the North Sea stock, whereas cod in the Kattegat are considered as belonging to a separate stock, and those in the western Channel are probably part of the Celtic Sea

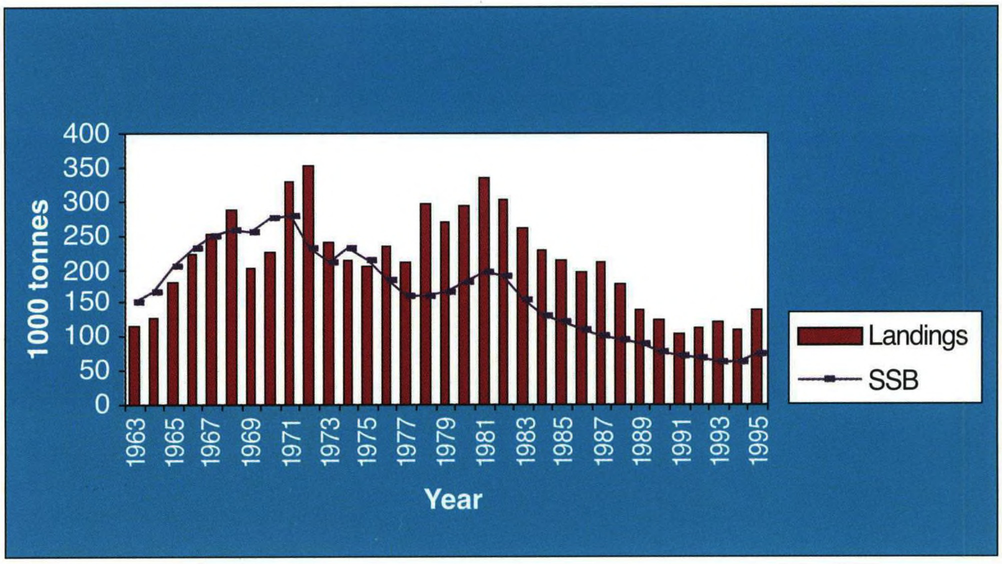


Figure 3.5. Landings and spawning stock biomass for cod in the period 1963-1995. (ICES 1997)

stock. Juvenile cod are spread over a wide area in summer, but usually concentrate in coastal areas in winter.

Cod are mainly caught in mixed demersal fisheries, either together with haddock and whiting, or with plaice and sole. There are also important fisheries targeted at cod using gillnets and lines. From the beginning of this century until the 1960s, landings of cod fluctuated between 50 000 tonnes and 100 000 tonnes. In the 1960s landings of North Sea cod increased and reached a maximum of 350 000 tonnes in 1972 (Figure 3.5). They then declined steadily from 1981 to 1991, since when they have shown a small increase to 140 000 tonnes in 1995. Fishing mortality on this stock increased from the early 1960s to 1991 and has been stable at a very high level since then. The spawning stock biomass increased in the 1960s to peak at 280 000 tonnes. Since 1981 the spawning stock biomass has declined and is currently around 75 000 tonnes, well below the MBAL of 150 000 tonnes. Due to the combination of the very high exploitation rate and the relatively advanced age at which cod mature (3 to 6 years), fewer than 1% of the 1-year-old fish survive to maturity. Landings of cod mainly consist of juvenile fish of two to three years of age. Sometimes considerable discarding of juveniles occurs, but discards are not included in the assessment because there are no estimates of the amounts of cod discarded in some important North Sea fisheries.

The cod stock is at such a low level that the spawning stock size may be having an effect on recruitment as a result of reduced production of spawn (when a stock has been reduced to this level by fishing it is said to be subject to «recruitment overfishing»); apart from the 1993 year class, all year classes from 1987 onwards have been below average. All the indications are that the current exploitation rate for cod is not sustainable and that a collapse of the stock is possible, unless there is a significant reduction in fishing pressure to bring the stock within Safe Biological Limits. This can only be achieved by a significant reduction in fishing effort in fisheries that exploit this stock.

Haddock

Haddock have a northerly distribution and are almost absent in the southeastern North Sea. Haddock in the North Sea and in the Skagerrak are likely to be from a single stock. Juveniles and adults have virtually the same distribution. Haddock are caught for human consumption in mixed demersal fisheries, together with cod and whiting. A sometimes large proportion of the catch is discarded at sea, because of its small size. Discard estimates are included in the assessment.

The catches of North Sea haddock are rather irregular and this can be explained by the fact that the haddock stock produces exceptionally strong year classes at irregular intervals. Catches increased in the early 1960s and peaked to a record high of over 900 000 tonnes in 1969 due to the recruitment of the very strong 1967 year class. Since then the catches have gradually decreased and reached a record low level in 1990. Subsequently the catches have shown some improvement due to an increase in recruitment.

Spawning stock biomass has followed more or less the same fluctuations as the catches, with a peak in 1970 and a historical low in 1991. Fishing mortality gradually increased from World War II onwards and has been at an extremely high level since the 1960s. The MBAL for the North Sea stock is estimated to be 100 000 tonnes. In the years 1990-1992 the spawning stock size was close to or below that level, fishing mortality was extremely high, and the exploitation pattern was far from optimal (only 2% of the age 0 recruits survived to reach maturity). Due to improved recruitment, the stock has increased and has been above MBAL since 1993. Maintenance of this level, however, is dependent on strong year classes and, under the present high fishing pressure, the stock is expected to fluctuate in response to the highly variable recruitment.

Whiting

Whiting is one of the most abundant and widely distributed gadoid species and is found throughout the North Sea area. Separate assessments are carried out for the North Sea and eastern Channel, the Skagerrak/Kattegat, and the western Channel combined with the Celtic Sea. Whiting in the northern North Sea, and in the southern North Sea plus the eastern Channel may, however, belong to different stocks. Most whiting are sexually mature when they are two years old. Whiting are caught for human consumption, mainly in mixed demersal fisheries, and to a small extent also in a directed fishery in the southern North Sea and Channel. Large quantities of whiting are discarded at sea in the human consumption fisheries. Information on discards is included in the assessment. Whiting are also taken as a by-catch in industrial fisheries, partly in the fishery for Norway pout and partly in mixed industrial fisheries in the southern half of the North Sea.

The landings of whiting were rather stable after World War II until the early 1960s, at a level of around 75 000 tonnes. From the late 1960s to the late 1970s they were at a much higher level, fluctuating around 175 000 tonnes. From 1975 to 1985 landings decreased and have been at a low level since then. The total catch, including industrial by-catch and discards, is currently around 100 000 tonnes.

The spawning stock biomass peaked in 1969 and 1976 at about 600 000 tonnes, but declined between 1980 and 1985. Since 1985 the spawning stock biomass has been rather stable, varying between 250 000 and 330 000 tonnes.

The assessment of North Sea whiting has always been of lower precision than those of cod and haddock, for example. Trends in spawning stock biomass and estimates of recruitment based on catch data do not correlate very well with survey data, and therefore the state of this stock is uncertain.

Saithe

Saithe are mainly found in the northern North Sea along the edges of the Norwegian Deep. Saithe in the North Sea and in the Skagerrak/Kattegat belong to the same stock. The spawning season is late winter and spring. The nursery areas are coastal, rocky areas along the Scottish and Norwegian coasts. At the age of five years 70% of the saithe are mature.

From the beginning of this century until the early 1960s the catches of saithe fluctuated between virtually nil and 50 000 tonnes. They then increased to over 300 000 tonnes in the mid-1970s and subsequently decreased again. Catches once again increased to a maximum of 200 000 tonnes in 1985. Since 1988 the annual landings have been around 100 000 tonnes. Saithe are mainly caught in directed fisheries which started in the beginning of the 1970s, but also as a by-catch in the mixed demersal fisheries in the northern North Sea.

The spawning stock biomass reached a maximum of about 450 000 tonnes in the early 1970s, but gradually declined until 1990 to a historically low level. It subsequently increased but is still not at the level of the 1970s. The stock is considered to be close to Safe Biological Limits and the scientific advice is that fishing mortality should not be increased.

Plaice

The plaice population in the Channel, the North Sea and the Skagerrak/Kattegat is composed of several sub-groups which separate during spawning but partly overlap during the feeding season. Nurseries of plaice are found in shallow coastal waters such as the Wadden Sea. When plaice grow older they gradually migrate to deeper water. Adult plaice are widespread over the North Sea, with the exception of the northwestern part. Most females are mature at an age of three or four. Males reach maturity at a somewhat younger age.

Plaice are fished in directed fisheries, often together with sole. Since the 1960s a large proportion of the catch has been taken by beam trawl, which is a very efficient gear for flatfish.

Four stocks are assessed separately: the North Sea, Skagerrak/Kattegat, eastern Channel and western Channel stocks.

During the first half of this century, plaice landings from the North Sea fluctuated around 50 000 tonnes. In the absence of major fisheries during World War II, the North Sea stock recovered from a low level and since then catches have remained at a higher level. From the mid-1950s to 1989, landings gradually increased from 75 000 tonnes to 170 000 tonnes, since when they declined sharply to just under 100 000 tonnes in 1995 (Figure 3.6). The level of fishing mortality increased steadily in the years 1957-1994, and is well above the level giving the maximum sustainable yield.

Recruitment is remarkably stable, but with occasional very strong year classes. The spawning stock biomass peaked at 500 000 tonnes in the late 1960s and then gradually decreased to 300 000 tonnes in the late 1970s and early 1980s. As a result of two very strong year classes the adult stock increased again to over 400 000 tonnes, but since 1989 there has been a sharp decline. The spawning stock size was estimated to be 212 000 tonnes at the beginning of 1995, well below the MBAL of 300 000 tonnes and the stock is thus considered to be outside Safe Biological Limits. At the present high level of fishing mortality, and with a

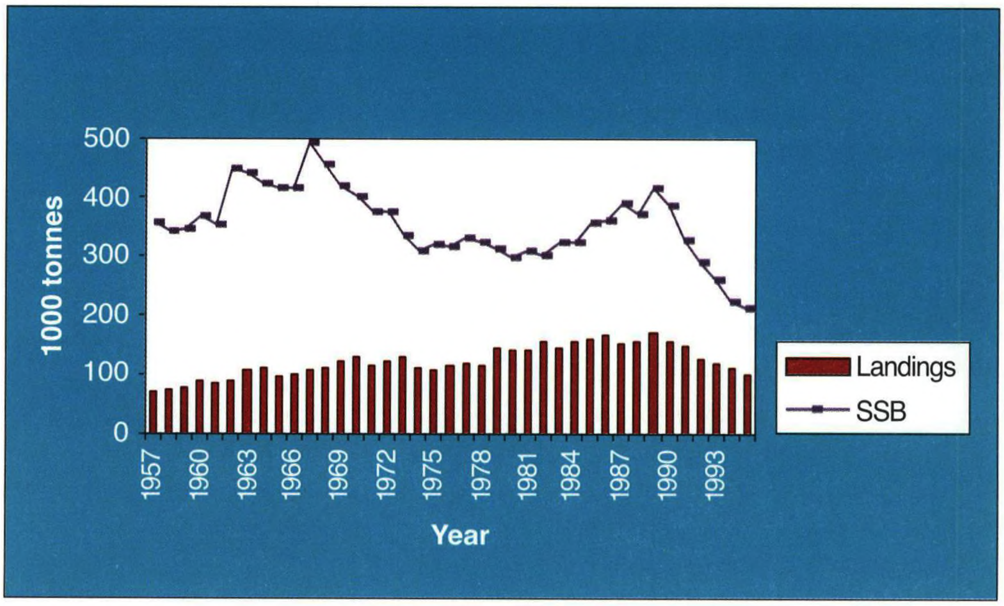


Figure 3.6. Landings and spawning stock biomass for plaice in the period 1957-1995. (ICES 1997)

number of consecutive years of below average recruitment, it is unlikely that the stock will increase to MBAL in the near future. A significant and sustained reduction in fishing mortality is required to allow the spawning stock biomass to increase to a level above MBAL.

The «plaice box» was introduced in 1989 to protect juvenile plaice along the continental coast. Originally the box was only closed to heavy beam trawlers (> 300 hp) for half the year, but a whole-year closure has been in operation since 1994. Survey results provide evidence that the abundance of marketable, as well as of undersize plaice, inside the box has increased compared to the pre-box years. However, exemption fleets of small beam trawlers (< 300 hp) more than doubled their effort in the box between 1989 and 1993. This has partly reduced the positive effect of the closure, which is now expected to result in a 14% increase in stock over that with no closure, as compared with slightly more than 25% had there been no increase in fishing effort by the small beam trawlers.

Sole

Sole reach their northern limit of distribution in the North Sea. This species is mainly found in the Channel and the southeastern North Sea, but also occurs in the Skagerrak and Kattegat. Several sole stocks are distinguished: two in the Channel, one in the North Sea and one in the Skagerrak and Kattegat. Most females are mature at an age of three years. They spawn in coastal areas in April-May. The nursery areas are in shallow water along the continental and English coasts.

Sole are primarily exploited together with plaice in a mixed flatfish fishery by the beam trawl fleet in the southern North Sea. They are also extensively fished by small inshore boats using otter trawls and fixed nets. Landings increased during the second half of this century, and are strongly influenced by occasional very strong year classes. Landings have fluctuated between 10 000 tonnes and 35 000 tonnes. Fishing mortality increased by a factor of four from the mid-1950s to the mid-1980s and has since remained at a very high level, and well above the level giving the maximum sustainable yield.

Recruitment is rather stable, with occasional very strong year classes. Since the sole is a southern species, it may be affected by cold winters. In the severe winter of 1962/1963 about 60% of the adult sole did not survive the extremely low water temperatures. It also suffered higher natural mortality in the cold winter of 1995-1996. The spawning stock size peaked in the early 1960s at around 150 000 tonnes but fluctuates strongly in response to recruitment fluctuation. The spawning stock size is presently above MBAL (35 000 tonnes) and the stock is considered to be within Safe Biological Limits. However, at the present high level of fishing mortality, the spawning stock is expected to decrease. In the absence of increased recruitment, it is quite likely that the stock will fall below MBAL in the medium term.

Sandeels

Five species of sandeel occur in the North Sea. Landings, however, consist almost entirely of a single species – *Ammodytes marinus*. Sandeels are assessed as three different stocks: the North Sea, the Skagerrak/Kattegat and the Shetland area.

The fishery for sandeels, using small-mesh trawls, takes place in spring and summer. The contribution of the northern North Sea to the total landings has increased in recent years. There is a small by-catch of TAC species (sprat, herring, haddock and whiting) in the sandeel fisheries but it is much lower than in the industrial fisheries directed at other species in the North Sea. Landings peaked at 1 000 000 tonnes in 1989, and have averaged 800 000 tonnes over the last eight years. Sandeels are, therefore, by far the largest component of total fish landings from the North Sea (Figure 3.7).

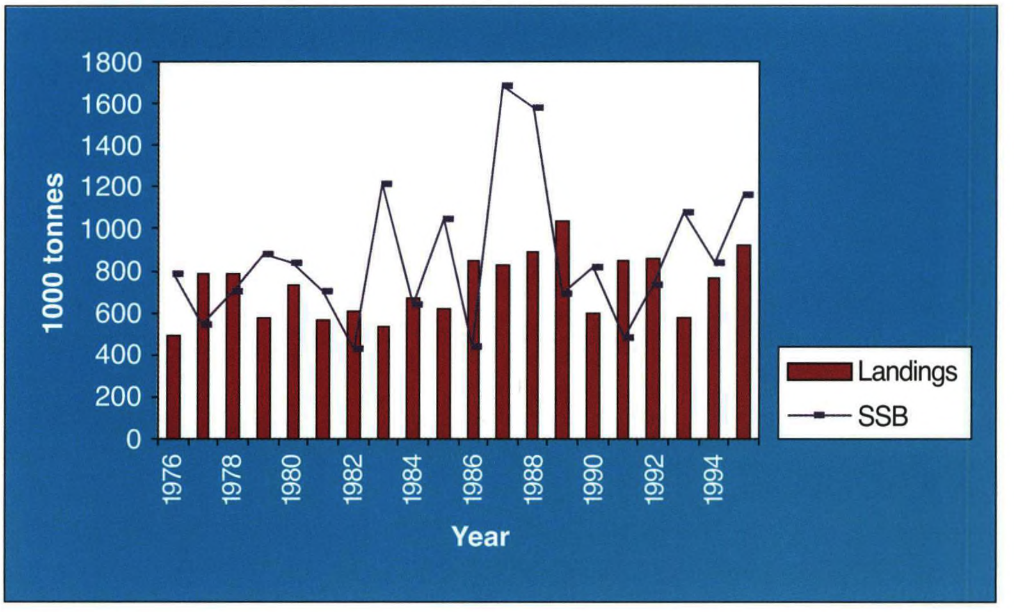


Figure 3.7. Landings and spawning stock biomass for sandeels in the period 1976-1995. (ICES 1997)

Over the last 20 years the spawning stock biomass has fluctuated between 400 000 and 1 700 000 tonnes, with a peak in 1987 and 1988, due to one very strong year class. Although the absolute magnitude of these estimates is subject to some uncertainty, there has been no evidence of any trend in spawning stock size over the past 20 years.

Sandeels are major prey species which play a very important role in the North Sea ecosystems as a whole and may be of particular importance in areas of local aggregation. The available information on the division of the stock into separate units, on the stock size and on the distribution of sandeels, is rather poor.

According to the available information, the total stock within the North Sea appears to be within Safe Biological Limits. The fishing mortality rate is estimated to be at a relatively low level and lower than the natural mortality rate caused mainly by predation.

Norway pout

Norway pout is a small, short-lived species belonging to the same group – the gadoids – to which cod, haddock and whiting belong. It seldom attains an age of over three years in the North Sea. It is distributed mainly in the deeper water areas of the northern and central North Sea and in the Skagerrak/Kattegat, and probably consists of a single stock.

Small-meshed trawls are used and the catch is landed for reduction purposes. The annual catches rose from almost nil in the 1950s to over 750 000 tonnes in 1974. They have fluctuated between 100 000 and 300 000 tonnes in recent years. In this fishery, which mostly takes place during winter, there is a by-catch of juveniles of protected species, especially haddock and whiting. The «Norway pout box» in the northwestern North Sea (an area in which fishing for Norway pout is prohibited) was introduced in the late 1970s to reduce this by-catch. In the deeper waters of the northern North Sea, it is caught together with juvenile blue whiting (*Micromesistius poutassou*).

The Norway pout stock is considered to be within Safe Biological Limits. Spawning stock size has increased in recent years and is at a high level. Recruitment, however, is rather variable and, since the species is very short-lived, this can strongly influence both the landings and the size of the spawning stock biomass.

Sprat

Sprat is widely distributed in the North Sea except in the northeastern and central parts; it is also abundant in the Skagerrak and Kattegat.

Sprat is caught for human consumption in the Skagerrak and Kattegat and in the coastal areas of the North Sea, but most of the landings are used for the production of fish meal and oil. In the Skagerrak and Kattegat sprat is caught both in a directed fishery and, together with juvenile herring and other species, in the so-called «mixed clupeoid» fishery.

Three stocks of sprat are assessed: the North Sea, Skagerrak/Kattegat and the Channel. Landings of sprat rose steeply from 1970 to 1975, when 700 000 tonnes were landed. Between 1975 and 1986 the landings gradually decreased but they have risen again in the most recent years. The main landings are from the North Sea itself.

The size and state of the sprat stock is not precisely known, but the stock does not show signs of overexploitation.

3.4.2 Other Fish Species

Sharks and dogfish

Several species of sharks and dogfish occur in the North Sea, with spurdog (*Squalus acanthias*) being the most abundant species. North Sea spurdog probably represents a relatively small component of a much larger northeast Atlantic population. Spurdogs are mainly landed as a by-catch in demersal fisheries, but directed fisheries with gillnets and long-lines still exist locally. Total landings of all species of sharks and dogfish from the North Sea increased after World War II. From the late 1950s to 1980 they fluctuated around 30 000 tonnes and then started to decrease, possibly due to overfishing. As with other elasmobranchs, sharks have a low reproductive rate and are therefore vulnerable to fisheries. According to survey data for the period 1970-1993 the abundance of spurdogs increased from 1970 to 1978, but since 1980 catches have been very low. The same trend has been observed in Scottish commercial catch-per-unit effort (CPUE) data. Spurdog, however, are known to be highly migratory and the observed changes are unlikely to reflect trends in the overall northeast Atlantic population.

Rays and skates

In the North Sea more than ten species of rays and skates may be found. Landings consist of a mixture of species, e.g. thornback ray (*Raja clavata*) and cuckoo ray (*Raja naevus*). Landings peaked immediately after both World Wars at around 18 000 tonnes, suggesting a rebuilding of the stocks in the absence of a fishery. From 1922-1940 and from 1955-1975 landings gradually decreased. From 1975 to 1983 they were at a low level of around 5 000 tonnes.

Due to their relatively low reproductive rate associated with high age at maturity and low number of eggs, rays and skates are very vulnerable to fisheries. The stocks of most species seem to have declined, with at least one valuable commercial species that has almost completely disappeared from the North Sea – the common skate (*Raja batis*). The starry ray (*Raja radiata*) is an exception to the general decline. Its numbers gradually increased in the period 1970-1993. Starry ray is a small species which is discarded because of its small size.

Gurnards

Four species of gurnard occur in the area, of which the grey gurnard (*Eutrigla gurnardus*) is by far the most common. Gurnards are landed for human consumption, although in recent years grey gurnard have also been landed for reduction purposes.

Grey gurnard in the North Sea have a strong seasonal migration. In winter they are especially abundant in the central western and northern North Sea, in spring they disperse in a southeasterly direction and in summer they are only absent from the northeastern North Sea. Three areas with high abundance can be distinguished, suggesting three sub-populations: one northwest of the Dogger Bank, one around Shetland and one in the Skagerrak/Kattegat. Over the period 1970-1993 there have been considerable fluctuations, but abundance has been consistently high since 1989.

Other species of roundfish

North Sea survey catches of three roundfish species, bib *(Trisopterus luscus)*, poor cod *(Trisopterus minutus)* and four-bearded rockling *(Rhinonemus cimbrius)*, show that the numbers of these species are subject to rather strong fluctuations, but no clear trend is apparent. Of these three species only bib is landed, in small amounts, for human consumption.

Another species of roundfish which is landed for human consumption is the hake *(Merluccius merluccius)*. North Sea landings of hake peaked immediately after World War II at 8 000 tonnes. Since then the landings have gradually decreased to approximately 2 000 tonnes in 1983. Survey catches, however, show an irregular pattern with no clear trend.

Ling and tusk

Ling (*Molva molva*) and tusk (*Brosme brosme*) are both caught along the edge of the continental shelf in the Faroe-Shetland Channel. The status of these stocks is not known, due to the lack of research and poor landings data. These species are considered to be sensitive to exploitation, however, as a result of the fact that they appear to be fairly long-lived and late maturing species.

Other species of flatfish

The most common flatfish in the North Sea is the common dab *(Limanda limanda)*. Only the larger specimens are landed for human consumption. Dab are distributed throughout the North Sea, with the highest abundance in the southeastern part. Long rough dab *(Hippoglossoides platessoides)* is a more northerly species, catches of which are usually discarded. Juvenile long rough dab have been particularly abundant in the Skagerrak/Kattegat in recent years. Lemon sole *(Microstomus kitt)* has a westerly distribution and is landed for human consumption. According to survey catches the abundance of all three species gradually increased in the North Sea in the period 1970-1993.

Catfish

Catfish *(Anarhichas lupus)* is distributed over the northern, deeper parts (> 50 m) of the North Sea and in the Skagerrak/Kattegat. The species is of moderate economic importance. North Sea landings fluctuated around 1 500 tonnes in the period 1903-1983. Survey catches are generally rather stable.

Anglerfish

Anglerfish *(Lophius piscatorius)*, often called monkfish, are distributed over the deeper parts (> 50 m) of the North Sea, Skagerrak/Kattegat and Channel. The anglerfish is of considerable economic importance. Until recently it was just a valuable by-catch but there is now a directed trawl fishery for this species along the edge of the continental shelf north and west of the British Isles. From 1900 to 1985 total North Sea catches fluctuated between 1 000 and 5 000 tonnes per year. Survey catches in the North Sea have increased in recent years.

Southern species

A number of species reach the northern limit of their distribution in the North Sea. North Sea catches of these «southern» species have shown a remarkable increase in the most recent period: e.g. lesser weever *(Echiichthys vipera)*, John Dory *(Zeus faber)*, mullet *(Mullus surmuletus)*, boarfish *(Capros aper)*, blue-mouth (*Helicolenus dactylopterus*) and red gurnard *(Aspitrigla cuculus)*. Some of these species, together with the seabass *(Dicentrarchus labrax)*, make quite an important contribution to the landings in terms of value, particularly in the Channel.

Other species

Certain other species, e.g. blue-fin tuna (*Thunnus thynnus*) and several shark species, are incidental visitors to the North Sea, their main distribution area lying outside the area. For these species, trends outside the North Sea determine their abundance. Some species, e.g. halibut (*Hippoglossus hippoglossus*), have almost disappeared from the North Sea part of their distribution area. The causes of such changes are not quite clear but, given the low fecundity of these species and the increased fishing pressure, the involvement of fisheries in these changes cannot be excluded.

3.4.3 Interactions between Fish Stocks and Changes in Fish Communities

Interactions between fish stocks

Changes in the abundance of fish stocks can be caused by a large number of different factors which can be anthropogenic or natural in origin. Changes in hydrography, for example, may lead to changes in current patterns which in turn may affect the drift and survival of the young fish to the age of recruitment. Recruitment can also be influenced by climatic factors, through changes in the timing and strength of the spring production of plankton. All these factors can act directly on the fish stocks themselves, or through the complex interactions between species, or in combination. Fishing pressure, however, has increased in many stocks to such a high level that it often obscures the effects of other influences on the dynamics of exploited stocks.

Stocks of pelagic species such as herring and mackerel declined in the North Sea in the 1960s and, approximately in the same period, the stocks of gadoids (cod, haddock, whiting, saithe and Norway pout) increased as a result of an increase in the level of recruitment. The increase in stock size of roundfish species that occurred at that time is known as the «gadoid outburst». In recent years the situation has reversed: the gadoid stocks have declined, some to historically low levels, and the northern North Sea is used, in summer, as the feeding ground for a large part of the mackerel stock.

Interactions are known to exist between pelagic species and gadoids. Pelagic species prey on the eggs and juveniles of gadoids and flatfish. There is also considerable overlap in the diets of larval and post larval gadoids and adult herring and mackerel. Following the decline of herring and mackerel in the 1960s there may have been reduced predation mortality on the juvenile gadoids which, in combination with an increased amount of food for these juveniles, resulted in higher recruitment levels.

Although such interactions may be the most obvious explanation for the changes observed, it is almost impossible to find the proof of the causal links involved. Through two large ICES-co-ordinated programmes in 1981 and 1991, in which the stomachs of very large numbers of fish were examined, the knowledge of inter-species relations between the main commercial species (who eats who?) was greatly increased. Possible interactions with and between other fish species, however, are still largely unknown.

Changes in fish communities

According to Scottish survey data for the periods 1929-1953 and 1980-1993 long-term changes in the fish species assemblages of the North Sea are rather subtle. Most apparent were the changes in the dominance of different species. The analysis of the Scottish data suggests that, although changes in the structure of the assemblage of fish species can be detected, when restricted to those groundfish that are not normally the object of specific fisheries, the assemblage appears to have remained relatively unchanged, despite a century of intensive fishing activity.

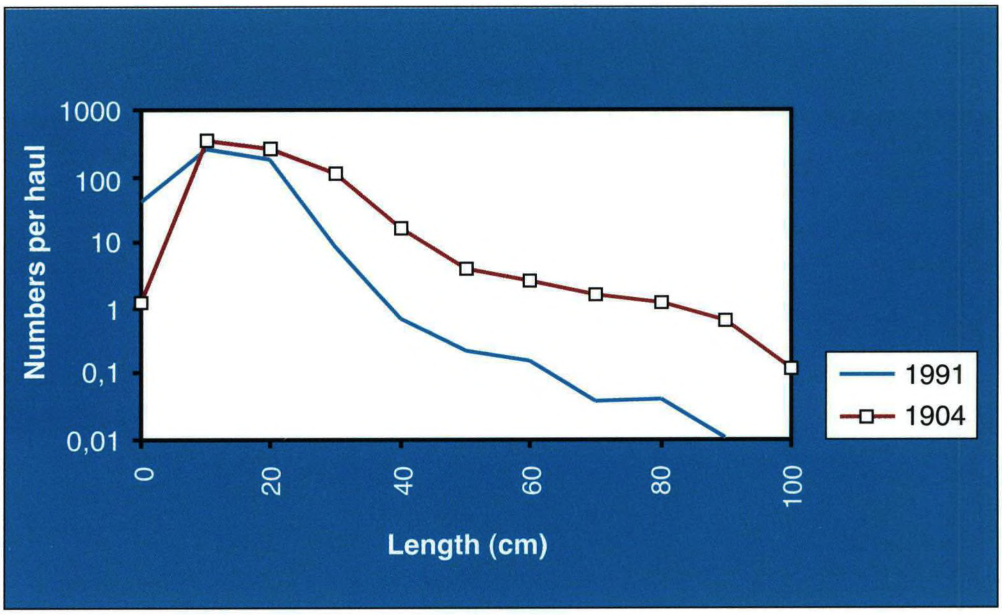
Comparison of English and Dutch survey data from 1906-1909 and 1990-1995 showed that the abundance of both roundfish and flatfish has decreased since the turn of the century. Noticeably, the haddock was more abundant during the earlier period. The catch rate of grey gurnard has decreased since the beginning of this century and the same holds for the elasmobranchs – spurdog and thornback ray. Greater weevers (*Trachinus draco*) have virtually disappeared.

Although there is no evidence of a major change in species composition in the North Sea over this century, there is more convincing evidence of changes in size composition. In data from the English Groundfish Survey, it was shown that, over the time period 1974-1992, the larger size groups of fish caught contained progressively fewer fish species. This is likely to be a result of the increasing exploitation rates on North Sea fish. A shift towards smaller-sized fish was also observed in a comparison of survey data from the periods 1906-1909 and 1990-1995.

The Scottish survey data also show a shift, by the 1980s, towards assemblages in which smaller fish are more highly represented. This was only apparent, however, in the whole groundfish species assemblage; the length compositions of those species not normally the object of specific fisheries were almost identical in the two time periods. A further point that emerged from the results of the English Groundfish Survey (1974-1992) was that diversity increased among smaller sizes of fish and decreased among the larger sizes.

The overall conclusion from the studies summarized above is that the fisheries have had the greatest effect on those species at which they are directed. As might be expected, the most obvious effects have been on the size composition of the fish assemblages as a result of selective and increasing fishing pressure on larger fish, in terms of both the species and the size groups within species that are caught (Figure 3.8).

Figure 3.8. Comparison of slopes of the size spectra of all fish species combined in 1904 and 1991 from the southern North Sea (North Sea Task Force sub-areas 3b, 4, 5 and 7b) as sampled on surveys. (Anon., 1909. Trawling investigation 1904-1905. International Fishery Investigation and unpublished results from R.V. Cirolana 1991.)



3.5 Seabirds of the North Sea

About 110 species of birds use the North Sea. These may be divided into three types: those which feed primarily intertidally (about 50 species), those using nearshore shallow waters (about 30 species), and those which feed offshore (about 30 species). The nearshore and intertidal groups tend to feed on benthic invertebrates, while those further offshore exploit fish and zooplankton. Patterns of usage vary between species. Some visit the North Sea during the summer, while others are present only in the winter. In many species, the immatures differ from the adults in their patterns of occurrence. Numbers of many inshore and intertidal species increase in the winter as birds move to North Sea coasts from frozen or colder areas to the north and east.

Some of the species among the intertidal and nearshore groups breed on North Sea coasts, but many more move into the area outside their breeding seasons. Proportionately more of the offshore group of seabirds nest on North Sea coasts but, nevertheless, considerable numbers use the North Sea outside their breeding seasons. This review describes the numbers of offshore and nearshore seabirds using the North Sea, both within and outside the breeding season. In some cases it is possible also to comment on changes in status of these populations. Some birds feeding intertidally may also be affected by fishing activities, but these are not described here.

3.5.1 Breeding Numbers

Numbers of breeding seabirds at colonies around the North Sea have been counted since the earliest parts of this century, and in some species for longer. There were no comprehensive counts of all seabirds in a country/region before the late 1960s. Most seabird populations have been censused again since the mid-1980s. The coasts of north Britain in the northwestern North Sea hold the largest numbers and greatest diversity; the Channel and southwest Norway hold the fewest birds of any of the regions. While it is possible to describe changes in some populations of birds breeding on the coasts of the North Sea, it is not possible to do this for all species. There are schemes on some coasts of the North Sea to monitor changes in numbers and breeding success of seabirds.

It seems likely that numbers of guillemots are higher than ever previously recorded in the core of their range in the northwestern North Sea, but numbers in the Channel were much higher in earlier parts of the century. Reasons for these regional changes and differences are likely to be complex and it is unlikely that we will ever be able fully to interpret the changes. Seabirds and their eggs, for example, used to be taken for human consumption. This has ceased in the North Sea, thus allowing populations to increase. Oil pollution and the increasing incidence of sea bird catches in gillnets has been more prevalent in the Channel than in the North Sea.

Populations of small prey-fish may have increased in the northwestern North Sea.

The influence of prey-fish population size on seabirds was demonstrated near Shetland in the mid to late 1980s. During summer, most breeding seabirds in the area rely on 0 and 1-group sandeels (*Ammodytes marinus*). From about 1984 to 1989, relatively few sandeels recruited to the area. As a consequence those birds that particularly relied on catching sandeels at the sea surface, such as kittiwake and arctic tern, suffered almost total breeding failure. This in turn led to a decline in numbers of adults attempting to breed in the succeeding years. This effect was compounded as some birds, such as great skua and great black-backed gull, which also depended on sandeels, switched to direct predation of adults and chicks of smaller seabirds. The net result on the kittiwake population in Shetland was an average annual decrease of 6.7% between 1986 and 1993, this has slowed to a 1.8% decline per annum since 1994.

It is noticeable that those species particularly associated with scavenging on discards and offal have all increased (Figure 3.9), as have those species that dive to depth to catch small fish. The former group includes fulmar, gannet, great skua, the larger gulls and kittiwake, while the latter includes the auks (guillemot, razorbill, black guillemot and puffin).

3.5.2 Offshore Numbers

Surveys of birds at sea have been carried out in the North Sea since the 1920s. Methods of counting introduced in the early 1980s have enabled comparisons of distribution to be made between months, and some estimation of total numbers present. Published data exist on distribution patterns throughout the year for all species recorded offshore, and on abundance for 30 species. Studies of numbers of scavenging species in the North Sea undertaken in four individual months between February 1993 and November 1994 revealed similar patterns of

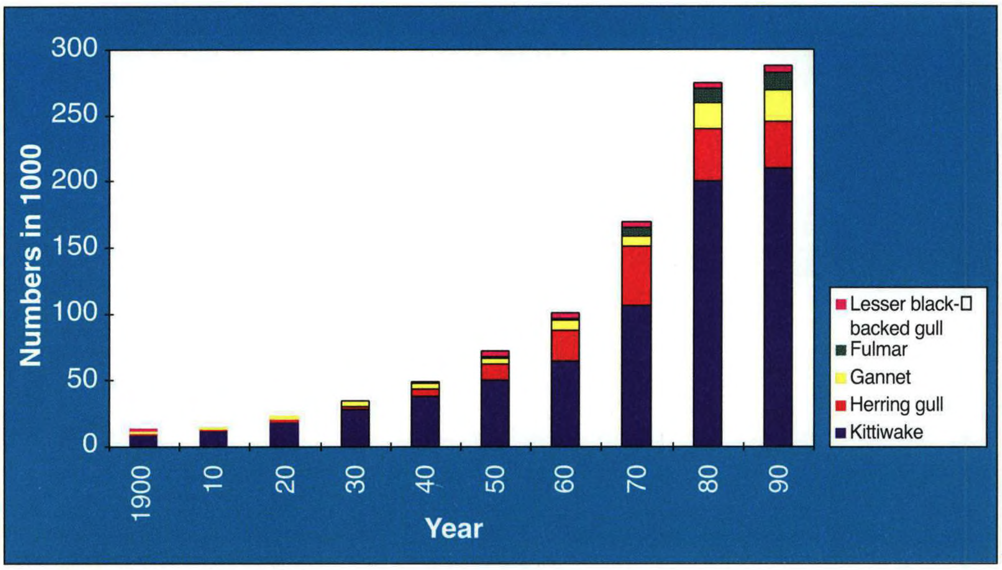


Figure 3.9. Number of breeding pairs of scavenging seabirds (Shetland, Orkney, Caithness to Banff and Buchan). (Furness 1992)

occurrence and abundance, indicating some consistency in their distribution at sea. There is insufficient information available to indicate trends in numbers of seabirds using offshore areas of the North Sea.

There is much information on seasonal distribution patterns of birds within the North Sea. There is some indication that not all of these patterns are stable. For example, in the early 1980s, it appeared that most guillemots remained relatively close to British coasts during winter. From the mid-1980s to early 1990s, greater numbers than previously were seen in the Kattegat and southern North Sea during winter. There may have been a return to the pattern of the early 1980s in recent years. Similar trends were found in razorbills and kittiwakes.

3.5.3 Nearshore and Intertidal Numbers

Nearly 10 million seaducks feed on shellfish in northwest Europe during the winter, as do over 1 million waders and several thousands of gulls. The most detailed regional data are available for the southeastern North Sea, where key species are the eider, common scoter, oystercatcher and herring gull. Natural fluctuations occur in the distribution of, for example, common scoter, probably in relation to the spatfall of their invertebrate food. In addition, there is evidence of shellfish fisheries (mussel, cockle, *Spisula*) reducing the abundance of available food and thus causing local reductions in numbers, forcing birds to take alternative prey, to leave the area or to experience increased mortality or breeding failure. In general, birds such as oystercatchers that are restricted to intertidal flats are more vulnerable to shellfisheries as they are immediately affected by the removal of prey, whereas seaducks can more easily switch to other (e.g. subtidal) areas. Monitoring therefore needs to be geographically comprehensive to detect changes in total numbers.

3.6 Marine Mammals of the North Sea

3.6.1 Cetaceans

Available information on the distribution and abundance of small cetaceans in the North Sea comes from three sources: i) dedicated sightings surveys; ii) surveys conducted primarily for seabirds; and iii) land-based sightings and other incidental sightings schemes. Information from strandings of cetaceans is difficult to interpret.

There have been only two extensive dedicated sightings surveys, and one of these only covered part of the area. In 1994 a large international shipboard and aerial survey (SCANS – Small Cetacean Abundance in the North Sea) was made in the entire North Sea, Channel and Skagerrak/Kattegat. Relevant analysis have also been carried out on the European Seabirds at Sea database.

Harbour porpoises

Harbour porpoise (*Phocoena phocoena*) are widely distributed throughout the North Sea and adjacent waters. The abundance of harbour porpoises in the North Sea, including the Channel and the Kattegat, is estimated at 304 000 (242 000 – 384 000) animals in 1994.

The harbour porpoise is the main cetacean observed in the Skagerrak, Kattegat, Belt Seas, Bay of Kiel and western Baltic, the highest densities occurring in the Great Belt and southern Kattegat. Harbour porpoise densities are also high on the western side of the Schleswig-Holstein/Jutland peninsula, particularly off Sylt and on the Amrum Bank and Horns Reef.

Around northern Scotland, including Shetland, and off the east coast of Britain, harbour porpoises are considered to be relatively abundant. Sighting rates were lower in the central North Sea than in the western area. They are rarely seen in the southernmost part of the North Sea or in the eastern Channel. There is no reliable information on trends in the status of harbour porpoises in the North Sea, but some evidence exists that they were commoner in the southern North Sea and the Channel in the past.

Bottlenose dolphins

Bottlenose dolphins (*Tursiops truncatus*) are resident in the Moray Firth, off the west coast of Normandy, off Dorset and off Cornwall. The total number is estimated at 250 animals. The resident groups are small; the largest known being that in the Moray Firth, which is estimated to contain 130 animals. Elsewhere they are rarely seen. There is good historical evidence that these dolphins were commoner and more widely distributed in the North Sea in the past.

Other dolphins

Whitebeaked dolphins (*Lagenorhynchus albirostris*) are the most frequently sighted dolphin species in the area. Sightings are concentrated in the north and west of the North Sea. There have also been several sightings of groups of more than 100 whitesided dolphins (*L. acutus*) in the central North Sea, often in mixed herds with whitebeaked dolphins. The total number of whitebeaked and whitesided dolphins in the North Sea was estimated at 10 900 (6 700 – 17 800) animals in 1994.

Risso's dolphins (*Grampus griseus*) occur in small numbers, mostly in the northern North Sea.

Common dolphins (*Delphinus delphis*) are rarely seen in the North Sea proper, but are the most commonly found species in the Channel.

There is no reliable information on the trends in the status of these western species.

Other species of cetaceans

Minke whales (*Balaenoptera acutorostrata*) migrate and are frequently seen in the northern and central North Sea during the summer, especially in the western part. They are rarely seen anywhere in the area at other times of the year. Minke whales in the North Sea belong to the northeast Atlantic stock for which the most recent point estimate made by the Scientific Committee of the International Whaling Commission (IWC) is 112 125 animals. The most recent point estimate for the stock in the North Sea is 20 294 animals (IWC/48/4 1996).

Pilot whales (*Globicephala melaena*) occur commonly in the northern and northwestern North Sea, with an indication of a higher occurrence in winter. The pilot whale stock is not restricted to the northern North Sea. The total estimate for the central and northeast Atlantic is 778 000 animals.

Large whales are also occasionally seen in the area, including sperm whales (*Physeter catodon*), fin whales (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae*).

3.6.2 Seals

Six species of seal – the harbour (or common) seal (*Phoca vitulina*), the ringed seal (*Phoca hispida*), the harp seal (*Phoca groenlandica*), the bearded seal (*Erignathus barbatus*), the hooded seal (*Cystophora cristata*), and the grey seal (*Halichoerus grypus*) – occur more or less regularly in the North Sea, but only the harbour seal and the grey seal breed there. Harp, ringed and hooded seals are recorded annually and harp seals may invade the North Sea in large numbers: the last such invasion was in 1987.

In most countries bordering the North Sea, harbour seal and grey seal numbers are determined annually, usually by aerial surveys at specific times of the year. The existence of time-series of counts or abundance estimates for both species has made it possible to detect trends in abundance over the last 20 years.

Harbour seals

The harbour seal is an abundant species with a circumpolar distribution. It is found throughout the North Sea, with the largest concentrations in the Wadden Sea (at least 8 900 animals in 1994), Orkney (7 900 animals in 1993) and Shetland (6 200 animals in 1993), and the Kattegat/Skagerrak (5 200 animals in 1994). Harbour seals are relatively stationary. The total number of harbour seals in the North Sea is 33 000, which is approximately 45% of the European population of this species, and 5% of the world population.

Grey seals

Almost all of the grey seals in the North Sea breed around the coast of the British Isles, although a few pups are born each year in the Wadden Sea, the Skagerrak/Kattegat, and Brittany. The largest concentration of breeding colonies is in Orkney, where 11 500 pups were born in 1994. The North Sea holds approximately 40% of the European population of grey seals and 15% of the world population. Grey seals can travel long distances (over 1 500 km) but most of their time is spent close to traditional resting sites. The total number of grey seals in the North Sea is estimated at 52 000 animals.

3.7 Benthic Organisms

The benthos consists of the organisms living near, on, or in the sea bed. A wide variety of animals belongs to the benthic community: crustaceans, molluscs, worms, echinoderms etc. Animals living in the sediment are called infauna, the fraction larger than 1 mm being called macrozoobenthos or macrofauna. Animals moving about on the sea bed belong to the epifauna. Some species are commercially exploited, partly as by-catch in demersal fisheries, and partly as a target in directed fisheries. In addition, aquaculture of benthic animals takes place, especially of mussels and oysters.

Relatively little is known about most benthic species. There has only been one comprehensive benthos survey in the North Sea proper, in 1986, co-ordinated by ICES. This survey resulted in a description of six North Sea macrobenthos assemblages. Six benthos communities are also recognized in the Skagerrak/Kattegat, and five offshore and two shallow water communities in the Channel.

The distribution of macrozoobenthos species is strongly linked to sediment type, and/or to different water masses. In the North Sea the average number of species per assemblage gradually increases with depth, with the maximum number of species in areas deeper than 70 m. In northern areas, diversity is considerably higher than elsewhere. Diversity also increases from southwest to northeast. Total biomass decreases considerably going north, the highest values being found south of the Dogger Bank in the southern North Sea. Mean weight per specimen also shows a clear decline with increasing latitude and, in areas to the north, with increasing depth.

There are two extensive time-series of data on North Sea benthos, one off Northumberland, the other in the Skagerrak. The Northumberland time-series is for two nearshore stations sampled since the early 1970s. A significant correlation was found between macrobenthos numbers and phytoplankton abundance two years previously. No marked change has been observed in total macrobenthos abundance over the last 20 years, although ottertrawling for Norway lobster (*Nephrops norvegicus)* in the area has increased. The Skagerrak time-series (1973-1988) demonstrates a change from undisturbed benthos communities in the early and mid-1970s to moderately disturbed communities in the late 1970s and 1980s.

On the Dogger Bank, changes in the macrobenthos between the early 1950s and late 1980s were dominated by an increased abundance of small, opportunistic polychaet worms, which was probably due to increased organic carbon as a result of increased eutrophication. However, fishing effort in this area was also higher in the 1950s. Total biomass declined by about 30%, mainly due to the disappearance of the bivalve *Spisula subtruncata*.

Fishing activities, especially of the demersal fleet, have changed the community structure of benthic invertebrates from long-lived to short-lived species, as long-lived and sensitive species are adversely affected by certain gear. Scavenging species and short-lived opportunistic species like worms seem to benefit from fishing activities, and their populations have increased. At the same time the populations of certain long-lived buried bivalve species, such as quahog (*Arctica islandica*) and horse mussel (*Modiolus modiolus*) may have decreased. The disappearance of the oyster (*Ostrea edulis*) from the North Sea during the first half of this century is partly attributed to a number of severe winters, diseases and partly to the fishery.

There are several commercially important shellfish species belonging to the crustaceans and molluscs. The most important crustaceans are: deep sea shrimp (*Pandalus borealis*), brown shrimp (*Crangon crangon*), edible crab (*Cancer pagurus*), spider crab (*Maja squinado*), Norway lobster and lobster (*Homarus gammarus*). Among the molluscs important species are: squid (*Loligo* sp.), cuttlefish (*Sepia officinalis*), oyster, mussel (*Mytilus*), scallop (*Pecten maximus*), *Spisula*, cockle (*Cerastoderma*), razor clam (*Ensis* spp.) and whelk (*Buccinum*).

Mussel, whelk, winkle, cockle, crab, lobster and shrimp fishing activities are concentrated in the coastal zones and estuaries.

Only for Norway lobster and deep sea shrimp are international assessments made. For most of the other species not very much more information exists other than landings data.

Deep sea shrimp

The nature of the fishery for deep sea shrimp differs between areas. In some areas such as the Norwegian Deep and Fladen Ground it tends to be an opportunistic fishery, strongly influenced by stock abundance and market prices. In some other areas such as those off the Swedish coast, the fishery is conducted throughout the year and the catch is directed to the home market. Deep sea shrimp stocks are short-lived and therefore very dependent on the recruiting year class. The spawning stock biomass of deep sea shrimp in the Skagerrak and the Norwegian Deep increased in 1994 to a level of around 15 000 tonnes due to the very rich 1992 year class. The stock is presently considered to be within Safe Biological Limits. The state of the stocks of deep sea shrimp on the Fladen Ground and in the

Farn Deep is not known, as no data are available for an assessment.

Norway lobster

The major commercial crustacean fishery in the North Sea is for Norway lobster. Areas which are of importance are the Skagerrak and Kattegat, the Moray Firth, Farn Deep, the Firth of Forth and, increasingly, the Fladen Ground. Over the last 10 years landings of Norway lobster from the Skagerrak/Kattegat were stable around 4 000 tonnes until 1991, and then decreased to 3 000 tonnes. Total landings for the rest of the North Sea increased gradually from 8 000 tonnes in 1985 to slightly less than 14 000 tonnes in 1994. This increase is largely due to the increased importance of the Fladen Ground. From this area landings increased from slightly over 1 000 tonnes in 1985 to 4 000 tonnes in 1994.

The bulk of the landings consists of males, since the egg-bearing females mainly stay in their burrows. Because of their burrowing habit Norway lobster are restricted to particular types of sediment. Areas where Norway lobster are found are separated from each other by large areas where they are absent.

The spawning stock biomass and recruitment of most Norway lobster stocks seem to be relatively stable. Fluctuations in landings are mainly caused by changes in the level of fishing effort. Although there are no signs of recruitment overfishing in Norway lobster, there are a number of stocks that show clear signs of growth overfishing.

Brown shrimp

The brown shrimp is an important target species for coastal beamtrawlers from Denmark to northern France, and also in some areas of the United Kingdom. The core area is in and near the Wadden Sea. Total catches vary considerably between years and averages around 25 000 tonnes. The main season is from August to October, with minor ones in spring and winter. Only larger boats can operate from December to March when weather conditions allow fishing for hibernating shrimp at depths of 15 to 20 m. The species is short-lived with a maximum age of three years. The catches consist mainly of around one year-old shrimps. Industrial catches of shrimps below 5 cm in length are about 10% of the total landings. Recruitment overfishing and a total depletion of the stocks due to fisheries are extremely unlikely, as no stock recruitment relationship has yet been found.

Mussel

The cultivation of mussels is a major activity in the Wadden Sea, the eastern Scheldt and along the northern coast of France. In the Wadden Sea, mussels occur on subtidal as well as intertidal beds.

The intertidal beds are mainly located in the sheltered zone behind the barrier islands. The development of the immature beds is governed by winters with heavy ice coverage. In the course of such winters most of the mussels are removed by the mechanical force of the ice. However, these events are followed by strong recruitment the next summer. Between 1987 and 1996 the beds showed a continuous decline caused by low recruitment, predation by seabirds, the effects of heavy gales and the fishery for seed mussels. The decline was heaviest in the lower Saxony subregion (Germany), even in areas without any fishery. As expected, the good recruitment in 1996 normalized the situation.

Mature beds are generally stable and are one of the most typical communities of the tidal area. The fisheries, especially for seed mussels, have contributed to the disappearance of mature beds. As a result, no mature beds remain in the Dutch part of the Wadden Sea and numbers have strongly declined in the Niedersachsen part of the Wadden Sea. The recovery of mature beds and the opportunities for the development of new mature beds is seriously hampered by these seed mussel fisheries. To allow recovery of mature beds several areas within the Wadden Sea have been closed.

The lifetime of the subtidal beds is often restricted to one or two years following formation, due to predation by eider ducks, starfish and shore crabs, and due to the effects of gales. In addition, the fishery takes most of the seed mussels from such subtidal spatfall areas. Large spatfall areas in Schleswig-Holstein were established in the summers of 1990, 1994 and 1996.

For the reasons mentioned above, mussel production, especially in the Wadden Sea, fluctuates strongly. Further, the availability of mussel seed restricts production. In recent years the shortage of mussel seed in the Dutch Wadden Sea has been compensated by importing half-grown mussels from the German Wadden Sea to stock the culture lots.

Natural fluctuations occur due to ice scouring on tidal flats and in shallow areas in cold winters. Poor recruitment can also be caused by heavy predation on mussel spat in all areas in years with mild winters.

Over the last five years (winters), annual landings from Dutch, German and Danish Wadden Sea totalled 110 000 tonnes.

The French production of mussels in the Channel was 26 500 tonnes. Although there has been a persistent spatfall (recruitment) failure since 1990, the mussel fishery in the Wash on the east coast of England yielded 5 - 10 000 tonnes per annum.

In the Danish Wadden Sea, fishing is restricted to natural mussel beds in the subtidal areas inside the islands, about 50% of which are closed to the mussel fishery. Following an almost complete depletion of stocks in the late 1980s due to a combination of overfishing, cold winters and poor recruitment, annual landings have increased to 5 - 10 000 tonnes in recent years, in which recruitment, however, has been poor due to mild winters.

Oysters

The French production of Pacific oyster (*Crassostrea gigas*) in the Channel was 41 000 tonnes. There is also small-scale production of oysters in several of the estuaries in southeast England. Mariculture in the Orkney, Shetland, and other Scottish regions produces oysters, scallops and mussels.

In the Wadden Sea area the European oyster (*Ostrea edulis*) is extinct. In the Danish Limfjord this species has re-established natural beds, on which some oyster fishery has revived.

The Pacific oyster imported for relaying has developed naturally in several Wadden Sea areas and might establish fishable stocks in the future.

Cockles

Cockle fishing is significant in the Moray Firth (Scotland), the Wash (eastern England), the Dutch Wadden Sea and the Delta area, and to a limited extent in Denmark. Annual landings in the Netherlands range from almost zero to about 7 000 tonnes of flesh or 50 000 tonnes wet weight. The proportion of total stocks harvested by the Dutch fisheries is below 10% in most years, but may reach 40% when stocks are low.

In Germany the cockle fishery has been ceased for bird protection reasons.

Spisula

Fisheries for trough shells (two species of *Spisula*) began around 1990 in Denmark and the Netherlands and have increased since. The occurrence of *Spisula solida* is restricted to areas with coarse sand at water depths of over 10 m. In Germany the fishery for this species started in 1992, mainly at one location (Amrum Bank).

In Dutch coastal waters *S. solida* is hardly fished at all. There, the fisheries concentrate on *S. subtruncata*, especially in years with low landings of cockles.

Statistics on stock sizes, production and fishery harvests are sparse. In 1995 off the German coast alone a stock size of about 200 000 tonnes was estimated. However, extremely low temperatures in the winter of 1995/1996 led to mass mortality of *Spisula solida*. A *Spisula* fishery is currently not possible in the area north of the Wadden Islands and might not be resumed before 1998.

Razor clams

Different species of razor clams form stocks off the Wadden Sea coast. In some years aggregations of clams pose hazards for nets in the trawl fishery, reflecting the possibility of some large fishable resources.

Other molluscs

Scallops have been fished for some years around Orkney and Shetland and in the Moray Firth. Maximum catches were 2 150 tonnes per year. Grounds to the east of Scotland were exploited for the first time in 1991, when catches exceeded 500 tonnes.

Queen scallops are fished in inshore areas around Orkney and Shetland, with catches of up to 330 tonnes per year, and off the northeast coast of England, where catches amount to some 600 tonnes annually.

4

North Sea Fisheries and their Management

Improvement of fisheries management policies aiming at the protection and sustainable use of the North Sea marine ecosystem can best be achieved by the adoption of appropriate medium-term and long-term objectives and associated strategies for their implementation.

(The Esbjerg Declaration, Article 14)

4.1 Summary and Issues of Concern

Fishing in the North Sea has a long history going back over many centuries. Statistics for total international landings are available from 1903 and for some countries even earlier. From the turn of this century significant technical developments have taken place in fishing gear and fishing methods. The pace of innovation has accelerated since then. Many of the technical developments have led to more efficient exploitation of the various commercial fish stocks. The total catch from the North Sea increased gradually from 1 million tonnes around 1900 to about 2 million tonnes around 1960. During the 1960s the catches increased steeply to about 3.5 million tonnes, followed by a gradual decline to around 2.5 million tonnes in recent years.

The capacity of the fishing fleet in the human consumption fisheries increased steadily after the turn of this century, as a result of an increase in efficiency and range of the vessels. From the early 1950s a fleet of bottom trawlers started an industrial fishery for species like sandeel, Norway pout, sprat and herring. The number and range of these industrial trawlers increased in the following decades, and today about half of the total landings from the North Sea is used for reduction to fish meal and oil.

Around 1960 a fleet of purse seiners began intensive exploitation of the pelagic species and there has also been a steady increase in beam trawlers targeting flatfish and roundfish.

In the roundfish fishery there has, in general, been an increase in fishing effort since the 1960s. In the flatfish fisheries the general trend since the 1980s has been a gradual decrease in the traditional otter trawling effort and an increase in the beam trawl effort. In the industrial fisheries there is no clear trend in the fishing effort for sandeel, while for Norway pout the effort has been considerably lower in the 1990s than in the first half of the 1980s.

Since 1945 there has been a general increasing trend in fishing pressure on all commercial species. Over the same period there has also been a change in the species composition of the landings.

It has been estimated that on average the total biomass of fish in the North Sea is about 10 million tonnes. The fishery thus removes at least 25-30% of the biomass each year (although some of this, e.g. immigrating mackerel and horse mackerel, may only use the North Sea seasonally as feeding grounds). This exploitation rate is high and the present catch levels may not be sustainable under the present fishing pressure. Indeed, the present situation is that several stocks (herring, North Sea mackerel and cod) are close to or outside Safe Biological Limits (SBL), i.e. there is a danger that spawning stocks may be reduced to levels where recruitment is negatively affected, with the accompanying risk that the stocks may decrease even further and ultimately collapse.

Over the last decades there have been changes in the form of the management advice given to administrators by scientists. Advice based on the maximum sustainable yield concept has been supplanted by advice formulated to ensure the sustainability of the resources. In this context, the concept of Safe Biological Limits was introduced to identify those stocks which are at levels at which their productive capacity is impaired or which may become so at current levels of exploitation. For some stocks it has been possible to define a Minimum Biologically Acceptable Level of spawning stock size (MBAL), i.e. the level of spawning stock below which the probability of poor recruitment (the replenishment of young fish by the population) increases as spawning stock size decreases. MBAL is not a target for stock management but rather an indicator of an emergency situation below which recruitment may be adversely affected, thereby threatening the future sustainability of the stock.

There is an increasing awareness that sustainability of the fisheries must be ensured as a basis before the long-term maximization of the yield can be pursued.

Although the analytical tools and the data necessary for setting objectives for fisheries management are available, at least in part, there are only a few cases where specific medium or long-term objectives related to stock management have been adopted by the relevant authorities.

The intensity of fishing on a stock is measured by scientists, not just in terms of the catch, but also in terms of the proportion of the available stock that is removed by fishing in the course of a year. This is expressed as the rate of fishing mortality, which is to a first approximation proportional to fishing effort. In the present situation in the North Sea, managers apply a system of TACs (Total Allowable Catches) and associated national catch quotas as the main instrument for attempting to control fishing mortality rates. There is general recognition that TACs have failed to control fishing mortality in most North Sea fisheries. This is because, without sufficient direct controls on the amount of fishing effort, fish can be caught in excess of the TAC and either discarded or landed illegally. Other, more direct measures to control fishing mortality require control of the fishing effort deployed, including restrictions on the number of vessels, their fishing capacity and their fishing time. While some North Sea states have reduced their fleet sizes, the fishing capacity reductions have so far not had the desired effect of reducing the overall fishing mortality rate.

The difference between the current fishing mortality rates and those corresponding to theoretically optimum values is very large. The long-term yield from many stocks, in particular the roundfish, could be significantly higher with a lower fishing mortality and a different exploitation pattern (i.e. if fewer small fish were caught). Despite recent regulatory efforts, the total fleet capacity of the North Sea is still at a level which exceeds the productive capacity of the available resources.

Other controls on fishing restrict the types of fishing and fishing gear that are permitted, as well as the area and time of operation at sea. Technical measures are primarily intended to protect juveniles in such a way that a more favourable exploitation pattern is achieved. Together with regulations on the minimum landing size, such technical measures contribute to reduced catches of juvenile fish. Alongside these controls on existing fishing techniques, the improvement of the selectivity of fishing gear for size and species (i.e. by increasing mesh size, introducing grids and escape panels) has been an active topic of research and implementation over the last 40-50 years.

Issues of Concern

The following issues of concern have been identified with regard to North Sea fisheries and their management:

- The lack of established medium and long-term objectives for the management of North Sea fisheries;
- The unaccounted fishing mortality associated with misreporting of catches by quantity, area and species, illegal landings, highgrading and discarding, leading to *inter alia* decreased reliability of catch statistics;
- The limited effectiveness of catch monitoring, control and enforcement;
- The imbalance between fleet capacity and deployed fishing effort (capacity and activity) on the one hand and available fish resources on the other, and the pressure for overexploitation caused by overcapacity;
- The high levels of catches of juveniles associated with particular fishing gear and practices;
- The threat posed by overexploitation to viable fisheries and the consequences for employment; and
- The lack of comprehensive socio-economic information.

The fisheries are monitored by a control and enforcement system involving surveillance of fishing activities at sea, as well as control at the point of landing. It is recognized that the present control system does not prevent misreporting (underreporting and report of wrong species) in some fisheries, both of which are associated with illegal landings. In particular, the extent of underreporting in the roundfish fisheries has been a serious problem in recent years. The current management system in the North Sea also permits discarding of fish, although this is now prohibited for the main commercial species by one North Sea state. There are currently no official statistics on the amount of fish discarded, although sampling schemes are in operation for some fisheries.

Fisheries are important for many societies, in particular for some coastal communities. Changes in fisheries policy will therefore in many cases have a significant impact on these societies, either for economic or sociological reasons.

4.2 Introduction

The North Sea is one of the world's most important fishing grounds. It is also one of the most complex, both with regard to its resources and to management. The North Sea is bordered by eight countries, seven of which belong to the European Union. The fish fauna of the North Sea includes over 200 species, of which about 20 are commercially important. About ten of these are sufficiently abundant to support one or more distinct fisheries targeted at that species. Mixed fisheries are, however, also important in the North Sea. A variety of different types of fishing gear is employed, and the catches are used for human consumption as well as for fish meal and oil production (the industrial fisheries).

This chapter will review the development of the different fisheries in the North Sea from around 1900 up to the present including the fishing methods, fishing effort, quantities landed and species composition, as well as the management and socio-economic aspects of the fishing activity.

4.3 Development of Catches of the most Important Species

Not only the volume but also the species composition of the fish catches from the North Sea has changed considerably during this century (Figure 4.1). The total landings remained

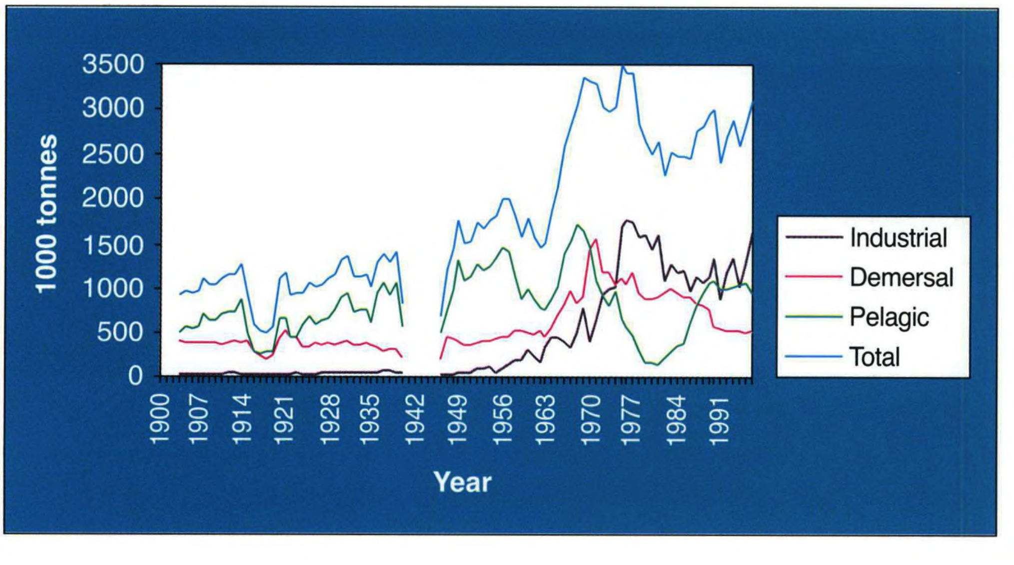


Figure 4.1. Landings of fish from the North Sea 1903-1995. (Updated from Knijn et al. 1993 using data from ICES.)

reasonably stable at 1.0-1.3 million tonnes until the Second World War and thereafter rose to a higher level in the 1950s, mainly due to increased exploitation of the herring and mackerel. The pelagic catches peaked in the late 1960s and then fell dramatically in the late 1970s when the herring fisheries were closed and the North Sea mackerel stock was severely depleted.

It has been estimated that the total biomass of fish in the North Sea is about 10 million tonnes. The fishery thus removes at least 25-30% of the biomass each year (although some of this, i.e. immigrating mackerel and horse mackerel, may only use the North Sea seasonally as feeding grounds). This exploitation rate is high and may not be sustainable. The yield from many stocks, in particular the roundfish stocks, could be significantly higher with a lower fishing mortality and different exploitation pattern. However, the present situation is that the stocks of several of the roundfish stocks and the plaice stock are near or below Safe Biological Limits, i.e. there is danger that the spawning stocks may be reduced to levels were recruitment is negatively affected, to the extent that the stocks may not be sustained. The same is the case for North Sea herring for which drastic conservation measures had to be taken in 1996 to avoid a severe depletion of the spawning stock.

Major changes in the demersal fish yield occurred in the 1960s, an event known as the «gadoid outburst». The landings of haddock, cod, whiting and saithe all increased in that period. The landings peaked in 1970 and remained higher than the pre-1960 level until the early 1980s, when a decline began. The industrial fisheries for sandeel, Norway pout and sprat became increasingly important through the 1960s and 1970s, and in the mid-1970s the total industrial catch reached 1.5-1.7 million tonnes per year. In the early 1980s the general picture was that of drastically reduced herring and mackerel landings, dominance of industrial species and stable or declining roundfish landings.

The flatfish landings consist mainly of plaice and sole. The total landings of flatfish have increased steadily since the Second World War, due to plaice landings. However, in very recent years a decline in plaice landings has occurred. The sole landings have been remarkably stable at around 25 000 tonnes.

In the last decade the herring and mackerel landings have generally increased in spite of the low level of the spawning stocks. This is partially due to the summer immigration of Western mackerel and Baltic spring-spawning herring. On the other hand the industrial catch has remained high, while the roundfish yield has been reduced. Around 1990, the total fish landings from the North Sea were about 2 million tonnes (plus 0.4 million tonnes from the Skagerrak and the Channel), of which about half was sandeel, Norway pout and sprat fished for reduction to fish meal and oil.

In the first half of the 1990s the pelagic catch of herring, mackerel and horse mackerel increased, and in 1994 it constituted about 35-40% of the total fish catch. The industrial catch was about 40% of all pelagic catches. Mainly due to the greater pelagic catches, the total increased to 2.8 million tonnes in 1994. Catches of non-target species are not included in these figures. Fish landings from the North Sea in 1995 are illustrated in Figure 4.2.

The relative importance of fishing mortality and natural mortality can be assessed by comparing the proportion of the annual production harvested by man and that removed by predation and other sources of death. The annual proportion of the total production harvested by human consumption and industrial fisheries, and that removed by natural mortality, is shown in Figure 4.3. The industrial fisheries take less than 25% of the total annual production of the industrial species sandeel, Norway pout and sprat. For human consumption species the importance of the fisheries increases and for cod about 80% of the annual production is landed in the human consumption fishery.

Present exploitation levels may also affect the fish community structure (see Chapter 3.4.3 for

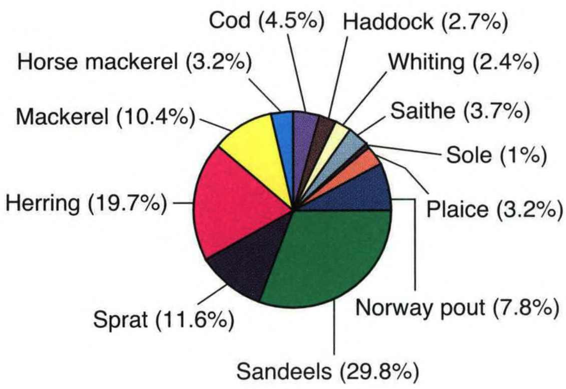


Figure 4.2. Composition of the fish landings from the North Sea in 1995. (Based on national statistics and ICES estimates.)

details). So far, few studies of such effects have been conducted. Long time-series of trawl data indicate that changes in diversity and species composition have occurred. Among demersal fish there seems to be a trend towards communities with higher proportions of small fish and this may be a result of the high fishing intensity. Some stocks or species which were depleted in the 1950s and 1960s are still at insignificant levels, notably the North Sea mackerel (i.e. the component spawning in the North Sea) and the bluefin tuna. There are also some species which have shown consistent declines in abundance over many years, e.g. Atlantic halibut and some of the skate and ray species, which have a low reproductive capacity and/or long lifespans (see also Chapter 3.4.2).

There is a large variation between North Sea states with regard to the magnitude of their respective fisheries. Figure 4.4 illustrates the relative importance of the North Sea states in the North Sea fisheries with regard to landings of fish and shellfish. It can be seen from the Figure that Belgium has the smallest landings with 1% of the total, while Denmark takes about 45% of the landings of fish and shellfish from the North Sea.

4.4 Development of Fishing Fleet Capacity and Fishing Effort

A trawler and seiner fleet was already fishing for roundfish and flatfish in the North Sea around the turn of the century. The total fleet capacity increased steadily in the following decades, because efficiency and range of the vessels increased. After the Second World War, however,

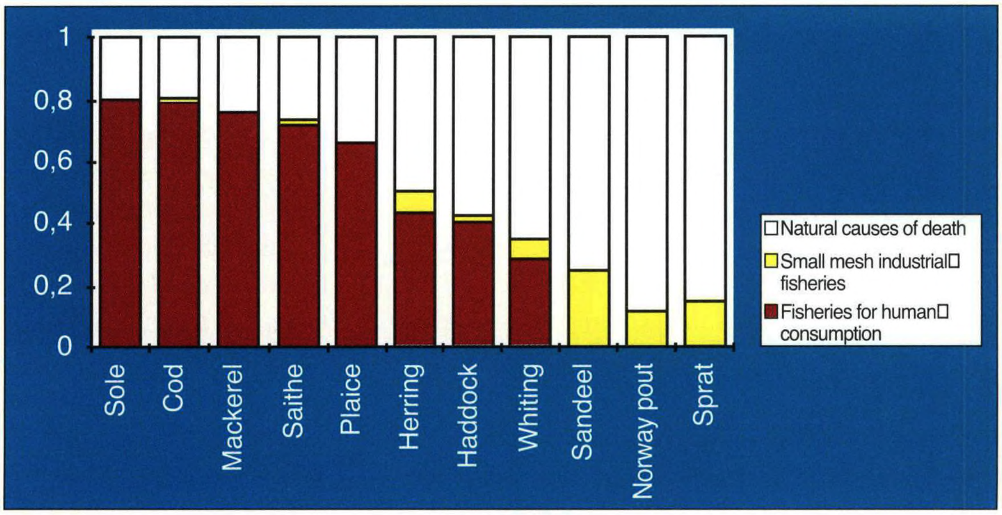


Figure 4.3. Proportion of the yearly production which is harvested by fisheries for human consumption, industrial fisheries and removed by natural causes 1985-1989. (Data from Multispecies Virtual Population Analysis, ICES 1992.)

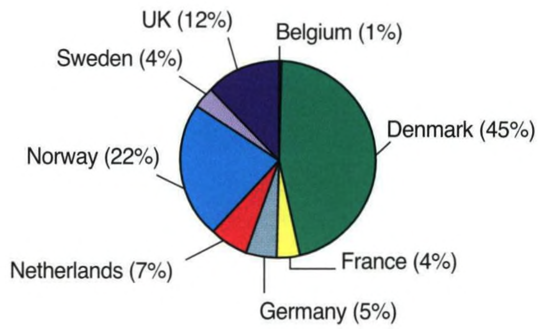


Figure 4.4. Landings of fish and shellfish from the North Sea, Kattegat, Skagerrak and the Channel by North Sea states in 1995. (ICES)

three vessel categories emerged which both increased the total capacity of the fleet and changed the species composition of the fish landings. From the early 1950s a fleet of bottom trawlers started to target small demersal and pelagic species, i.e. sandeel, Norway pout and sprat, which were resources for the fish meal and oil industry. The number and range of these industrial trawlers increased in the following decades and today about half of the fish landings from the North Sea is used for industrial purposes. Also, in the late 1950s and early 1960s a modern fleet of purse seiners started a massive exploitation of North Sea herring and mackerel, and soon became dominant in the pelagic fisheries. The third vessel category which has shown a steady increase in capacity since the 1960s is the beam trawlers targeting flatfish and roundfish, primarily in the southern and central North Sea.

Fishing fleet capacity may be defined as the total tonnage of fish which the fleet engaged in fishing in a given area can catch, provided its resources are unlimited. Fleet capacity varies through time according to the number and hold capacity of different vessel categories, and a number of other factors such as engine power, range and efficiency. Good time-series of data for fleet capacity for the North Sea are difficult to obtain, but some major developments are reasonably clear.

Fishing effort is a measure proportional to the fishing mortality. The effort deployed can be considered as composed of three elements: a capacity element related to the vessel, a capacity element related to the gear, and an activity (utilization) element. It is expressed as:

Deployed fishing effort =
capacity (vessel) x capacity (gear) x activity.

European Community

Since 1983, the European Community has addressed the problem of overcapacity by means of Multi-Annual Guidance Programmes (MAGPs). These programmes set targets for tonnage and power for the fleets of each Member State. The first set of programmes appeared in 1983 and simply tried to arrest the increase in fleet capacity. The later generations of MAGPs ran from 1987 until the end of 1991, setting targets of 3% reduction in tonnage and 2% reduction in power over the whole of the period.

The problem of overcapacity is addressed more firmly in the present generation of programmes, with reductions of 20% for roundfish trawl fisheries, 15% for flatfish and other benthic fisheries using towed gear, and a stabilization for pelagic fisheries and fixed gear. These targets were to be achieved by the end of 1996. Grant aid for decommissioning is available under the regulations. The current generation of MAGPs introduced for the first time the concept of fishing effort, where part of the target could be achieved by a reduction in activity. No Member State submitted a programme to the Commission to this effect. Effort by fishery is, however, controlled under the new regulations concerning access to western waters.

Norway

The Norwegian adaptation of the fleet capacity and fishing effort to the available resources is to a great extent accomplished by administrative measures. These measures include restrictions on the number and size of vessels that may participate in the various fisheries. Furthermore, there are regulations concerning the use of fishing gear, as well as licence- and quota systems.

Since 1950 Norway has introduced different kinds of basic legal instruments in order to limit the fishing effort, such as the following:

Act of 20 April 1951 relating to Fishing with Trawl. All fishing activity which implies the use of trawl, irrespective of the vessel's size, is prohibited unless a special licence is issued by the competent authorities, and the Act of 16 June 1972 relating to the Regulation of the Participation in Fisheries. A licence issued by the fishing authorities is required in advance before purchasing a fishing vessel larger than 50 feet. Specific conditions related to the buyer of a vessel must be fulfilled and there must be an acceptable economic basis for the vessel (*inter alia* fishing licence and quotas).

Fishing licences are issued by the Authorities upon application from the fishermen. A licence does not, however, represent a permanent privilege to participate in specific fisheries, and may be withdrawn. The system in force applies to vessels exceeding a certain size and participating in fisheries for specific species, fishing in specified areas, and to the use of certain fishing gear.

Since 1978 several capacity reduction programmes have been introduced in Norway. About 40% of the permanent capacity reduction resulting from these programmes took place in

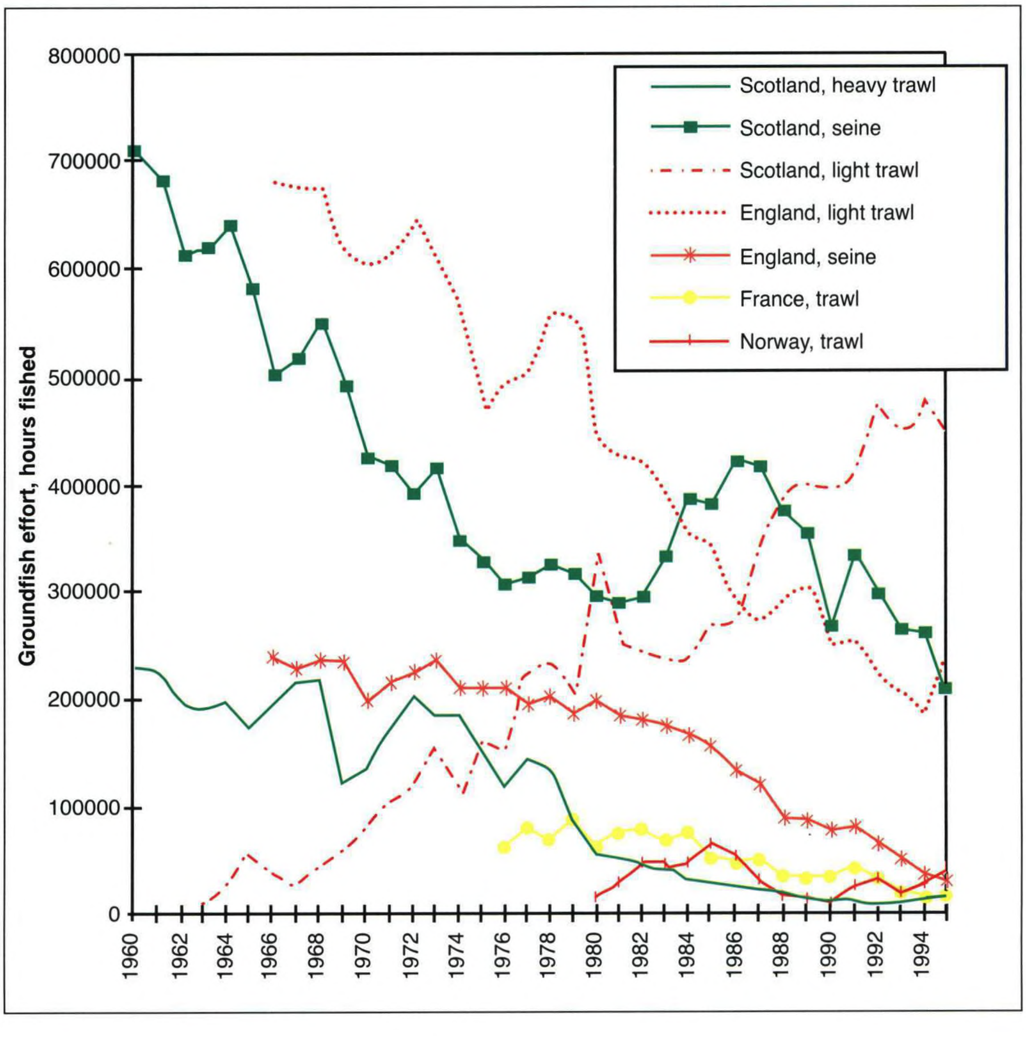


Figure 4.5. Effort of selected groundfish fleets in the North Sea. (ICES 1996.)

the period from 1978 to 1983. The total number of fishing vessels has been reduced from 26 000 in 1986 to 14 500 in 1996. The total reduction in gross tonnage from 1986 to 1994 was 50 000, i.e. from 300 000 gross tonnage to 250 000 gross tonnage.

4.4.1 Fishing Effort and Mortality

Data on fishing effort, i.e. measures of time actually engaged in fishing, are available for a few vessel categories, and some time-series assembled and used by the ICES assessment working groups illustrate trends over the last decades. It should be noted that these data do not represent total effort, only time-trends for selected important vessel categories. The working groups have made attempts to standardize the effort over time as efficiency and reporting procedures changed. The longest time-series, going back to the 1960s, are those for the Scottish and English roundfish trawlers and seiners (Figure 4.5). Except for the Scottish light trawlers, which increased their effort over the last two decades, there has been an almost continuous decrease in effort of the UK roundfish fleets. The effort of French and Norwegian roundfish trawlers has not changed much since the 1970s.

Pronounced changes have occurred in the flatfish fisheries where the general trend in fishing effort since the early 1980s has been a gradual decrease in the traditional trawler effort and an increase in the beam trawler effort. This trend was most pronounced in the UK. The fishing effort of the French trawlers increased, while the UK and Danish seining effort decreased in the same period. Other traditional flatfish fisheries, such as the Danish gillnet fishery did not show clear trends. The relative trends in effort in the North Sea flatfish fisheries is presented in Figure 4.6.

Estimates of the effort in the Danish and Norwegian small-meshed industrial trawl fisheries aimed at sandeel are shown in Figure 4.7. Considerable variation has occurred in the effort directed at sandeel but there are no clear trends. Periodic changes occurred in the geographical distribution of effort, e.g. in the early 1980s the effort was rather low in the north. The changes are related to factors such as the density distribution of the sandeel which seems strongly dependent on recruitment in different areas. The Scottish fishery for sandeel at Shetland started in 1974 and reached a peak in 1982. Since then the landings have decreased dramatically and the fishery was closed from 1991 to 1994.

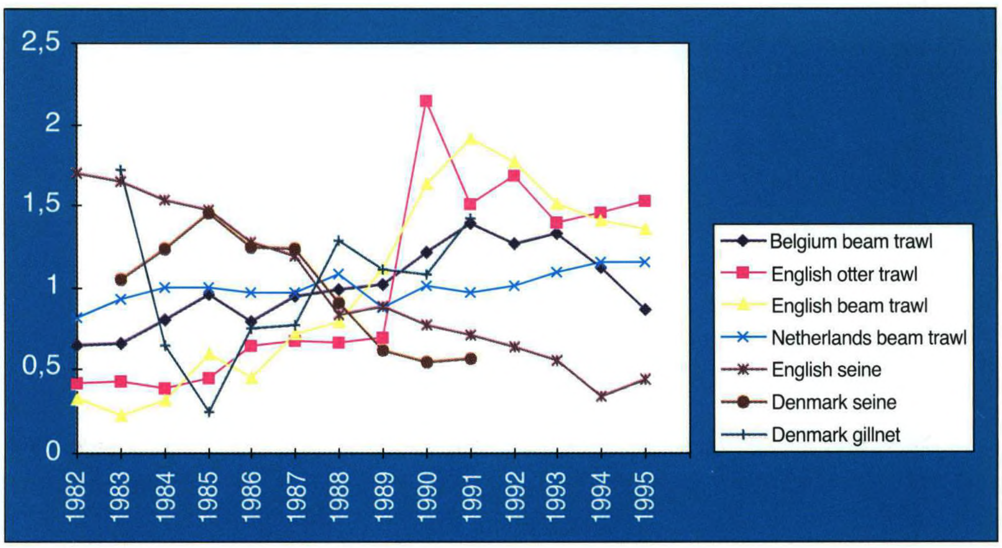


Figure 4.6. Relative trends in effort in the North Sea flatfish fisheries. These estimates are not based upon a harmonized methodology between fleets and are presented only to show trends within each fleet. (ICES 1992, 1996.)

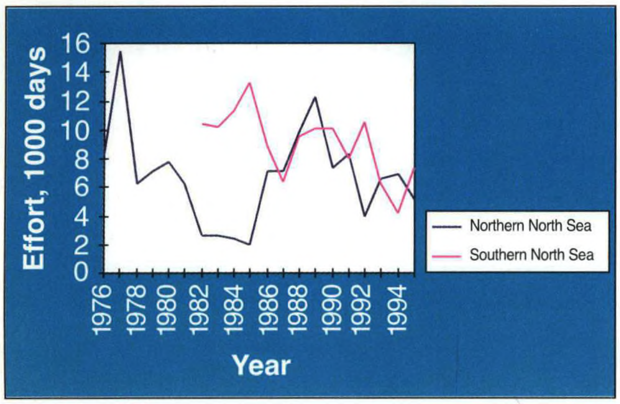


Figure 4.7. Total international effort directed at sandeels in the North Sea. (ICES)

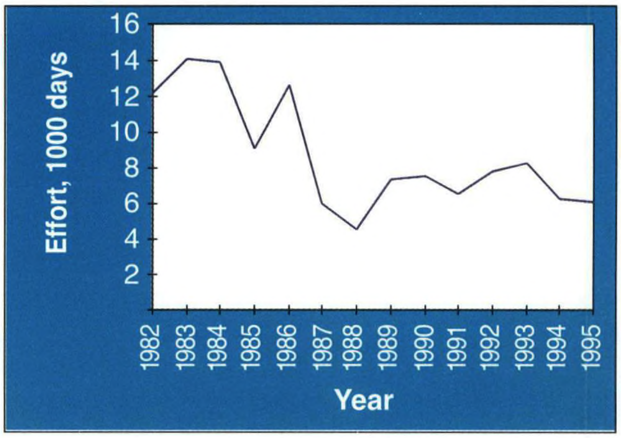


Figure 4.8. Total international effort directed at Norway pout in the North Sea. (ICES 1996)

The effort directed at Norway pout has been considerably lower in the 1990s compared with the first half of the 1980s. The main reason seems to be that the sandeel fishery was relatively poor in the early 1980s and subsequently improved. The fleet normally prefers sandeel to Norway pout and may even within a season direct the effort to either species, depending on prospects. Norway pout effort may also be temporarily reduced when fishing for juvenile blue whiting along the Norwegian Deep is more profitable. The total international effort directed at Norway pout in the North Sea is presented in Figure 4.8.

Consistent data on fishing effort are normally only available for a limited number of years and vessel categories. Longer-term trends in effort on different fish stocks can, however, be illustrated by plotting the instantaneous fishing mortality generated by the varying fishing effort. Figure 4.9 shows the intensity of fisheries as time-series for roundfish (whiting, cod and haddock), flatfish (plaice and sole) and herring.

The fishing mortality for haddock and whiting has been high and fluctuating for most of this century. Since the 1960s there has been a

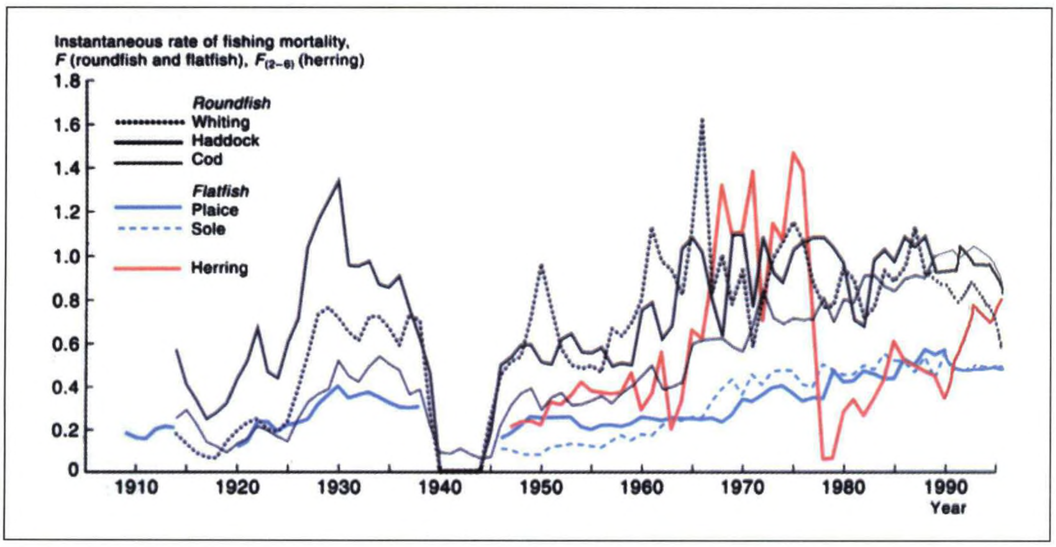


Figure 4.9. Intensity of fishing for North Sea roundfish, flatfish and herring, expressed as the instantaneous rate of fishing mortality of fully exploited age groups (roundfish and flatfish) and the 2-6 year age group (herring). (Figure reproduced from North Sea Quality Status Report 1993 and updated by ICES.)

significant increase in the fishing mortality of cod, and a level comparable to that for haddock and whiting was reached. In the same period, fishing effort on saithe in the northern North Sea increased. All the roundfish stocks showed an increase in recruitment from the 1960s onwards, a phenomenon often referred to as the «gadoid outburst». A gradual decline in the spawning stock and landings started in 1970, but at least for cod the fishing mortality continued to increase and is presently at a very high level, matching that of haddock and whiting.

The fishing mortality for plaice was already high before the war and since the 1960s a steady and steep increase has been observed for both plaice and sole. The increase has been linked to the development of the very efficient southern North Sea twin beam trawl fishery in the 1960s.

The North Sea herring (autumn spawning herring) is exploited by many different fleets, including small-meshed trawlers fishing juvenile herring as a by-catch. The time-series of fishing mortality show the steep increase dating from 1964 when the highly efficient purse seiners joined the fishery. The high level of fishing mortality was maintained until a near collapse in the stock occurred in the mid-1970s. The fishery was closed in the second half of the 1970s and the stock gradually recovered through the early 1980s, when the fishing mortality again rose to 0.4-0.5. ICES has over the years repeatedly stated that a continued exploitation of juvenile herring by the industrial fleets may result in a dangerous depletion in the spawning stock and that significantly higher yields could be obtained by a different exploitation pattern. In 1995-1996, a steep decline in the spawning stock was observed, and drastic cuts in the quotas were agreed in an effort to avoid an imminent collapse.

The purse seine effort directed at mackerel increased sharply in the mid-1960s and the catch reached almost 1 million tonnes in 1967. This fishery targeted the stock of mackerel which spawned in the North Sea. The stock was reduced to a level which is so low that separating the present catches from those of immigrating mackerel belonging to the stock spawning west and south of Ireland is virtually impossible. The North Sea mackerel stock shows no signs of recovery. Present TAC and area closure regulations aim both at protecting juveniles of the western stock and maintaining the chances of recovery of the North Sea stock.

There is a general problem of overcapacity and too high a level of fishing effort in the North Sea fisheries. Despite recent regulatory efforts, the total fleet capacity of the North Sea is still at a level which undoubtedly exceeds the available resources. Some vessel categories may to some extent compensate for this by fishing outside the North Sea for parts of the year, others by becoming more flexible and able to target many different species. The more specialized vessels, or those fishing within limited ranges, may experience major economical problems when resources become limited. One of the main challenges is to reduce the fishing capacity and the deployed fishing effort to a level which balances with the available fish resources in the North Sea.

4.5 The present Management System

4.5.1 Development of the Management Objectives

Before the turn of the century, fish stocks were mostly believed to vary according to natural fluctuations and availability. The effects of fishing were thought to be negligible, and as a consequence few management objectives were established for the fish stocks.

Concern for the effect of fishing on the fish stocks accompanied fisheries development from the beginning of this century. A recognized need for a scientific approach led to the establishment of the International Council for the Exploration of the

Sea (ICES) in 1903. The concern for the state of the resources arose partly from a wish to know whether the North Sea stocks were threatened by the increasing trawl fisheries. The scientists could soon explain some of the fluctuations in the fisheries as natural variations. However, several decades passed before the scientists were in a position to offer adequate answers to the key question of how to regulate a fishery so as to obtain a high and sustainable yield.

After the Second World War, it was soon evident that the rapid increase in fishing effort in itself had a negative effect on various fish stocks. Awareness of this fact motivated management objectives aimed at a sustainable harvest of the fish stocks. Priority was given to establishing minimum mesh sizes and minimum fish landing sizes.

During the last two decades ICES has discussed the best way of providing management advice to fisheries administrators. These discussions were based on the assumption that the fishing industry would be interested in high and stable catches of the more valuable age groups of the fish stock. The open question was which target fishing mortality would provide the best combination of yield-per-recruit, catch-per-unit-effort, and stability of catches. In this context, the concept of Safe Biological Limits (SBL) was introduced to identify those stocks which are at levels at which their productive capacity is impaired or which may become so at current levels of exploitation. For some stocks it has been possible to define a Minimum Biologically Acceptable Level of spawning stock size (MBAL).

It is difficult to establish MBAL for the different fish stocks with a desired degree of precision. Recruitment depends not only on the parent stock but also on a wide range of environmental factors responsible for the recruitment variability. Nevertheless, by examining the historical variation in recruitment at different levels of spawning stock, some idea of the limits within which MBAL may lie can be obtained.

According to the FAO Code of Conduct for Responsible Fisheries the overriding management objective is to ensure long-term sustainable use of fisheries resources. Management objectives can roughly be divided into two groups:

1) Objectives concerned with the sustainability of the stocks and the fisheries, e.g. maintenance of the spawning stock size above a critical minimum size; and

2) Objectives concerned with the maximization of the output from the fisheries, e.g. maximization of yield or socio-economic benefit to society.

There is increasing awareness that these two sets of objectives must be considered as hierarchical; the sustainability of the fisheries must be ensured before objectives concerning output maximization can be pursued. This hierarchy is implicit in the precautionary principle and is also the basis for the biological advice given by the advisory bodies. The fishing mortalities associated with the two sets of objectives can be used as, respectively, limit and target reference points for medium-term management. However, such fishing mortalities are not available for all stocks and therefore reference points cannot be established in such cases.

Although the analytical tools and the necessary data for setting objectives for fisheries management are available, at least in part, there are only a few cases where specific objectives related to stock management have been adopted by the relevant authorities.

4.5.2 Setting TACs

With the exception of the industrial species, most commercially valuable fish stocks in the North Sea, about 40 fish and crustacean stocks altogether, are managed by quotas (Total Allowable Catches (TACs)) established each year on the basis of scientific advice from ICES. It should be noted that ICES does not analyse the state of numerous other, less commercially important species/stocks in the North Sea. An overview of the fish and shellfish stocks in the North Sea currently included in the Report of the ICES Advisory Committee on Fishery Management or managed by TACs and quotas is in Annex III. TACs based on the advice from ICES' Advisory Committee on Fishery Management (ACFM) are set according to three procedures:

1) For stocks existing entirely in waters of the EU, the TACs are decided annually by the Council of Ministers. For each such stock, the TAC is then allocated among Member States according to a previously agreed key;

2) For joint EU - Norwegian stocks TACs are agreed in negotiations under the Joint EU - Norway Fisheries Agreement; and

3) The decision on TACs for stocks occurring only in the waters of Norway is taken by the Ministry of Fisheries.

Within the EU, analytical TACs are set for stocks where scientific knowledge is of such a quality as to predict future (next year's) stock size and development. Precautionary TACs are set by the EU for stocks where such scientific knowledge is inadequate. The levels for these TACs will normally be set according to past catches, such that a primary effect is to curtail unregulated expansion of fisheries.

The TAC system has suffered from enforcement problems of varying magnitude. This is mainly due to the current lack of balance between available resources and fishing capacity, and the ensuing socio-economic pressure generated from the fishermens' perception of the restrictiveness of the TACs and other regulatory measures in force. Such pressure may lead to extensive misreporting of quantity, species or area where the catch is taken. One of many unfortunate effects of this situation is that the quality and reliability of catch statistics has deteriorated.

The misreporting and the unreliability of the catch statistics are causing problems in formulating the advice on TACs, especially in cases where the unreported fraction of the catches are variable from year to year. An ICES working group on catch reporting and catch statistics has been set up to look into this problem. The working group will study how to reduce discrepancies between reported catches and ICES catch statistics, by assessing misreporting, inadequate accounting of discards, by-catches and other factors contributing to the total out-take of the stocks.

All fish stocks respond to environmental variability and interact as either predator or prey, or as competitors for food. Despite such complex interaction, it is not yet possible to manage the North Sea fish stocks beyond simple technical interactions between fisheries. Significant scientific effort is directed towards creating multi-species models that would make such considerations operable. However, the application of reliable multi-species management simulations presupposes extremely accurate scientific stock data.

Although the intention of a TAC is to control fishing mortality directly, the TAC set may not reflect the actual catch from a given stock from the sea. First of all, such a system presupposes a fully reliable control and enforcement system. Furthermore, the existence and extent of discards in various fisheries have unknown consequences, since discards in many fisheries are not accounted for, either by quantities or sizes.

Under the EU - Norway Fisheries Agreement it is agreed to work jointly towards a responsible and sustainable utilization of North Sea fish stocks, and in this respect to convene joint scientific working groups to develop common views in respect of the management of common stocks.

In the context of the quota agreement for 1996, Norway and the EU decided to implement a multi-annual management strategy for herring, mackerel and plaice. The purpose of such a strategy is to take management decisions that will apply over more than one year in the light of the current scientific knowledge of the stocks. This in turn should provide for greater stability of exploitation. The strategy incorporates the objective of successively rebuilding stocks to higher levels, thus increasing current yields.

Both the EU and Norway are concerned about the quantities of young herring taken as by-catch in industrial fisheries directed at species other than herring. These catches are taken in addition to existing agreements on TACs for herring and work against the intention of the TACs to ensure acceptable levels of spawning stock biomass and fishing mortality rate.

Following meetings in 1993 and 1994 in which sampling schemes for industrial by-catches in Norway and the EU were evaluated and described, the EU and Norway met in 1995 to further discuss possible improvements in the management regime for herring. The report from the meeting, SEC(95) 1600/ 27 September 1995, reviews current problems relating to the management of North Sea herring. A main conclusion of the review is the assumption that the most effective way to improve both the exploitation pattern and the overall management of herring catches, particularly by-catches of predominantly juvenile herring, will be achieved by enlarging the scope and application of quantitative measures and by the use of additional monitoring and sampling schemes.

The result of this meeting, in conjunction with further discussions carried out during bilateral consultations, has led to the intention to institute a new management regime for North Sea herring by the start of 1998.

An EU/Norway working group to evaluate the effectiveness of management measures presently in use for demersal stocks in the EU and Norwegian parts of the North Sea was convened in the autumn of 1995. The report, SEC(95) 2159/ 6 December 1995, contains useful and updated information on the state of affairs relating to demersal fisheries in the North Sea. A main conclusion of the report is that the manner in which current fisheries are conducted causes removal of a very high proportion of the stocks annually, resulting in a high dependency on fishing for the younger age-groups, and hence a high dependency on recruitment. In this context it is recognized that quantitative management decisions in the form of TACs must be accompanied by appropriate technical measures that will result in better selectivity in catches to ensure a more rational exploitation pattern.

The use of management measures other than TACs such as minimum mesh sizes, minimum landing size and closed areas is motivated by the objectives to protect the juvenile fish and to safeguard the spawning population.

4.5.3 TACs and Actual Catches

For many fish stocks in the North Sea there are discrepancies between the advice from ICES for TACs or recommended fishing mortality, the agreed TACs and the reported amount of fish landed. For the North Sea herring, this is illustrated in Figure 4.10 showing the relationship between the TACs recommended by ICES and the actual catches. In 1979 and 1980 the landings were close to the recommendation of zero catch, while a small TAC was recommended for 1981. For 1995 the advice was that long-term gains in yield could be achieved by reducing the fishing mortality. In previous years the TACs advised corresponded to a fishing mortality of 0.3.

The discrepancies between the recommended TACs and the actual catches are mainly due to the unregulated fishery for juvenile herring by the industrial fleet, which in 1991 recorded a level of 134 000 tonnes but which has since fallen to a level of 65 000 tonnes in 1995. In addition the agreed TACs of adult herring between Norway and EU for most of the years have been set higher than recommended.

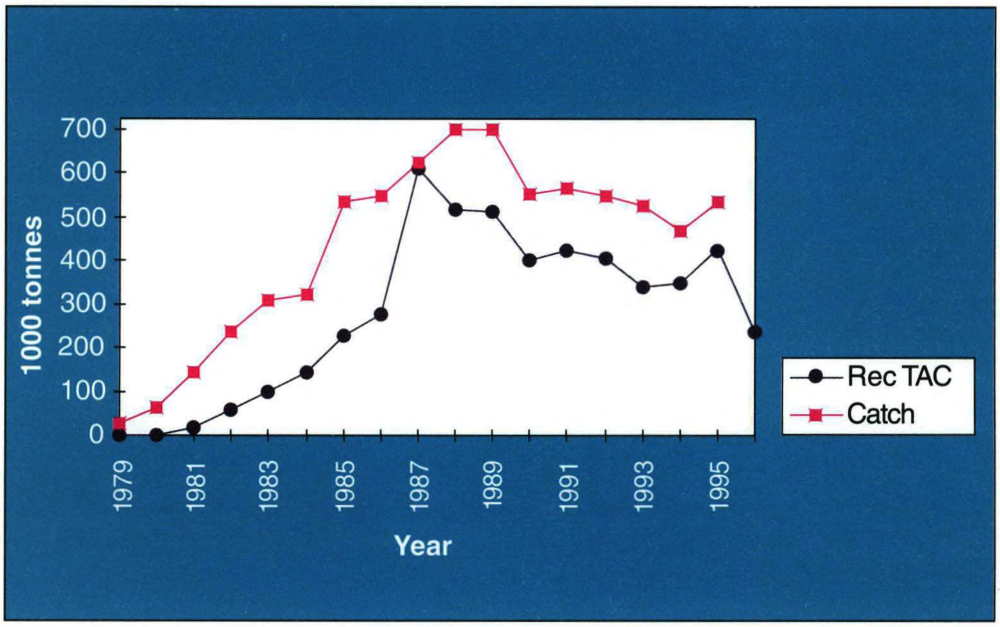


Figure 4.10. Recommended TACs and corresponding catches of North Sea herring. (ICES 1996)

For the North Sea cod stock, however, the situation is different. As seen from Figure 4.11, which shows the recommended TACs, agreed TACs and reported landings, the management seems to have been more or less in accordance with ICES advice in recent years. However, the scientific advice was always related to fishing mortality, and after 1986, when the TACs were relatively low, the actual fishing mortality has always been much higher than the intended fishing mortality (Figure 4.12). The reason for this is that the models used in stock assessment have a tendency to underestimate the fishing mortality for the last year. This in turn is partly caused by misreported and unreported landings and discards. However, the stock size and fishing mortality have to be adjusted in the subsequent year, and as can be seen the intended reduction in fishing mortality was not achieved. The probability of an increase of the estimated fishing mortality for 1995 is high. The recent fishing mortality rates have been close to values which would be expected to result in stock collapse.

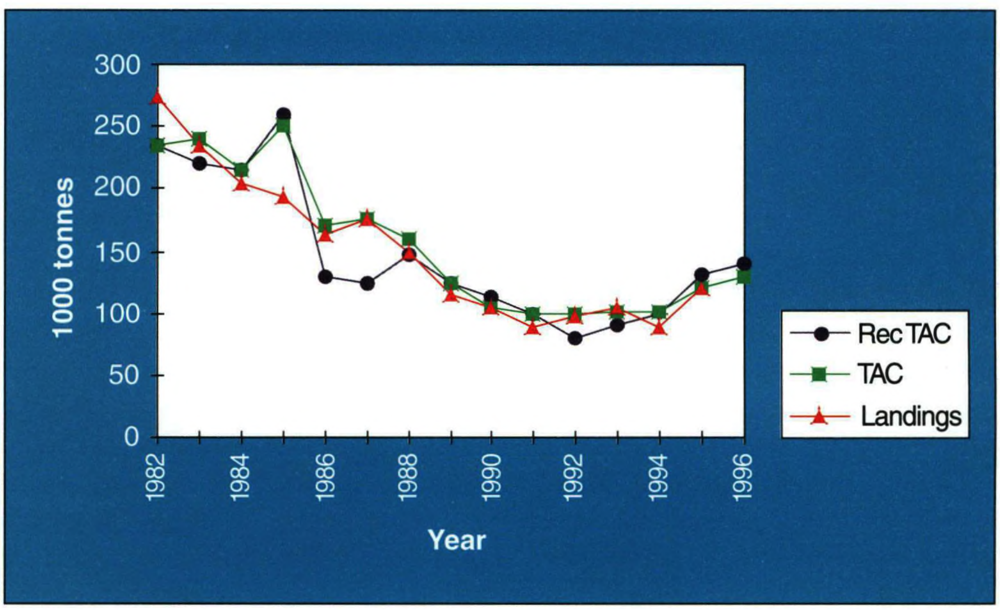


Figure 4.11. Recommended TACs, actual TACs and corresponding landings of North Sea cod. (ICES 1996)

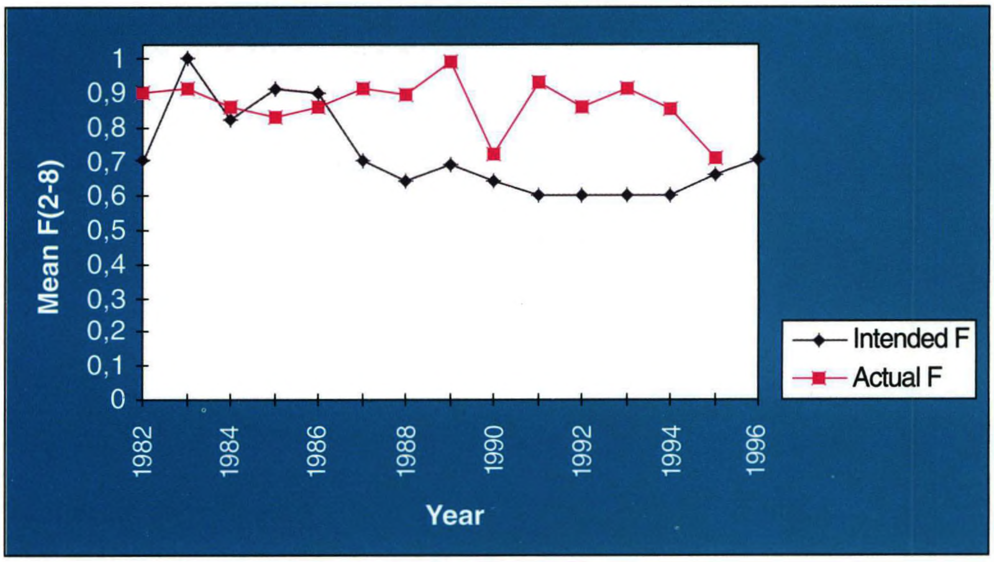


Figure 4.12. Intended fishing mortality and actual fishing mortality for North Sea cod. (ICES 1996)

4.5.4 Control and Enforcement

The fisheries are monitored by a control and enforcement system consisting of both control of landings and catches as well as control at sea.

The basis for the establishment of landings figures in the Member States of EU for species subject to quotas are the logbooks and the landing declarations. Fishing vessels must keep a logbook on a daily basis. Member States may require their fishermen to record non-quota species. The logbook contains estimates of the quantities of each species retained on board (live weight). No later than 48 hours after a landing is completed, the fishermen must complete a landing declaration which must contain the exact weight of the species landed (processed weight). Member States must register all landings of quota species and collect logbook sheets and landing declarations. The methodology employed to organize the processing of these documents and to compile landings figures differs among Member States.

Each Member State verifies compliance of EU Regulations on its territory and in the waters under its jurisdiction. Logbooks are inspected at sea and upon landing, landings declarations are inspected after the landings have been discharged. Cross checks are on the basis of information in logbooks and sales notes for the further marketing. The EU inspectorate monitors the activity of the control authorities, both on land and at sea.

Member States of the European Union must forward a catch report on a monthly basis no later than 15 days after the end of the month concerned (this is, on average, one month after the catches took place). This report consists of two parts. Part A gives the details of the Member State's own catches expressed in terms of «landings» (except landings in other Member States), «transhipments» and «catches not landed or transhipped». Part B gives the details of the landings of vessels of other Member States in the territory of the reporting Member State.

After compilation of the catch reports, the European Commission obtains a consolidated view of the uptake of the quotas by each Member State. Catch reporting to the European Commission is the corner stone for the short-term management of the annual TACs and quotas. Registration of catches, landings and transhipments and reporting thereof are defined in the «Control 3 Regulation» (Regulation 2748/93). Basically there is no provision for the construction of statistical time-series.

There are three bodies responsible for the enforcement of Norwegian legislation, i.e. Directorate of Fisheries, the Coast Guard and the Sales Organizations.

According to the Sea Fishery Act, the Directorate of Fisheries shall ensure that the provisions laid down in that Act are observed, giving the Directorate of Fisheries responsibility for carrying out control. The control is conducted by the Directorate of Fisheries' supervisors, a Surveillance Programme and the Directorate's special departments.

The Directorate of Fisheries has assigned to the Control Authority the responsibility of ensuring that Norwegian fishermen and first-hand buyers comply with existing regulations. The Control Authority is one of two operative service branches («outer departments») under the Directorate of Fisheries and is organized in five regions under Supervision District Leaders.

The regional offices have a total of 91 appointed inspectors who are stationed in main fishing harbours along the entire coast. The inspectors, when carrying out their duties, shall be given free access to vessels, processing plants, consignments in transit, storage buildings and harbour areas and be given all necessary assistance and information on documents, logbooks, etc. Vessels may be stopped for inspection and the Directorate of Fisheries may, if necessary, request police assistance to carry out controls.

In order to conduct control of foreign vessels fishing in the Norwegian economic zone, the Directorate of Fisheries established a computer-based quota control system in 1977. Vessels fishing in areas under Norwegian jurisdiction must report catches on a weekly basis to the Directorate of Fisheries, including reports on entry to and exit from the fishing zone. Declarations shall include quantities of species in kilograms (live weight).

The Norwegian Coast Guard's surveillance activities comprise various types of controls. Particularly important tasks are control of minimum sizes of fish, by-catches and mesh-sizes, logbooks, catch onboard, as well as the supervision of closed areas and in periods during the year when fisheries are closed. Officers of the Coast Guard have police authority when enforcing fisheries regulations.

The Sea Fishery Act contains provisions under which the Sales Organizations may be given responsibility for control of fishery legislation. This will mainly concern control of landed quantities and quotas.

Regarding enforcement, the Sales Organizations shall make provisions for the confiscation of the value of catches exceeding a vessel's quota. The Sales Organizations may also in accordance with provisions of the «Raw» Fish Act, take administrative measures against infringements.

As mentioned, an ICES working group on catch reporting and catch statistics has been set up to look into the problem of misreporting and the resulting unreliability of catch statistics. The working group will study how to reduce discrepancies between reported catches and ICES catch statistics, by assessing misreporting, inadequate accounting of discards, by-catches and other factors contributing to the total catches from the stocks.

According to reports by the Commission on the monitoring of the common fisheries policies in the EU Member States, the controlling and monitoring of their national fleets and of third countries vessels including in the North Sea, is not good enough.

The proportion of catches of small pelagic species not declared is considerable. One of the biggest problems is misreporting of species (confusion of mackerel and horse mackerel, herring and sprat) or catch zone. The problem of discards used to be negligible when set against the volume of pelagic catches but it is growing and – a serious development – is centring on specific fisheries where on-board sorting results in retention of only a fraction of the catch, e.g. herring fisheries targeted on the sale of roes.

It is recognized that the present control systems for North Sea fisheries do not prevent underreporting from some fisheries. In particular for roundfish fisheries, underreporting is acute and the problem is becoming worse.

4.5.5 Technical Measures

The catches of juveniles and the by-catch both of fish and of other species are two of the major problems in North Sea fisheries. Therefore, understanding and improving the selectivity of fishing gear has been an active topic of research. The processes of capture by mobile and static gear are now reasonably well understood and this knowledge has been applied to the development of a number of methods for improving the size or species selectivity of fishing gear. Given the difference in shape and behaviour of the many species of roundfish, flatfish and crustacea taken by commercial fisheries, the approach to improving catch selectivity has to be appropriate for each species and fishing method.

Various techniques for improving the selectivity of fishing gear have been developed and tested by a number of institutes and the findings have been widely publicized in scientific reports, in the trade press and in video-films. Members of the European fishing industries are generally well aware of these techniques.

Voluntary adoption of these techniques by the fishing industry has been limited, as it is rarely possible to selectively release small fish under the minimum permitted landing sizes or unwanted species without losing some marketable fish. This presents the individual fisherman with an immediate personal economic loss for the possible future benefit of all in a common access fishery, so there is little enthusiasm for voluntary use of selective gear. At present, regulations are in force to require the use of selective nets but there is evidence that nets can be adjusted at sea to reduce selectivity.

Size Selectivity

Size selection in towed nets is improved by widening the openings through which fish can escape, usually the meshes of the codend where the catch accumulates. Grids can also be used for size selection when sited in an escape route, but these have received only limited testing in the North Sea. Size selection in dredges used for bivalves is improved by increasing the spacing of the teeth which dig into the sea bed and by increasing the diameter of the rings and/or mesh size of the netting used in the bag.

The predominant means of improving selectivity enacted by the European Union has been to increase mesh size in towed nets (trawls, Danish seines etc.) and, recently, to define minimum mesh sizes for static gear (gillnets, trammel nets and tangle nets). In recent years, additional methods have been developed for improving selectivity, notably square-meshed panels, separator trawls and sorting grids.

At present, Community regulations regarding selectivity mainly concentrate on definition of minimum mesh sizes. However, in certain cases, reference is also made to voluntary use of square-mesh netting, voluntary use of separator trawls and some aspects of the geometry of towed fishing gear. Community regulation 3094/86 (the technical measures regulation) specifies minimum mesh sizes to be used when fishing for defined target species.

In the trawl fishery for Norway lobster, encouraging results have been achieved in improving size selectivity of the target species by using a solid grid in front of the codend. The selectivity result obtained with such a device is superior to that of a standard diamond mesh codend. The device has not been introduced in the commercial fishery yet. In the trawl fishery for deep sea shrimp in the Norwegian Trench and in Skagerrak, the selective grid device is used voluntarily on many Norwegian trawlers. The shrimp grid is often used in combination with a large mesh codend, which catches larger fish escaping through a fish outlet in front of the grid.

Species Selectivity

The avoidance of the capture of non-target species has been the driving force for the development of gear that can limit these catches.

Separation of species of fish and crustacea has been achieved to some extent in mobile gear by the use of separator trawls with internal horizontal dividing panels; by rigid grids (or gratings) set at an angle to the water flow; by escape panels set in the top and sides of nets and codends; and by the inclusion of veil nets in shrimp beam trawls. For shrimp fisheries several measures are established for the use of sorting mechanisms in order to prevent larger organisms from entering the nets. In the trawl fishery for deep sea shrimp in the Norwegian Trench and in Skagerrak, the selective grid device referred to above, is also effective in species separation. Separation is most readily achieved when the species to be separated differ widely in form and behaviour, e.g. separation of shrimp and roundfish by a rigid grid. Veil nets are required by some countries in the North Sea shrimp fisheries and the UK requires the use of square mesh escape panels in Nephrops trawls.

Recent research has demonstrated that providing escape routes for unwanted species is not in itself enough to ensure that they pass out of a fishing gear. It is necessary to construct the gear so as to provide a stimulus to escape, otherwise escape rates tend to be low. The escape route must be made to appear safer than remaining within the gear. This is achieved in shallow water by the use of netting and other components of high visual contrast. It is also necessary to ensure that the net is structured such that the water flow pattern does not inhibit escape.

Gear modified to reduce by-catch of marine mammals is as yet not applied in the North Sea fisheries. The creation of escape gaps between set nets to provide obvious bypass routes has been investigated and found to be effective at times. If relatively short nets are used and checked regularly whilst fishing, the by-catch of mammals can be reduced. There is some evidence that active and passive sonic devices make pelagic (and demersal) set nets more readily detectable by mammals and therefore reduce the mammal by-catch. Experiments with such sonic devices are carried out in some North Sea states.

Community regulation 2847/93 (the control regulation) specifies the means by which mesh sizes and associated percentages of target and by-catch species are to be controlled.

4.5.6 Closed Areas

The aim of closed areas is to protect juvenile fish and spawning adult fish by limiting fishing activities in certain areas and seasons.

Closed areas are important elements in the EU Community regulation 3094/86 laying down certain technical measures for the conservation of fishery resources.

Within European Community legislation a number of areas are defined within which fishing activities are limited. The limitations may be defined as lasting for the whole year or for only part of the year. All closed areas for the conservation of fish stocks established in Community regulations are firmly based on scientific advice. Various fishing activities potentially directed at certain age groups of certain species are restricted or prohibited within these areas, where these can be justified and are beneficial. The European Commission believes, therefore, that the establishment of closed areas is an important tool for the conservation of fish stocks. Examples of closed areas are the plaice box in the southeastern North Sea and the Norway pout box.

The application of closed areas is also an important element in fisheries management in Norway. In Norway, trawling (except trawling for shrimps and Norway lobster) is prohibited within 4 nautical miles off the coast. Another type of closure applied in the Norwegian fisheries management is the protection of spawning grounds for Norwegian spring spawning herring.

In the UK a system of 34 nursery areas has been designated for the protection of juvenile bass under national legislation. Both in UK and Sweden, closed areas for salmon and sea trout species have also been designated, with regulations implying a total or partial prohibition on fishing in defined areas for specific time periods.

Molluscan shellfish fisheries are subject to a variety of national regulations and in the Wadden Sea and the Oosterschelde as far as the Voordelta, considerable parts of the tidal and sub-tidal areas are closed to mussel and cockle fisheries.

4.6 Socio-economic Aspects

While statistics on the fisheries in the North Sea are quite good in terms of catches, fishing area and time spent fishing, economic data are more limited. There are data on prices and production of different sub-sectors of the fishing sector[2] and, before the open market in EEZ, also reasonable foreign trade statistics. The statistics often lack mutual common reference correspondence. It is for example not possible to find the production value of the final fish products from the North Sea fisheries, or the distribution of the economic benefits and costs from this economic activity. Both the value of landings from the North Sea and also the production value of the fish processing industry are available, but these figures also include imports and catches from other fishing areas. The purpose of this chapter is first of all to describe some of the economics related to the North Sea fisheries. Some additional aspects which might be included in a more comprehensive economic analysis of the North Sea fisheries will also be discussed, e.g. the external benefits and cost of fishing, and the cost of management.

Employment and income are considered as the major socio-economic indicators. Income formation is the basis of consumption and savings, and also a very important source of tax revenues. There is not necessarily a proportional connection between income generation and employment. If an industry is characterized by a high capital/labour ratio, a large part of the income goes to capital, leading to a low employment effect, while a low capital/labour ratio gives – all things being equal – a higher employment effect. The human consumption fishery and processing industries are, for example, more labour intensive than the fish meal industry. A factor which is often overlooked is the effect on balance of payment, which in the case of fisheries is positive, because the importshare of the total costs is relatively low and the exportshare of the final production is relatively high.

The generation of income and employment not only happens in the fishery sector itself, there are also important indirect and derived effects on sectors other than the fishery sector, such as backward linkages and forward linkages. Backward linkages refer to the inputs from other sectors to the fishery sector, such as repair and construction of ships, technical service and equipment. Forward linkages refer to sectors which process the fish and/or put it on the market, such as the fish processing industry, transportation, sales and marketing. All these directly related activities result in derived income and employment effects (the multiplier effect) in other industries. By adding all these effects, it is possible to estimate the total employment and income effects of fishery.

A careful statistical survey of employment and income effects would require a detailed study of the cost structure of the fishing sector and directly related sectors. However, it is only possible to give some indication of the order of magnitude based on the information provided.

4.6.1 Quantity and Value of Landings

The calculations are based on a total reported catch in 1995 from the North Sea area of

[2] Fishing sector refers to both the primary fishery sector and the fish processing sector.

1 657 732 tonnes for human consumption and 1 755 603 tonnes for industrial purpose (see Table 4.1). While the quantities for the two different uses are more or less equal, the total landing value (i.e. the quay price) is very different, reflecting the different unit prices.

Table 4.1. Total quantity and value of landings from the North Sea area for 1995. (Danish Institute of Fisheries Economics Research 1997.)

	Quantity in tonnes			Value in mill ECU		
	Total landings	Landings for human consumption	Landings for meal/oil**	Total landings	Landings for human consumption	Landings for meal/oil**
Belgium*	23 328	23 328	0	47.0	47.0	0.0
Denmark	1 654 676	374 426	1 280 250	311.9	216.7	95.2
Norway	869 873	431 639	438 234	197.2	162.1	35.2
Sweden	114 000	89 049	24 951	48.0	45.5	2.5
The Netherlands	271 758	271 758	0	396.9	396.9	0.0
UK*	479 700	467 532	12 168	415.8	414.5	1.3
Total	3 413 335	1 657 732	1 755 603	1 416.8	1 282.6	134.1

Notes:

* Live weight.

** Sandeel, sprat, blue whiting and Norway pout.

4.6.2 Employment Effects

Based on the information provided, the employment originating from the North Sea area in the fishery sector and in the fish processing and meal/oil industry is calculated and presented in Table 4.2.

Table 4.2. Employment in the fishing sector originating from the North Sea area as man-years for 1995. (Danish Institute of Fisheries Economics Research 1997.)

	Fishermen	Processing		Total
		Human consumption	Meal/oil	
Belgium	488	916	0	1 404
Denmark	2 199	4 807	361	7 367
Norway	5 065	6 658 *	96	11 819
Sweden	1 346	1 570	13	2 929
The Netherlands	2 575	5 211	0	7 786
UK	10 388	10 963 **	-	21 352
Total	22 061	30 125	470	52 657

Notes:

* Not available («guesstimate»).

** Total for human consumption and meal/oil (1993).

The direct employment in the fishery is 22 061 fishermen (man-years). The effect of the fishery on the processing sector is a total employment of 30 595. The fishing and processing activities have indirect effects on other sectors, or require inputs from other sectors. An analysis of these indirect effects is beyond the scope of this section, but other analysis have shown that these effects can be quite large, as much as 50% of the employment in the fishery and processing sector. To this can be added the derived effect stemming from the formation of income in the fishery, processing and connected sectors, as this income is spent in other sectors. A «guesstimate» of this multiplier effect is 1.3-1.5. A rough estimate of the total employment effect of the fisheries in the North Sea area could therefore be about 100 000-120 000 persons (man-years).

4.6.3 Income Effects

The income effects can be assessed by calculating the share of value added (income) of the production value of the final output. The share of value added of 1 ECU production value of the final output is on average about 0.5-0.6 and 0.7-0.75 for the catches and production of human consumption and industrial species, respectively. The production value of the industrial catches is about 420 million ECU and the production value of the human consumption catches is about 6 250 million ECU. Based on these estimates it is possible to calculate the direct and indirect income effects of the fisheries.

The value added (income) in the fisheries is therefore multiplied about four times through the whole production process assuming a direct income share in the fisheries of about 60% of the landing value[3]. To this can be added the derived effect, given a total income effect between 4 445 and 6 098 million ECU.

Interpretation of the Effects

The purpose of this analysis has been to show the economic size of the North Sea fisheries and the extent of employment and income dependent on the fisheries, not to measure the economic value of the fisheries. The impact analysis does not show anything about the economic value, i.e. net economic benefit of the fisheries to the nations around the North Sea as a whole, unless it is assumed that the factors used in the fisheries (i.e. capital and labour) do not have any alternative value. The general fleet overcapacity may not be considered as a cost, which is fair if the fleets consist of vessels without any alternative value. For many fleets in the North Sea this is actually the case and this is one of the explanations – probably the single most important – for the slow adjustment in the fishing fleet to the resource situation.

In practice the socio-economic issues of income and employment, together with concerns of biological yield and conservation play a larger role than economic value (i.e. efficiency), particularly since many fisheries may serve for small local communities. In addition, the total economic value of North Sea fisheries is small in comparison to the total economy. Losses in economic efficiency for employment gains seems to be the *de facto* policy of the North Sea nations.

Table 4.3. Income effects of the fisheries in the North Sea area 1995. (Danish Institute of Fisheries Economics Research 1997.)

	Production value (mill ECU)	Income share	Income effect (mill ECU)
Human consumption	6 250	0.50 - 0.60	3 125 - 3 750
Industrial	420	0.70 - 0.75	294 - 315
Total	6 670		3 419 - 4 065

[3] An income share at 60% of the landing value, 1 416.8 mill ECU gives a value added at 850 mill ECU (1995).

4.6.4 Regional Aspects

The employment and income effects are small on a national level, but as shown there are considerable backward and forward effects from the fishing industry, which means that changes in the conditions in the fishing industry will have a kind of domino effect on other industries – both on directly related industries and on other industries in general – located in the same region. Fishing communities are often located in regions characterized by an isolated economic structure.

The industry structure is often very weak. The labour market is more or less isolated and there is often a lack of alternative employment possibilities in sectors other than fishery related sectors. The fisheries may serve as the only viable option for employment for residents of small local communities. The fishing industry is in many regions the sector which gives the region more or less autonomy in its economic life.

4.6.5 Cost of Management

So far this contribution has concentrated on some of the positive socio-economic effects of the fisheries. Another issue is the impact from the regulation of fisheries. The purpose of regulation is often to generate income and employment while at the same time maintaining the fish stock. However, the regulation can also have negative effects which often are ignored. It is believed that the way the regulation is conducted in general, puts pressure on the individual fishermen to keep the balance between making a living from the fishery and at the same time obeying the regulation. An outcome where the two objectives are in conflict is, for example, the discard and illegal landings, which in some fisheries are substantial. This kind of regulation requires a lot of enforcement and control resources as well as resources from the legal sector (and from the fishermen themselves), which all together can be said to be some of the socio-economic costs of the fishery politics. The estimated cost of management, research and enforcement of the fisheries[4] is shown in Table 4.4, based on information provided by each government.

Table 4.4. Total employment and budget (mill ECU) for fisheries management, resource research and enforcement in the North Sea area for 1995 (not including data from France and Germany). (Danish Institute of Fisheries Economics Research 1997.)

	Employment	Mill ECU
Ministry	1 074	91 816
Research	954	78 663
Enforcement	1 613	122 890
Total	3 641	293 369

The figures do not include cost of ICES and the European Commission. Since some of the enforcement lies outside the Ministry of Fisheries these costs are not included either.

The expenses of management, research and enforcement are equivalent to about 15-20% of the employment and 7-9% of the total income-formation in the sector (see Table 4.2 and 4.3). The lower income share is due to the fact that the fishery is a capital intensive sector.

4.6.6 Non-market Considerations

There are other, non-market, values related to the use or non-use of the fish resource from the North Sea. An external cost or benefit is said to exist if the actions of one group adversely or beneficially affect other groups without the mediation of a market. Such interaction could exist between different groups of fishermen or between fishermen and other groups in society. Examples of interactions between fishermen are the discard of by-catch which leaves fewer fish to other fishermen, and the different fishing technology effects on the ecosystems and hence production of other species. Examples of interactions between fishermen and other groups in society are losses to recreational

4 Cost of management etc. has to be deducted from the consumer and producer surplus to get the net-benefit of the fisheries to the nations involved.

fisheries and impacts on marine life and tourism.

There are other categories of economic values that may be affected by the fisheries in the North Sea. These include non-consumption use (e.g. on-site observation of the species), indirect use (e.g. viewing programmes featuring these species), ecological value (importance in the food chain), preservation value (preservation of the species for their own good), and bequest value (preservation of the species for use by other generations).

In principle all these values have to be assessed in a comprehensive economic costbenefit analysis of the fisheries.

From the point of view of nutrition, fish is an important source of food particularly as regards protein. There is no doubt about direct links between diet and health and in this respect, food from the sea is extremely important. Fish contains all amino acids in the proportions the body needs for growth and repair of body tissues. Omega-3 fatty acids protect against cardiovascular diseases. They are also necessary for foetal and infant development. Fish and seafood have a high content of a number of B vitamins. Oil-rich fish are an important source of fat-soluble vitamins A, D and E. Seafood also gives a well balanced intake of a number of minerals.

5

Present Environmental Management

5.1 Summary and Issues of Concern

The reduction of pollution has so far been the main issue in the environmental management of the North Sea. Over the last decade there has been an increasing awareness that the impacts of other human activities on the North Sea ecosystems are also very important and it is recognized that the combined effects could be detrimental.

The term biological diversity means the variability among living organisms and the ecological complexes of which they are parts; this includes diversity within species, between species and of ecosystems. The conservation of biological diversity in the North Sea is dependent on the specific protection of species and habitats. Presently there are no protected offshore areas.

The management of species and habitats outside protected areas is an important challenge in the total management of the North Sea, as it includes the major part of both habitats and species. Environmental impact assessment and development planning is also management measures applied with the aim of the protection of species and habitats.

Issues of Concern

The following issues of concern have been identified:

- Lack of ecosystem approach in the management of the North Sea;
- Lack of knowledge on species and habitats in offshore areas as a basis for management measures to conserve the biodiversity in the North Sea; and
- Lack of knowledge concerning the need for protected areas in the North Sea.

5.2 Introduction

As mentioned in Chapter 2 the growing concern in the early 1980s among North Sea states that the large inputs of various harmful substances could cause adverse effects on the North Sea ecosystems, led to the First International Conference on the Protection of the North Sea in Bremen 1984. At that time, emphasis was put on pollution from different sources. Only later were other issues such as the impact of human activities in general included as important elements of the North Sea environmental management.

This chapter describes the international environmental management bodies for the North Sea, the important concept of biological diversity and the use of protected areas as one management tool for protection of diversity.

5.3 Environmental Management Bodies and Conventions

There are two regional bodies in the field of environmental management acting in the North Sea area, The European Union that covers most of the North Sea and the OSPAR Convention (the Convention for the Protection of the Marine Environment of the northeast Atlantic) that covers the whole North Sea area. Both bodies are acting through the implementation of legally binding instruments, in particular geared at reduction of pollution. The member states and contracting parties are, however, able to introduce stricter regulations on a national basis.

The Convention has been signed by all states bordering the North Sea in addition to the Commission of the European Communities, Finland, Iceland, Ireland, Portugal, Spain, Luxembourg and Switzerland. The OSPAR Convention will enter into force when it has been ratified by all of the Contracting Parties to the present Oslo or Paris Conventions. It will then replace the Oslo and Paris Conventions but decisions, recommendations and all other agreements adopted under the present conventions will continue to apply.

In relation to species and habitats, a new Annex to the Convention has been developed to be adopted by a ministerial meeting in 1997. At present the OSPAR Convention organizes monitoring and assessment of species and habitats through the Joint Assessment and Monitoring Programme.

In addition, some of the species found in the North Sea have been given special protection through global or regional conventions like the Bern-, Bonn- and Washington Conventions.

To implement relevant conventions and to achieve other environmental objectives, the

North Sea states and European Community have adopted environmental measures to protect the marine environment and its species and habitats. These measures are generally based on the precautionary principle, although this principle is not yet fully implemented in all areas. On the one hand, control of direct and indirect inputs of pollutants to the marine environment has been established in conjunction with specific quality objectives, and on the other, specific measures have been designed to protect species and habitats in designated areas.

5.4 Pollution

Measures to reduce pollution of the North Sea have been in effect since the 1970s. Inputs of dangerous substances are controlled through European Community and national legislation requiring limitation of discharges of dangerous substances, as well as through restrictions or prohibitions on the use of certain dangerous substances in products where there is a risk that these substances may reach and endanger the marine environment. Furthermore, North Sea state legislations and regulations and European Community legislation establish specific controls on *inter alia* the inputs of pollution from urban waste water treatment plants, agriculture in the form of nitrate, from industry and from indirect inputs of nitrates originating from the exhausts from motor vehicles and from the agricultural use of pesticides. European Community legislation regulating direct and indirect inputs of pollutants to the marine environment also applies in the wider European Economic Area.

At each Ministerial Conference on the Protection of the North Sea, Ministers have made commitments to take certain measures aimed at protecting and enhancing the environment of the North Sea. These have included far-reaching undertakings to reduce aqueous discharges and atmospheric emissions of substances that are toxic, persistent and liable to bioaccumulate; to phase out certain substances and practices in the North Sea; to base their actions on agreed principles, notably the «precautionary principle»; to apply control over industry and other activities by requiring best available technology and best environmental practice; to take measures to enhance habitats and species protection in the North Sea and its coastal regions; and to enhance scientific knowledge.

The effects of pollution on marine species in the North Sea is described in Chapter 7.

5.5 Protected Areas

The North Sea and its adjoining coastal regions contain some of the richest wildlife habitats in the world. The purpose of protected areas (*inter alia* national parks) is the protection of the specific characteristics of these areas, in particular, flora and fauna. It is also important that all natural processes are allowed to act as undisturbed as possible. Protected areas therefore normally imply restrictions on aggregate extraction, dredging and infilling, and in some cases, on demersal trawling and aquaculture.

In European Community nature conservation legislation, there are two relevant protection categories, both of which contribute to the «Natura 2000» ecological network in the European Union:

1) Under Directive 79/409/EEC on the conservation of wild birds, Member States classify Special Protection Areas (SPA's) for the protection of habitats of endangered and migratory bird species. Most of the EU North Sea states have coastal/marine SPA's within their territorial waters; and

2) Under Directive 92/43/EEC on the conservation of natural habitats and wild fauna and flora, Member States were required to propose, by June 1995, a national list

including coastal and marine sites within their territorial waters for the protection of listed species (other than birds) and habitats of EU interest. However, to date and with reference to the North Sea, only partial national lists have been provided by Denmark and UK. Belgium has proposed a list of sites to be included in the «Natura 2000» network, one of them being entirely marine.

Within the OSPAR framework the Netherlands recently collected information on habitats and species protection. One of the conclusions from the resulting report was that bias exists towards the protection of coastal and inshore marine areas, while offshore areas are at present not protected. There is, however, limited knowledge on which offshore species and habitats should be given priority with a view to their protection.

The impacts on the North Sea other than those caused by pollution, such as the impact of fisheries on habitats and associated species, are at present on the agenda, but limited knowledge on the actual long-term effects of fisheries on the North Sea ecosystems exists. At the Fourth International Conference on the Protection of the North Sea the European Commission in co-operation with the relevant Norwegian authorities was invited to consider a proposal before 1997 for the choice of location and the establishment of undisturbed areas in the North Sea.

5.6 Planning and Development Controls

Several measures are taken to control man's activities (other than fisheries) in order to minimize or limit impact on the environment. The European Union's Directive on Environmental Impact Assessment requires that specified new development and activities are assessed for their impacts on the environment and where possible such impacts should be reduced or mitigated. Planning regulatory authorities also take account of such assessments when reaching their decisions.

5.7 Biological Diversity (Biodiversity)

An important basis for environmental management is the Convention on Biological Diversity (CBD) that was signed in June 1992 and entered into force in November 1993. The Convention is a global and legally binding instrument. The highest decisionmaking body is the Conference of the Parties (COP) assisted by a subsidiary body on scientific, technical and technological advice (SBSTTA).

The objectives of the Convention on Biological Diversity signed in 1992 in Rio are «the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources....».

According to the Convention biological diversity means «the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic systems and the ecological complexes of which they are parts; this includes diversity within species, between species and of ecosystems».

In the context of the Convention, sustainable use is «the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet needs and aspiration of present and future generations».

As one of their duties, the parties to the Convention shall «identify processes and categories of activities which have or are likely to have adverse impacts on the conservation and sustainable use of biological diversity, and monitor their effects through sampling and other techniques».

One important consequence of these obligations is that biological criteria must be given more weight in management policy in all areas, with implications for the status of ecosystems, species and habitats. In fisheries, this implies that natural fish resources should be properly and sustainably utilized and with as little adverse effect on biodiversity as possible. The effects of harvesting, both on the target species and on other parts of the ecosystem, must be monitored, and remedial action taken where serious negative consequences are found.

No quantitative guidance is given in the text of the Convention as to the degree of reduction in biodiversity nor level of utilization other than that it should be sustainable. However, Chapter 17 of the Rio Agenda refers to MSY (Maximum Sustainable Yield) as an objective.

At its second session in Jakarta in 1995, the Conference of the Parties adopted a decision on Conservation and Sustainable Use of Marine and Coastal Biological Diversity (Decision COP II/10) called the Jakarta Mandate. The Mandate recommends action in the following five areas:

1) Integrated marine and coastal area management:
   Current sectoral approaches to the management of marine and coastal resources have generally not proven capable of conserving marine and coastal biological diversity. New models are needed to move managers toward multiple-use, system-oriented modes of management, based on the precautionary approach and ecosystem management principles. Crucial components of integrated marine and coastal area management are relevant sectoral activities, such as construction and mining in coastal areas, mariculture, tourism, recreation, fishing practices and land-based activities, including watershed management. Parties should, where appropriate and practical, prevent physical alteration, destruction and degradation of vital habitats and pursue restoration of degraded habitats, including spawning and nursery areas of stocks of living marine resources and minimize or eliminate inputs of pollutants (including persistent organic and radioactive substances and excess of nutrients).

2) Marine and coastal protected areas:
   Protection of critical habitats for living marine resources should be an important criterion for the selection of marine and coastal protected areas, within the framework of integrated marine and coastal area management. Conservation measures should emphasize the protection of ecosystem functioning in addition to protecting specific stocks.

3) Sustainable use of coastal and marine living resources:
   The COP supports the implementation of the FAO Code of Conduct for Responsible Fisheries and the Agreement for the Implementation of the Provisions of UNCLOS of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks.

4) Mariculture:
   Mariculture should be incorporated into integrated marine and coastal area management and be subject to prior environmental and social impact assessments. Use of chemicals for therapeutics and other applications and high nutrient losses should be minimized. Mariculture operations should not result in the overexploitation of natural stocks through harvesting of wild larvae. Introduction of alien species, products of selected breeding and living modified organisms should only be allowed following thorough examination according to the international codes of practices such as the FAO Code of Conduct for Responsible Fisheries, and those developed by ICES and «the Organisation International Epizootique».

5) Alien species:
   Means to prevent, control, or eradicate, where possible, those alien species which threaten ecosystems, habitats or species, should be elaborated by the parties in accordance with the IMO ballast water guidelines or ICES Code of Practice.

6

Ecological Impact of Fisheries

The Ministers recommend that policies of the European Union and the competent Norwegian authorities should be such as to minimize by-catch and other negative impacts on marine mammals, seabirds and benthic organisms and to minimize discarding of fish and benthic organisms.

(The Esbjerg Declaration, Article 16.iii)

6.1 Summary and Issues of Concern

Fishing has a major impact on the North Sea ecosystems. Harvesting fish and shellfish directly affects both target and non-target species and, in a number of cases, it can affect habitats as a result of its effect on the abiotic environment. These direct effects are:

- mortality on target fish species and on other biota such as non-target fish species, marine mammals, seabirds and benthic organisms;
- disturbance to the sea bed and the consequent damage to habitats and benthic organisms as a result of impact by fishing gear (notably the beam trawl); and

- input of offal and discards into the sea. Such inputs are important to scavenging seabird and other marine species but may also cause anoxic conditions in some local areas.

The impact of fishing may also have wider implications (indirect effects), e.g. for the long-term sustainability of populations of relatively scarce species and for the maintenance of biological diversity in the North Sea. This is of particular significance in the case of the effect of demersal gear on benthic species.

Considerable changes have been observed in the size and species composition of the fish community during the course of this century. Some species which grow to a large size are much scarcer than they were at the beginning of the century and there has been a shift in favour of short-lived species that only grow to a small size. Observed changes in the size composition of the target species used for human consumption are related to fishing pressure. As a result of these changes, the predation levels on smaller individuals and species of fish have become less and this may have contributed to the greater abundance of small fish observed in the last few decades. There are also indications that demersal fishing activities have resulted in a shift in the benthic community structure to the benefit of short-lived species with a high reproductive potential. This could mean that a considerable restructuring of the North Sea ecosystems has taken place.

Other human activities and natural (climatic and ecological) factors also have an important impact on the ecosystem. Under an ecosystem approach to fisheries management, it would be necessary to take these into account to allow the ecosystem to cope with the variability of natural factors.

Issues of Concern

On the basis of this chapter the following are the issues of concern:

- The high fishing pressure on many North Sea fish stocks;
- The extent of change in age structure and size composition of the fish stocks as a result of fisheries;
- The decrease in abundance of some fish species, mostly species with low reproduction rate;
- The high by-catches of many non-target species of fish and shellfish and of some benthic species;
- The effect of some demersal gear (notably the beam trawl in the flatfish fisheries) on benthic communities, notably the shift from long-lived to short-lived species due to repeated disturbance by demersal gear;
- The effect of demersal gear on habitats;
- The localized effects of the return to the sea of large quantities of dead organic material;
- An unnatural increase in the population of some scavenging species as the result of discarding of fish and fisheries waste;
- By-catch mortality of marine mammals and seabirds;
- The potential effect of some fisheries (notably industrial fisheries) on the food supplies for fish, seabirds and other organisms; and
- The mortality on fish and other organisms caused by lost fishing gear.

6.2 Introduction

Many of the undesirable environmental effects of fishing are manifestations of the general problem of overfishing. It is therefore likely that many of the effects of fishing activities on the ecosystem will be reduced or eradicated if overcapacity and excessive fishing effort are addressed by a reduction in fishing over all fishing methods. Certain specific problems will still remain, however, and these should be covered by precautionary action, where necessary by measures additional to those needed to protect the target species.

The effects of fishing activity may occur at several spatial scales: local, regional or North Sea wide. In some cases species may occur predominantly in a small area. In these instances, the effect of fishing may have a significant effect on the total population. In other cases, particularly in the coastal zone, fishing activity may have large effects in the areas where fishing takes place, while such effects may be local in character, their impact on a larger scale cannot be excluded.

Fishing has a number of effects on the ecosystem. As well as causing changes in stock abundance, length and age structure and possibly in the genetic composition of the target stocks, fisheries also affect other components of the ecosystem such as non-target fish species, seabirds, marine mammals and benthic organisms. The direct effects of fishing are the result of:

- the fishery causing mortality on target and non-target species;
- disturbance of the substrate which can cause alteration of habitats; and
- continued fishing by lost fishing gear.

These direct effects may in turn lead to indirect, and in some cases long-term, effects such as modification of predator-prey relationships, as a result of the provision of food in the form of discards and offal, and as a result of the removal of large quantities of prey organisms, predators or competitors. The manifestation of such long-term effects may be seen on the broader attributes of communities, such as species diversity and size composition. There is also the risk of eliminating vulnerable species if exposed to a continuously high exploitation rate, whether caught in a directed fishery or as by-catch.

Several gaps in the scientific knowledge of the long-term impact of fisheries upon the ecosystem exist. As scientific means to increase this knowledge and to assess the recovery and redevelopment of marine ecosystems, the establishment of undisturbed areas was considered at the Esbjerg Conference. No specific areas have yet been chosen.

6.3 Direct Effects of Fisheries

6.3.1 Fishing Mortality on Target and Non-target Species

As a general rule, fishing activity is directed at one or more target species or at a group of species. Various gear are used in the North Sea fisheries (see Figure 6.1). The main effect of mortality on the target species is a reduction in the average age and size of fish in the stock and hence a reduction in the overall stock biomass, particularly the spawning stock biomass. Most fish species produce many eggs and are able to withstand quite large reductions in the biomass of fish of spawning age. This reproductive strategy allows them to tolerate losses caused by natural factors. However, in some cases, as a result of fishing mortality, the spawning stock may be reduced to such a level that recruitment is reduced as a result of inadequate egg production. This is referred to as «recruitment overfishing». In the most serious cases, this may lead to a collapse of the stock and the fishery.

This happened to the herring and the mackerel stocks in the North Sea in the late 1960s. While the herring stock showed some recovery after a closure of the fishery, mackerel has shown no signs of recovery in over 20 years.

The North Sea cod stock has also recently reached its lowest level of spawning biomass in the past 30 years as a result of high fishing mortality and poor recruitment. This has given rise to serious concern about the future stability of the stock, especially in view of the recent collapse of cod stocks in the northwest Atlantic.

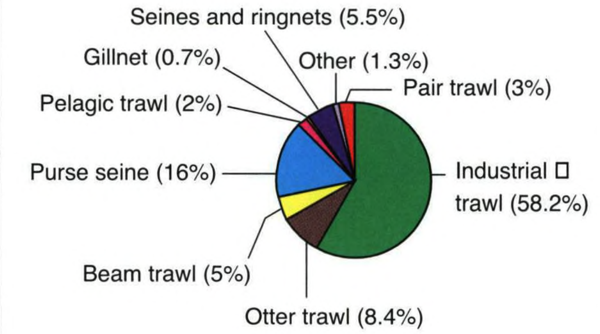


Figure 6.1. Percentage of total North Sea fish landings taken by various gear in 1989. (North Sea Quality Status Report 1993.)

The incidental catches of non-target species may cause changes in the populations of these species in the same way as for the target fish species. Such incidental catches, whether landed or discarded at sea, are usually termed by-catch. The mortality that fisheries cause on non-target fish, seabirds, marine mammals and benthic invertebrates through incidental catch is seldom directly quantified. Some of these species, however, have life histories characterized by low reproductive rates as a result of low number of eggs and long maturation periods. Marine mammals and elasmobranchs (sharks, rays and skates) are at particular risk in this context due to their low reproduction rate. The stocks of skates and rays in the North Sea have followed a steady decline in landings since the 1960s. The common skate (*Raja batis*) is now seldom caught in the central-southern North Sea and has not been caught in Dutch coastal waters since the mid-1950s. The common skate is the least resilient species of ray and would be expected to disappear under the level of exploitation that has existed in the Irish Sea and the North Sea for many years. It is a clear example of a species which has become locally extinct due to the effects of fishing. Other species of ray would be expected to be more resilient to heavy fishing pressure, particularly if they are subject to fairly low fishing mortality before they mature.

Fisheries also cause incidental and unrecorded mortality of both target and non-target species as a result of impact by the gear when towed by a vessel. At a very rough approximation, it might be assumed that only about 75% of the fish that escape from towed gear survive. Estimating the scale of these hidden incidental mortalities is very difficult. In contrast, estimates of discard and by-catch mortality can be made through monitoring programmes.

The scale of by-catches and other forms of impact varies between the different fisheries. In the case of most active gear and some passive gear, there is some unrecorded mortality of fish and other organisms which escape from the gear, for example as a result of escaping through the meshes. A brief summary of some types of fishing gear used in the North Sea and the associated by-catches is given in Table 6.1.

Table 6.1. Some of the gear types used in the North Sea fisheries in 1996 in relation to target species and by-catches of target and non-target species.

Fishing gear	Fisheries	By-catch
Demersal active gear:		
otter trawl (human consumption fisheries)	*nephrops*, roundfish and some pelagic species	unwanted sizes of target and non-target species of fish and other vertebrates
otter trawl (industrial fisheries)	small fish species (sandeel, Norway pout, sprat)	human consumption fish species
demersal seines: single and pair	human consumption fish species (roundfish and flatfish)	unwanted species and sizes of fish
beam trawl: light nets equipped with bobbins	brown shrimp	significant by-catch of flatfish and benthic organisms
heavy gear equipped with chains	flatfish (mostly sole and plaice)	juvenile target species, non-target fish and benthic organisms
dredges	molluscan shellfish	flatfish, damage to target and non-target benthic species
Pelagic active gear:		
purse seines, pelagic trawl, single and pair	shoaling pelagic species (herring, mackerel and sprat)	low by-catch of non-target species. Unmarketable* fish released dead or damaged
Passive gear:		
Nets:		
gillnets, demersal set nets, drift nets	human consumption fish species (cod, turbot and other species)	seabirds, harbour porpoise (for which species gillnet is the main source of by-catch)
Traps:		
portable baited traps and coastal trap nets	crustacean shellfish and salmonids	undersized and non-target shellfish
Lines:		
long lines and hand lines**	deep-water demersal fish species	seabirds

Notes:

* Unmarketable: non-commercial species or under-sized commercial species.

** Little used in the North Sea.

Entanglement of seabirds in fishing nets occurs in various parts of the North Sea. Although in terms of the total populations of the species concerned it has no detectable effect, locally it has the potential for more serious impacts. The species most vulnerable are auks and other diving seabirds. Inshore gillnetting takes the highest incidental by-catch of seabirds, especially juveniles, when nets are set near wintering concentrations. As an example, there is recent evidence of a heavy by-catch of wintering auks on the French side of the Channel. However, the high incidental mortality of guillemots in the southeast Kattegat in the 1980s seems to have receded. For nets set close to seabird colonies the effect of such incidental mortality may be particularly important as they then kill mainly adult, breeding birds. Seabirds are also caught as they scavenge from baited long-lines and handlines during deployment. These fishing methods are at present little used in the North Sea, but there has recently been a growth in long-lining for deep-water demersal fish on the shelf edge of the Faroe-Shetland Channel.

Marine mammals are also vulnerable to accidental capture in certain types of fishing gear, particularly by entanglement in nets. Incidental catches of marine mammals in fishing gear in the North Sea are poorly documented, however, and it is difficult to estimate the total number of marine mammals killed by fishing operations.

In the North Sea, the harbour porpoise is particularly vulnerable and the by-catch in the bottom-set gillnet fishery is probably the most serious threat to harbour porpoise populations. The current level of harbour porpoise by-catch mortality is estimated to be roughly 1.7% of the North Sea population. This value is substantially higher than the 1% limit adopted by the International Whaling Commission's Scientific Committee as the level at which by-catches of north Atlantic harbour porpoise may not be sustainable and at which urgent investigation and possible mitigating action is required.

Fixed gill- and tangle nets have minimal effects on benthic taxa, with the exception of crabs which become entangled. On the other hand, a number of benthic species may be at particular risk from gear that have a physical impact on the sea bed. Notable among these is the quahog which has shown a considerable decline in many areas of the North Sea in recent years. Species like lobsters, edible crab and the hermit crab may also suffer from incidental mortality from mobile gear. Beam-trawling undoubtedly has a major effect on benthic habitats and organisms but the direct and indirect effects are difficult to separate. Other types of mobile gear have greater or lesser effects on the sea bed. The effects of scallop dredging may be more severe, though less widespread, than those of beam-trawling. Hitherto, most research on scallop dredging has been confined to the effects on the target species, both those captured and those left in the dredge track. Scallop dredging within the Skomer Marine Reserve (Wales) showed that much epifauna was collected or destroyed by the dredge, so much so that a byelaw was passed prohibiting scallop dredging on the reserve. Scallop dredging has also been known to kill sandeels aggregating in substrates. Considerable physical disturbance is caused by gear used in other bivalve fisheries, such as those for cockles or *Spisula* spp. Cuttlefish eggs attached to the sea bed are also easily damaged by mobile gear.

6.3.2 Lost Gear and Ghost Fishing

Some gear such as gillnets and traps may continue to fish for some time when lost or discarded – a phenomenon known as «ghost fishing». Because most fishing gear is made of non-biodegradable synthetic materials, if lost at sea it will decay only very slowly, and organisms may incidentally become entangled. The gear most likely to continue fishing in this way are gillnets and lost creels. Continued fishing by lost traps may occur as long as the bait or catch is attractive.

There is no requirement for fishermen to report lost fishing gear but, in view of the replacement costs involved, the individual fishermen will have an incentive to retrieve lost gear. No action has been taken at present to identify the full extent of gear loss.

There are no indications that lost mobile gear causes a significant problem. Static gear units (nets, lines and traps) are individually less costly and are more readily abandoned when lost and thus potentially more damaging than lost mobile gear.

6.3.3 Physical Disturbance

Towed demersal gear causes physical disturbance of the bottom, particularly those with heavy ground gear such as beam trawls, otter trawls or scallop dredges. The importance of such disturbance depends on the depth of sea bed penetration, the area affected and the intensity of the use of the gear in a given area. In order to illustrate the scale of the physical disturbance by fishing, rough estimates from 1989 indicate that the total area swept by beam trawl was 323 000 km^2 or about 45% of the whole North Sea area, while that swept by otter trawl boards was 24 000 km^2. On average, the continental coastal areas in the southern North Sea are trawled over by beam trawls 2-4 times per year. This, however, does not take into account the distribution of effort on the various fishing grounds and on a smaller scale the impact may be considerably higher. The total area swept by beam trawl and otter trawl boards is given in Figure 6.2.

The depth of penetration into the sea bed varies with gear type and with the type of substrate. The otterboards of otter trawls penetrate 6-20 cm into the sea bed if the sea bed consists of soft sediment and beam trawl tickler chains can penetrate into the sea bed to a depth of 4-8 cm on a soft bottom and 3-6 cm on a hard bottom (see Table 6.2). Disturbance of the sea bed therefore increases suspended sediment load and to a varying degree alters substrate structure and in-fauna communities. Beam trawls have been shown to create conditions for settlement of sediment fines in trawl tracks on otherwise coarse sediments that are normally swept clean by wave and current action. Displacement of boulders and damage of hard substrates also have an influence on the habitats of many epifaunal taxa.

6.3.4 Discards and Offal

Discarding of unwanted catches and of offal arising from on-board cleaning of fish constitutes the return to the North Sea of a considerable food source for scavenging species. This can have an effect both on local benthic ecosystems as well as throughout the North Sea.

Discards

Fish and benthos that are caught and thrown back into the sea are known as discards. According to EU fisheries regulations it is illegal to land fish that are undersized, of non-authorized species, over-quota etc. Such catches are discarded. The need to discard heavily in the North Sea reflects the pattern of sustained overexploitation which has generated an age structure dominated by juvenile fish. Most discards thus reflect what amounts to the deliberate targeting of juvenile fish around the minimum landing size. Discarding also takes place as a result of high-grading strategies, i.e. catching more than is necessary to permit sorting of the most valuable components of the catch. In Norway discarding of the most important commercial fish species is illegal. There is no statutory obligation on skippers of EU vessels to record quantities of fish discarded, so no official statistics derive from this source.

At present there is insufficient information from which to estimate the total amount of fish discarded annually. Studies from some trawl fisheries indicate that the annual discards can be of the same order of magnitude as the landings from these fisheries.

In the case of North Sea cod and haddock, for example, the estimated average percentages discarded are 22% and 36% respectively by weight and 51% and 49% respectively by number.

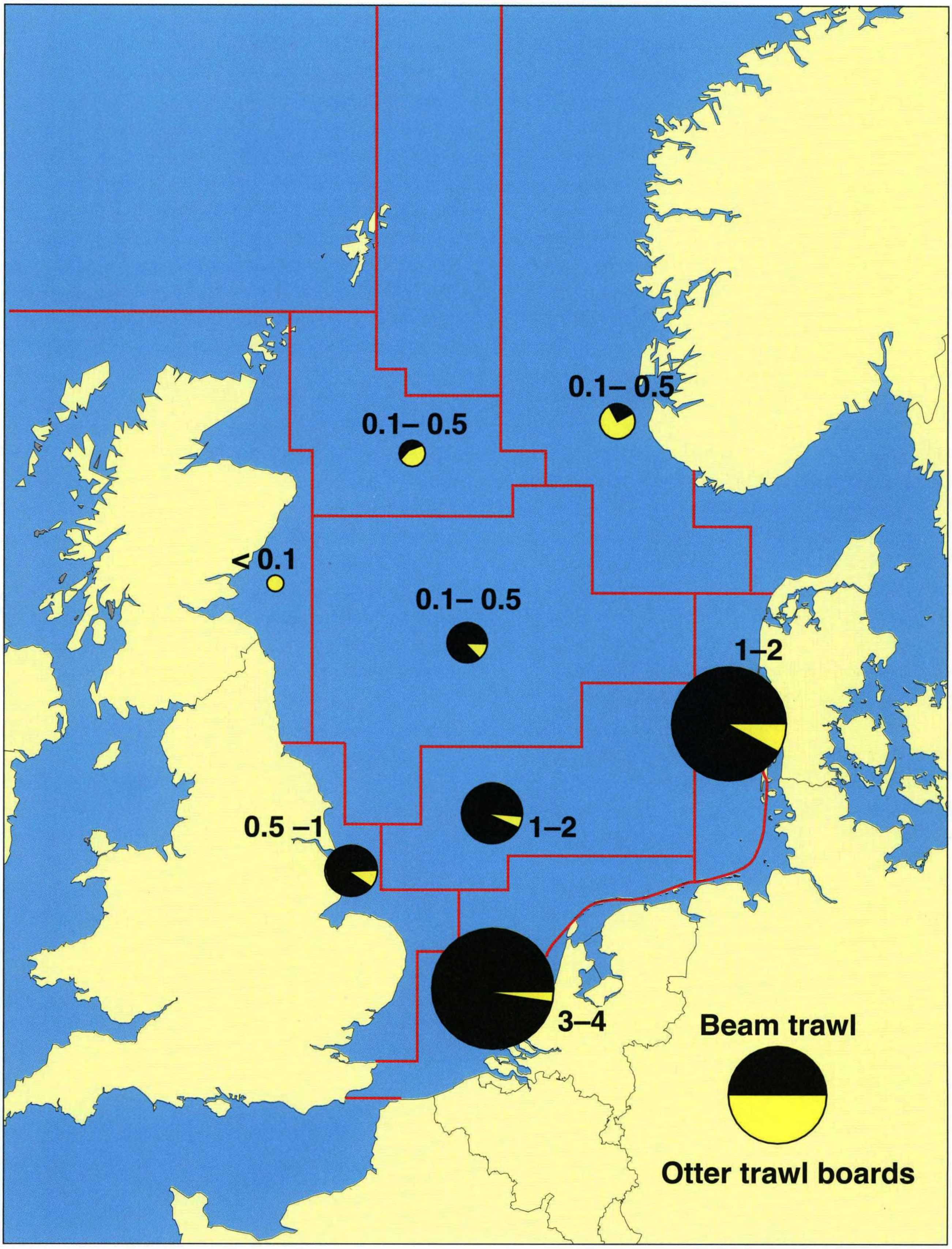


Figure 6.2. Total area swept in 1989 by gear that penetrates the sediment, relative to the size of the corresponding North Sea Task Force areas. (North Sea Quality Status Report 1993.)

Table 6.2. Depth of penetration into the sea bed, species and area affectedby types of fishing gear applied in the North Sea fisheries.

Type of fishing gear	Penetration depth	Species affected	Area affected (location)
Otter trawl, pair and twin	ground rope, bobbins and chains: < 5 cm (soft bottom) < 2 cm (hard bottom) trawl door: 6–20 cm (soft bottom)	epifauna (e.g., crustacea: *Corystes* and *Eupagurus*; molluscs: *Alba alba, Arctica islandica*; *Donax vitatis*; *Spisula subtruncata*, *Placopecten*; echinoderms: juvenile *Echinocardium*, *Psammechinus miliaris*; cnidaria: hydroids, *Alcyonium digitatum*)	98 956 km^2 per year 1989 (whole North Sea area where otter trawl is used)
Beam trawl	chains: 4–8 cm (soft bottom) 3–6 cm (hard bottom) trawl heads: 7-10 cm combined effect of beam trawling in some other areas <10-20 cm deep tracks	same epibenthic fauna as mentioned under otter trawl, as well as the following infauna species: various polychaetes: *Pectinaria* sp. *Aphrodite aculeata*; sipunculids and tunicates; molluscs: *Tellinaya ferrigunosa*, *Turritella communis*, *Chamelea gallina*, *Dosinia lupinus*, *Mactra corallina*	323 009 km^2 per year 1989 (central and southern North Sea)
Demersal pair trawl	ground rope: 1–2 cm	same as for otter trawl	107 549 km^2 per year 1989 (whole North Sea)
Twin trawl	see otter trawl but no trawl door	see otter trawl	
Seines and ring nets	zero	minimal effect on benthos	245 km^2 (whole North Sea)
Pair seine	see seines and ring nets	see seines and ring nets	
Dredges	mussel dredge: 5-25 cm cockle dredge: 5 cm scallop dredge: 3-10 cm (> 15 cm)	see beam trawl (note: the use of multiple scallop dredges markedly increases the swept area)	(estuarine and coastal areas of the North Sea)
Shrimp beam trawl	bobbins: 2 cm	in addition to benthos killed in the trawl path, a high mortality of benthos and juvenile fish in small-mesh sized nets	(estuarine and coastal areas of the North Sea)
Prawn trawl	see shrimp beam trawl	see shrimp beam trawl	(northern North Sea)
Industrial trawls	see otter trawl	epibenthic fauna (see otter trawl)	industrial pair trawl 10 648 km^2 (central North Sea) industrial single trawl 127 165 km^2 (whole North Sea)

It has been estimated that approximately 260 000 tonnes of fish per year are discarded in the beam trawl fishery. The estimates in the roundfish fishery are up to 270 000 tonnes per year for commercial species and 20 000 tonnes per year for non-commercial species (ICES, 1994). The available observations vary widely due to annual differences in discarding resulting from differences in year class strength. However, these figures are underestimates, as data for fisheries for pelagic species as well as for Norway lobster and deep sea prawns are not included.

Offal

Demersal fish species used for human consumption are usually gutted at sea. The resulting offal corresponds to approximately 12% of the weight of landings of fish that are gutted, or 65 000 - 70 000 tonnes per year. The pelagic and industrial fisheries do not generate significant amounts of offal because fish are in general landed whole.

Discards and offal as a source of food for marine organisms

Discards and offal provide a source of food for several different types of organisms. The best known example is scavenging seabirds but discards and offal may also be an important source of food for other marine organisms. Some discards and most offal are utilized by surface feeders such as scavenging seabirds. This issue is described further in Chapter 6.4.2.

Those discards that sink are utilized by organisms which feed on the sea bed or in midwater, including some commercially and non-commercially exploited fish species, benthic organisms and possibly marine mammals. The provision of food by discarding has undoubtedly been of importance in the population growth of a number of scavenging seabird species. However, the overall effect of discards on fish and benthic species is not known.

6.4 Indirect Effects of Fishing Activity

In the following the indirect effects of fishing activity on some of the main groups of species in the North Sea, such as changes in prey availability, are described.

6.4.1 Fish and Shellfish

The effects of fisheries on fish stocks include the selective removal of particular species and of particular sizes within each species. This can change the balance between large and small fish in the ecosystem, as well as change the characteristic size composition of individual stocks. In the long-term, the composition of the fish and shellfish fauna could be affected by changes in the balance between the numbers of large predators in the sea and the amount of small prey. Fishing has undoubtedly reduced the numbers of large predatory fish in the North Sea and this may have been followed by increased abundance of smaller fish species. Dragonet and solenette are examples of species that may have benefited, but there is also circumstantial evidence that a number of more abundant species such as Norway pout, sprat and possibly sandeel may have increased following the reduction in predatory species around the 1960s. In turn, small fish provide more abundant food for predatory fish and other components of the ecosystem. These effects can be substantial. They have been partly quantified by multispecies models but the processes are not yet completely understood. For example, the consumption rates of sandeels by cod and other roundfish in areas of high-intensity sandeel fisheries need closer investigation, particularly in the light of the current state of some of these predatory fish stocks.

Non-target fish species (notably dab and gurnard spp.) may derive benefits from discarded fish and offal, and from food made available by the mortality on, and disturbance of, benthic organisms created by the action of fishing gear on the sea bed. In some cases it is possible that fisheries effects on substrates may adversely affect the recruitment of young individuals. In particular some dogfish, skates and rays attach their eggs to the substrate which might be disturbed by fishing.

6.4.2 Seabirds

The structure of the North Sea seabird community is to a certain extent dependent on what happens in the fisheries, and certain species are vulnerable to changes in fishing practice.

The majority of seabird species eat fish either caught alive or taken as discards and offal. Some feed on benthos and a few consume zooplankton. Those species that are most likely to benefit directly from North Sea fisheries are those that utilize discards and offal from fishing vessels. The discharge of fishery waste in the North Sea in the form of discarded offal, fish and shellfish is estimated to support between 2.5 and 3.5 million seabirds, about ten species of which regularly scavenge behind fishing vessels and thus benefit from this activity. There are some differences between seabird species in their utilization of fishery waste. Fish offal is taken primarily by fulmars, kittiwakes, herring gulls and lesser black-backed gulls while discards, especially from whitefish, *Nephrops* and shrimp fisheries, are taken by a wider range of species including gannets, great black-backed gulls, herring gulls, lesser black-backed gulls, great skuas and to a small extent kittiwakes, common gulls and fulmars. Increases in the provision of fishing waste are thought to have contributed to significant increases in the populations of gannet, great skua and great black-backed gull. The large increase in fulmars over the past few decades is a direct result of the increased amounts of discards of fish and offal in these waters. If, however, the discarding of fish and offal were to be reduced, this could bring about major changes in the composition of e.g. seabird colonies where fulmars occupy the same breeding habitat as guillemots. Similarly, decreased breeding success and population numbers of large gulls could reduce gull predation on other seabirds. The largest seabird species gain the most discards and are best able to swallow them; smaller species obtain relatively fewer discards and may be outcompeted by the larger species, putting them at a disadvantage if the level of discarding were to decline. Thus, when some species benefit, others are likely to be adversely affected.

Over the last 20 years several seabird species have increased in abundance, possibly as a result of an increase in small shoaling fish. These seabird species may have benefited from fishing on large predatory fish which has reduced pressure on their prey. Thus, prey fish such as sandeels and sprats, which are utilized for fish-meal and oil production, may have increased in numbers as a result of the relaxation of predation, particularly by herring and mackerel. Without appropriate historical data this process is impossible to quantify and, for several seabird species, difficult to disentangle from the parallel increase in alternative food supplies and changes in other factors.

In some areas close to breeding colonies, the industrial fisheries for sandeels could compete directly with those seabird species dependent on catching small fish near the sea surface, although there is no conclusive evidence that competition has in fact occurred. Depletion of the stocks by recruitment overfishing could potentially have a major effect on the food required by these seabird populations. Sprats are important for many seabirds in winter when sandeels are less available.

In the southern North Sea and the Wadden Sea some species are especially dependent on shellfish as a food source. The most important shellfish for birds in these areas are bivalve molluscs (mussels, cockles and *Spisula* sp.). In the Wadden Sea, the consumption of bivalves by birds is of the same order of magnitude as that taken by the fisheries. In years of low shellfish abundance, there is therefore a risk of food shortage for these birds. In the last decade, harvesting of cockles and mussels has reduced food availability for eider and oystercatcher, while the *Spisula* fishery in shallow water currently competes with common scoter.

Many prey species have been recorded in the diet of seabirds. In the North Sea, the most important fish prey for birds are sandeel, sprat and herring, particularly the two or three youngest age classes, but gobies and young gadoids are also important food items for some bird species. Seabirds in the North Sea are estimated to consume 600 000 tonnes of food per annum, including 200 000 tonnes of sandeels and 30 000 tonnes of sprat and (to a much lesser extent) small herring. Low consumption rates by seabirds over large spatial scales imply that seabirds are unlikely to compete with fisheries, but do not necessarily indicate the reverse – that seabirds are unaffected by commercial fishing. In this respect, in areas important to seabirds it is more important to focus on local changes in prey concentration (which can profoundly affect the status of seabird populations through changes in breeding success and overwintering survival) than on overall stock changes at a North Sea scale.

6.4.3 Marine Mammals

A change in the availability of preferred prey species is likely to result in a switch to prey species which marine mammals can use less efficiently. Consequences of reduced availability of preferred prey could be: an increase in foraging effort, reduced juvenile growth rate, increased mortality during the first months of life, reduced birth and weaned weight of pups and calves and (ultimately) reduced growth rates.

Cetaceans

For the harbour porpoise both the fishery-induced depletion of its main prey species (herring) and the by-catches are identified as possible reasons for the decrease in abundance, as well as for the reduced growth rate and body size at sexual maturity, recorded between the periods 1941-1943 and 1980-1981. Past depletion of herring stocks may have contributed to the disappearance of harbour porpoises from coastal waters in the southern North Sea during the last 50 years.

Seals

Harbour seals eat a wide range of fish species and a number of examples of changes in diet, apparently in response to changes in prey availability, have been documented. A change in the diet of young seals in the Kattegat/Skagerrak was recorded following an invasion of smaller fish, and changes in the foraging behaviour of harbour seals in the Moray Firth were reported following a decrease in inshore abundance of overwintering clupeids (sprat and herring).

6.4.4 Benthic Organisms

The fishery related physical disturbance of the benthic fauna is a problem in some parts of the southeastern North Sea. Observed changes in benthic populations can be the result of direct impacts of fishing, through selection in favour of the most productive species and indirect factors due to changes in food supply. The state of knowledge about the population dynamics of benthic organisms rules out any firm conclusions about the cause of most of the changes observed.

There are indications that demersal fishing activities have resulted in a shift in the benthic community structure to the benefit of short-living species with a high reproductive potential. Opportunistic worms and resistant invertebrates may become more common, while more vulnerable species may be locally eliminated. The reproductive rate of some of these species may be too low to counterbalance these negative effects. Fragile epibenthic organisms have been affected by fishing activities as well.

Oysters were common in many parts of the North

Sea until about the 1870s, at which time there was an active fishery for the species. Many factors other than overfishing may have influenced their decline, including hydrographic changes and diseases. Given that their numbers are now so low that fishing is uneconomic, they are no longer a target species and their numbers probably remain low through the action of mobile gear.

In areas where gear such as beam trawls disturb the same ground several times a year, changes in species composition and in the relative abundance of species in the benthic invertebrate communities are reported. The effects of fishing activity on the sea bed and associated species depend on the type of gear and type of sediment, and on the relative vulnerability of the species.

Experimental studies with beam trawls have shown that disturbance of the sea bed exposes many species and makes them more vulnerable to predators and scavengers. In some cases species may benefit from these fishing activities, e.g. by modification of the relative abundance of predators and their prey or by a reduction in the number of food competitors. A number of crustaceans (swimming crabs and hermit crabs), starfish and some fish species feed on benthic invertebrates that become available due to disturbance of the sea bed by, e.g. the beam trawl fishery. This disturbance may cause habitat destruction (burial and removal of stones) and as a result have a negative effect on oysters, lobsters, edible crab and helmet crab.

Benthic communities

Consideration of the biology of many benthic species suggests that although the populations are directly affected by fisheries, the species concerned are unlikely to suffer from recruitment failure at the current level of fishing. The reason for this is that benthic organisms have a vast production of eggs and larvae, which is capable of regenerating the population even at relatively low levels of adult population. In certain cases, however, fishing has led to structural changes in the habitats which may have induced changes in species composition. The evidence for more general and widespread effects, however, is unclear due to the lack of appropriate large-scale time-series of data.

Some benthic communities may be more vulnerable to physical disturbance than others. Inshore communities inhabiting sandy substrates in exposed areas would generally be expected to be more resilient, while the fauna associated with stable deposits may be more sensitive. This is because a number of the characteristic species associated with stable deposits have a lower reproductive rate, and thus a longer generation time and a lower recovery rate.

6.4.5 Habitats

Within the North Sea the following substrate types can be distinguished: mud, silt, sand, gravel and rock or similar hard substrate. Within these substrate types organisms may create conditions which provide a habitat for other organisms. Examples of such biogenic structures are mussel beds, oyster reefs, *Sabellaria* reefs and structures formed by tube-building species such as many polychaetes and some crustaceans. Disturbance of these species will therefore have an impact on all the associated species. Kelpforests also provide shelter for certain fish and shellfish species as well as for other organisms.

The impact of fisheries is very different on different types of substrate. All towed demersal gear can alter soft substrates, at the very least by winnowing and redistributing the sediments, or by eradicating certain species in those areas and optimizing conditions for colonization by others. Organisms most seriously affected belong to epifauna, long-lived infauna (mollusca and echinoderms), maerl beds (calcareous algae) and seagrass communities. Habitat destruction is a particular problem where there are diverse communities based on fragile species and where the physical habitat is altered by the removal of stones and shells which provide substrata for epibenthic species, or where very stable communities with long-lived species are disrupted. Hard substrates may be less vulnerable except for the effect of boulder turning, scraping and abrasion.

In the past, reefs of *Sabellaria*, beds of *Zostera* and oysters were found in the Wadden Sea, but these features have disappeared completely in some areas possibly due to fishing activity. Heavy fishing gear also inflicts physical damage on hard and soft substrates, potentially flattening, e.g. soft chalk reefs to the detriment of crustacean fisheries for smaller inshore vessels.

Hard substrates often contain protected space which is used as shelter by a variety of organisms. They also act as a substrate for sedentary organisms. Some fish species require hard substrates for depositing and attaching their eggs. Several organisms which drill holes in peat, clay or wood are fully dependent on this habitat type. Fisheries using heavy gear are considered a threat to these habitats.

7

Impact of other Human Activities on Fisheries Resources and Fisheries

There is a recognised connection between fisheries and the marine ecosystem but gaps exist in the scientific knowledge of the impact of fisheries upon the ecosystem and of the impact of environmental changes and pollution upon fisheries.

(The Esbjerg Declaration, Article 16.)

7.1 Summary and Issues of Concern

Fish may be impacted by all human activities that alter the marine environment such as pollution by hazardous substances, oil and radioactive substances, excessive inputs of nutrients leading to eutrophication, the introduction of alien species, stock enhancement activities and physical changes. These factors are most likely to have an effect on fish stocks in spawning and nursery areas.

Increased inputs of nutrients have led to increased primary production. This may result in changes in species composition, including the increased occurrence of harmful algae, as well as in reduced oxygen concentrations in bottom waters of certain areas, with resulting mass mortality of benthic organisms and fish. The heavy growth of annual, filamentous algae in shallow waters due to eutrophication in some areas displaces perennial seaweeds and seagrass, and thus reduces habitats suitable for fish and shellfish.

Pollution by hazardous substances may adversely influence both the reproduction and survival of young fish, the prevalence of fish diseases and the quality of seafood. Some examples are:

- In some areas tributyltin (TBT) has led to the development of male sexual characteristics in the female dogwhelk, resulting in sterility and destructive effects on the population;
- TBT has also led to deleterious effects on the shell structure, growth and condition of Pacific oysters in some areas;
- There seems to be an increased prevalence of tumours in flatfish in contaminated areas and exposure to sediment-associated contaminants such as polycyclic aromatic hydrocarbons (PAHs) is a suspected cause. The availability of data on ecological effects of organic contaminants is, however, still very limited;
- Experiments show that organochlorine compounds in fish can reduce the hatching success of their eggs; and
- Contaminants entering the North Sea will also to a varying extent have a negative impact on the quality of food obtained from the sea with the possible negative effects on consumers (concentrations of polychlorinated biphenyls (PCB) and mercury have been of particular concern). Many of the trace organic contaminants entering the North Sea are only very slowly degraded and accumulate in the marine food chain and also give rise to concern.

Oil pollution is more frequent in coastal areas. Species are also more vulnerable in these areas where the spawning grounds and nursery areas of many species are located. Oil pollution can cause a direct mortality on fish eggs and larvae. It is not clear, however, whether oil pollution has an effect on the stocks on a local or North Sea scale.

A number of non-indigenous species have been introduced into the North Sea over the years. Aquaculture and ballast water from ships are the main sources of such introductions. Their introduction may have serious effects in the new environment, an example being the seaweed *Sargassum muticum* which is now replacing native algae in some locations. Other non-indigenous species reported to have negative impact on commercial important organisms are the slipper limpet *(Crepidula fornicata)*, the oyster parasite *(Bonamia ostrea)*, the parasite eel nematode *(Anguillicola crassus)* and the dinoflagellate *Gyrodinium aureolum*.

Fish aquaculture is often accompanied by the escape of individuals. Substantial escaping can have significant consequences on local populations through the spread of diseases, ecological competition and genetic change.

The North Sea may be subject to conflicting user interests such as between the sand and gravel extraction industry and other users of the ocean and its resources, in particular the fisheries. Other activities (*inter alia* construction work) also have the potential to change shores and sea beds, and to destroy coastal spawning and nursery areas. Offshore activities such as oil and gas exploration may reduce the area available for fisheries.

Issues of Concern

On the basis of this chapter, the following issues of concern have been identified:

- Reduction of the quality of spawning and nursery grounds due to inputs of hazardous substances, oil and excess nutrients;
- Impact of bottom substrate extraction and coastal construction work on important fish habitats;
- Impact of non-indigenous organisms and possible future impacts of genetically modified or selected organisms on native populations and communities of marine organisms;
- Direct or indirect impact on fish and shellfish of hazardous substances (e.g. hormonelike substances, TBT, PCB, PAH etc.) through, for example reduced reproduction and increased prevalence of diseases;
- Deterioration of seafood quality due to contamination by hazardous substances and oil and, in the case of shellfish, as a result of excess nutrient inputs, contamination by toxin from algal blooms;
- Impact on fish of discharges of chemicals, production water and cuttings from offshore oil and gas installations; and
- Impact on fish from oil pollution associated with transport of oil.

7.2 Introduction

This chapter will discuss the various impacts on fisheries resources and fisheries resulting from activities other than fisheries. These are impact from pollution (basically caused by the excessive discharge of nutrients leading to eutrophication and the introduction of hazardous substances to the North Sea), the impact from the introduction of non-indigenous species and impact from physical changes such as construction activities or gravel extraction.

The effects of pollution, in particular those caused by nutrients, are difficult to assess, as changes in the marine environment are often concealed by a high natural variability.

7.3 Impact from Pollution

Marine pollution may be divided into the following five groups:

1) Nutrients and eutrophication
2) Hazardous substances such as:
   - Persistent organic contaminants, e.g. polychlorinated biphenyls (PCBs), dioxins, pesticides including DDT;
   - Heavy metals (e.g. lead, copper, mercury, cadmium);
   - Antifouling agents (e.g. TBT); and
   - Polycyclic aromatic hydrocarbons (PAHs)
3) Oil and oily wastes
4) Radioactive substances
5) Litter

Nutrients and contaminants enter the North Sea via rivers, land run-off, atmospheric fall-out and direct discharges from land-based and sea-based activities, or are transported in and out of the North Sea via ocean currents. Inputs of oil to the North Sea are from shipping activities, offshore oil production and land-based activities.

The status of pollution in the North Sea caused by these inputs are described and discussed in the North Sea Quality Status Report 1993, and the progress on reduction of these inputs are described and assessed in the Progress Report of the Fourth International Conference on the Protection of the North Sea.

7.3.1 Ecological Impacts

The increased input of nutrients and the resulting change in nutrient ratios have altered phytoplankton community structure and succession in some regions of the North Sea. These changes have led to increased production and biomass of phytoplankton, changes in the species composition including the increased occurrence of harmful algae, and changes in benthic plant and animal communities. Increased input of nutrients may also reduce oxygen concentrations in the bottom waters of certain areas and result in mass mortality of benthic organisms and fish when the oxygen concentration decreases below critical levels.

Harmful algal blooms have on several occasions occurred in the North Sea. These blooms have been associated with a combination of high levels of nitrate, a high nitrate to phosphate ratio, and unusual meteorological conditions. One of the best examples has been the dominance and bloom of *Phaeocystis* sp. in the Wadden Sea over the last three decades. Another example is the *Chrysochromulina polylepis* bloom in the Skagerrak and the Kattegat in 1988.

Increased biomass and changes in the composition of zooplankton and zoobenthos have been observed in coastal areas. From some of these areas reduced bottom-water oxygen concentrations have been documented. In offshore and high-salinity areas of the North Sea, however, no clear signs of eutrophication effects have been observed. Temporal changes in plankton communities in these areas are thought to be more related to climatic effects. More generally, massive inputs of nutrients from rivers modify the structure of phytoplankton communities, which causes changes in the pelagic and benthic ecosystem.

All toxic anthropogenic substances released into the marine environment via various pathways may have an impact on the survival rate of eggs, larvae and juveniles of marine organisms. The growth rate of exposed marine organisms may be affected either by specific toxic action or by causing unspecified physiological stress, when critical concentrations of these substances are exceeded.

However, clear cause/effect relationships between exposure to contaminants and the above effects are hard to establish, due to the complex multifactorial environmental interactions affecting the health status of marine organisms.

Data on the biological effects of contaminants, such as persistent organics, trace metals and petroleum hydrocarbons, on the North Sea ecosystems are still very limited. The fact that only a few persistent organic contaminants have received any attention at all is a major cause for concern and uncertainty. However, some negative effects on animals have been observed, e.g. decreased reproductive success, increased susceptibility to diseases and lower survival rates. Concerns have been expressed about the potential effects of high concentrations of copper (mainly on lower trophic levels) and lead, cadmium and mercury, in relation to top predators such as seals and certain seabirds.

Several synthetic organic chemicals have been detected in estuaries and in the open North Sea, both in sediments and organisms. The occurrence of PCB has received much attention in recent decades and high concentrations have been observed particularly in predators such as mammals and birds. There is serious concern regarding the possible adverse effects of the high concentrations of organochlorine contaminants in top predators.

Exposure to tributyltin (TBT), derived predominantly from anti-fouling paints on ships, has been shown to produce distinctive changes in various organisms, which in severe cases can result in sterility and destructive effects on the population.

There are significant groups of substances whose risks to the marine environment are unknown. Evaluating potential threats in the marine environment is important and it would encompass threat caused by complex mixtures of substances (which may individually, be present in the environment at very low concentrations) and the impact of environmental chemicals with estrogenic effects. Additional research and probably the development of new techniques are required to estimate this type of effects.

Effects from the offshore oil and gas industry are more easily identifiable when approaching the coastal margins and estuaries. However, there are reports of oil being detectable in the tissues of fish well away from oil production platforms and this has been identified as stemming from oiled drill cuttings. Probably of greater concern are the quantities of oil entering the sea from ships as illegal discharge and from incomplete gas flaring operations on oil platforms. These can lead to death of seabirds, and the oiling rate of birds found on the North Sea coastline has in general not declined. There is an increasing oil contamination and input of oil production related chemicals from produced water and potential effects of this should not be ignored.

7.3.2 Mortality

In areas where eutrophication occurs there has been increased biological production. The degradation of organisms that have not entered the food chain, but have sedimented to the bottom prior to their decomposition, may result in extensive anoxia both on shallow and deep waters. In some areas this has led to mass mortality of fish and shellfish, including for example the collapse of Norway lobster stocks in southern Kattegat.

The *Chrysochromulina* bloom in 1988 in the Skagerrak and the Kattegat caused extensive mortality of benthic and pelagic organisms in addition to farmed fish, due to the toxins produced by the *Chrysochromulina* algae.

There is no evidence of direct mortality on fish stocks from hazardous substances. There are many reports on mortality of seabirds from oil, and oil can also cause a direct mortality on fish eggs and early stages of fish larvae.

7.3.3 Recruitment

There is increasing evidence of links between concentrations of organic contaminant (mainly PCBs), and impaired reproduction in harbour seals. The evidence of a link with decreased resistance of the seals to diseases is still inconclusive. Organochlorine compounds in female fish have been shown in laboratory experiments to reduce the hatching success of their eggs but field observations on this matter are not conclusive. In field studies a fundamental problem is how to ascribe the observed effects to specific compounds, because they tend to be present in complex mixtures.

A sensitive indicator of the toxicity of TBT to marine organisms is its effect on dogwhelks (*Nucella lapillus*) and whelks (*Buccinum undatum).* The effects caused by TBT-based anti-fouling paints are manifested as the development of male sexual characteristics (termed «imposex») in the female dogwhelk. Results from a Dutch survey in 1991/1992 indicate that TBT, probably from shipping, affects the whelk population in the southern North Sea. The findings of the survey were that no whelks at all were present in the very busy coastal shipping areas and a high incidence of imposex in whelks was observed in the offshore deepwater shipping lane.

It is suspected that a number of substances with endocrine- or hormone-like effects might impact the ability of many types of marine organisms to reproduce. Such substances are for example nonylphenol, nonyl phenolethoxylates, certain pesticides and also certain substances in washing powder. Several of these substances are accumulated in the marine food chain but current knowledge on their endocrine effects is limited.

Some studies on eutrophication in coastal areas have indicated that overgrowth of annual, filamentous algae in shallow waters has displaced perennial seaweed and seagrasses, which has resulted in reduced recruitment of fish and shellfish in these nursery areas owing to a loss of favourable habitat. The 1988 *Chrysochromulina* bloom resulted in a significant reduction in recruitment to the gadoid stocks along the Norwegian Skagerrak coast.

In the southern Bight of the North Sea, the reproduction rates of mussels (*Mytilus edulis*) is positively correlated to the *Phaeocystis* blooms. In addition, off the coast of Wales some fish-nursery areas have been reduced due to the appearance of anoxic zones resulting from *Phaeocystis* blooms.

7.3.4 Diseases

Fish diseases are a result of a combination of causes and it is usually difficult to explain the process of their initiation and development. They are subject to spatial, temporal and biological variations that have natural causes. Thus, considerable differences in disease prevalence levels can occur with no known association with pollution. For example, elevated prevalence of externally visible diseases of flounder has been found to be correlated with fluctuating salinity conditions in some coastal regions of the North Sea.

Several studies of North Sea flatfish that inhabit contaminated sediments have revealed an increased prevalence of tumours, particularly in the liver. Although tumours can occur naturally, exposure to sediment-associated chemical contaminants such as PAHs is suspected to be a main cause. Also reduced scope for growth in mussels, and induction of the EROD enzyme in flatfish liver, have been attributed to elevated levels of PAHs in some North Sea sediments.

The use of organotin compounds such as TBT has been shown to have undesirable effects on non-target organisms. Studies have shown that TBT has led to deleterious effects on the shell structure, growth and condition of Pacific oysters in some areas.

For some other fish diseases, reports indicate that a higher prevalence can be found in known areas of pollution: e.g. in the former dumping grounds for wastes from titanium dioxide production. Additionally, higher prevalence of some diseases has been shown under low oxygen conditions due to eutrophication.

7.3.5 The Impact of Pollution on Sea Food Quality

Pollution entering the North Sea may have serious negative impact on the seafood quality. The quality of the seafood harvested from the North Sea is related both to consumption quality and to the virtual marketing quality which could be imposed by environmental events such as a harmful alga bloom.

Many of the trace organic contaminants entering the North Sea are very slowly degraded and bioaccumulate in the marine food chain. The highest concentrations of these compounds are found at the top of the food chain, particularly in top predators. The high concentrations found, as in liver of certain fish species from certain areas, have led to precautionary controls being imposed on the human consumption of particular species and tissues. For example, there are restrictions on human consumption of fish and shellfish from the Frierfjord and the Kristiansandfjord in Norway because of high levels of organochlorines, and from the Elbe estuary because of high levels of mercury.

For PCBs in fish liver there is a clear gradient in concentrations from low values in the northern North Sea to high values in the southern North Sea. In mussels the highest concentration of PCBs are found in the estuaries of the western Scheldt and Ems and in the Wadden Sea. Concentrations of heavy metals in fish are generally found to be below the standard set for contaminants in food for human consumption. Exceptions are flounder and eel in the Elbe and its estuary, which may not be sold due to their high mercury content.

The occurrence of algal toxins in mussels is a continuing problem in some parts of the North Sea where eutrophication has been linked to the occurrence of Paralytic Shellfish Poisoning (PSP) caused by dinoflagellates.

Diarrhetic Shellfish Poisoning (DSP) caused by *Dinophysis* spp. is probably one of the most serious contaminations caused by toxic algae. There is, however, no clear link between eutrophication and its occurrence. DSP has been found in Dutch, Danish, Norwegian and German waters, and the frequency of reports of occurrence is increasing.

Furthermore, deterioration of shellfish quality for consumption due to the presence of coliform bacteria and the content of salmonella is a problem in some parts of the North Sea.

7.4 Impact from Introduction of Non-indigenous Species

7.4.1 Non-native Organisms

A number of species have been introduced into European waters in historical or more recent times. The most important vectors for these introductions are shipping (ballast water and fouling) and aquaculture. Secondary dispersal into new regions from introductions in other parts of Europe also play an important part. A third area of possible introduction of non-native organisms is through aquatic products as human food. It is through this route (Japanese eels) that the parasite *Anguillicola crassuss* (swim bladder nematode) was introduced into Europe, and this organism is currently spreading and causing severe problems in wild and farmed stocks of European eels in several European countries. The slipper limpet (*Crepidula fornicata)* is reported to have negative impacts on scallop and other shellfish culture. Other species observed to cause negative effects on commercially important organisms are the oyster parasite (*Bonamia ostrea)* and the dinoflagellate (*Gyrodinium aureolum),* which have been responsible for fish kills.

Released or escaped exotic species rarely flourish in their new environment, but it does happen occasionally. The effects of any introduction of a non-indigenous species are unpredictable. Many of the cultivated species, which produce valuable food and generate income and employment, often in deprived areas, were originally exotic species.

Deliberate transfers for mariculture purposes may be accompanied by other organisms, frequently seaweed and invertebrates, as well as diseases and parasites. Such transfers are accidental, but may nevertheless have serious effects in the new environment. The seaweed *Sargassum muticum* is believed to have been introduced into European waters on imported Japanese shellfish and is now replacing native algae in some locations.

Introductions via ships' ballast water and sediments are also considered a major threat, since a large variety of exotic marine organisms belonging to many taxonomic orders enter the maritime waters of many countries via this pathway. If these organisms find suitable environmental conditions they may reproduce and spread, and may replace natural flora and fauna. If pathogenic organisms (virus, bacteria, parasites) are introduced, they may directly or indirectly affect growth, reproduction and survival of populations of aquatic organisms.

7.4.2 Aquaculture

Aquaculture is unavoidably accompanied by the escape of individuals by accident or intent. If this happens on a substantial scale, either because of mass releases or because of continuous low-level losses from widely cultured species, there can be significant consequences to local populations or species. Problems arise mainly from the spread of diseases, ecological competition and genetic change.

Most of the currently-used aquaculture stock is selected for economically important characteristics. Triploids have been developed for Pacific oyster, rainbow trout (*Oncorhynchus mykiss*) and salmon, as they have good growth characteristics and have been thought to be sterile. However, the ICES Working Group on Introduction and Transfer of Marine Organisms have reported that the introduction of triploidy in Pacific oysters may be incomplete or reverted, resulting in changes in safety. The ICES Working Group on the Application of Genetics in Fisheries and Mariculture has recommended that ploidy manipulation is included in the definition of genetical modified organisms (GMOs).

Genetic changes result *inter alia* from escaped fish interbreeding with native populations. This may cause long-term damage by the loss of genetic diversity and reduction of fitness. Release experiments suggest that populations of anadromous or freshwater organisms are adapted to local conditions and that a genetic change may produce individuals which are less able to survive or reproduce. Salmon used in aquaculture is genetically different from the wild salmon because of crossbreeding and selective breeding. Escaped farmed salmon are capable of spawning in the wild and of having offspring. In addition, escapees are known to destroy spawned eggs in salmon rivers. They may therefore represent a threat to the local genetic adaptation of the wild stocks. In Norway, the overall relative abundance of escapees from aquaculture in the salmon spawning population has varied between 20 and 30% in the last five years, with the highest proportion in regions with a high density of aquaculture installations. However, in some rivers proportions of 80-90% have been recorded.

There is also increasing focus on genetically modified fish for mariculture or other purposes. Atlantic salmon with anti-freeze genes and greatly enhanced growth is currently in use in a secured, self-contained plant in Scotland. Such GMOs may pose a major threat to the wild stocks and could also destabilize aquatic ecosystems. In assessing risks related to GMOs, these threats should be recognized, and there should be a strong presumption against any activity which would risk the introduction of such fish to the wild.

The evolutionary potential of species and populations depends strongly on their level of genetic variability. The introduction of fish for restocking, enhancement or mariculture, (e.g. salmon and sea trout) may lead to loss of genetic diversity within and between natural populations either directly or through escapees. Moreover, genetic differences may lead to a replacement of natural populations of the same species, both if the newly introduced species are more opportunistic and successful competitors for food and other resources, or if indirect effects cause a sustained reduction in the success of the native stock at critical stages of its life cycle.

7.4.3 Stock Enhancement

Stock enhancement has been practised for decades for several marine and anadromous fish. Recent experience from projects with various species, including salmon and cod, has encouraged scientists and fisheries managers to consider the use of stock enhancement. Different enhancement techniques have been tested and examined in order to facilitate development of suitable methods which could be used for various purposes such as increased productivity from existing fisheries, establishment of new fisheries and protection of threatened species.

There is a lot of interest in the ongoing development of stock enhancement and many new pilot projects are presently being planned. The reason for this is the growing concern regarding the poor condition of many commercial fish stocks and especially the level of the ongoing overfishing of juvenile fish.

From an ecological perspective, the proposed enhancement activities are associated with considerable risks including genetic erosion. The release of large numbers of hatchery reared juveniles has the potential to impact the stability of ecosystems, both through changes of the ecological equilibrium or the genetic constitution of the wild fish, and through spread of severe fish diseases and parasites.

Although stock enhancement may be appropriate in some situations, it is important that they should not be used as a substitute for effective adjustment of fishing capacity and practices. Enhancement activities cannot be considered as sustainable management for rehabilitation of overfished stocks. There is a need to assess the biological and ecological effects of enhancement activities on the marine ecosystem and the benefits of such practices before any large scale projects are launched.

7.4.4 Measures to Reduce Negative Impacts

Transfers and introductions of aquatic non-indigenous species and genetically altered stocks are the subject of a code of practice jointly issued by ICES to cover marine organisms and European Inland Fisheries Advisory Commission (EIFAC) for freshwater. This code has recently been revised. Although the code has no legislative force, countries which are members of ICES and EIFAC have agreed to abide by its conditions and some now have, or are introducing, appropriate national legislation. Even countries which are outside ICES and EIFAC areas are adopting at least part of the code into local laws.

To control the risk of introduction of exotic diseases and parasites, the code requires that the imported organisms are pathogen-free and are then reared to maturity in quarantine facilities where all effluents are sterilized. Regular pathogen screening of the broodstock and the progeny ensures that first generation offspring are only transplanted into the open environment if they are entirely free of diseases and parasites. The organisms originally imported are never removed alive from quarantine. But despite legislation designed to prevent the introduction of exotic diseases, there are examples where transfers of salmon have introduced diseases like furunculosis and parasites like *Gyrodactylus.*

The escape of fish from fish farms is a serious threat to the genetic variability in wild fish populations of farmed species in the North Sea. The production of sterile fish may eliminate this problem but today no such strains are available. The development of commercially viable strains of sterile fish seems to be a future option.

Other measures would be the improvement of security and husbandry in culture facilities and site locations. The use of locally-derived populations will also reduce the potential for ecological and genetic damage to native stocks. Cost-effectiveness, insurance requirements and legislation will all contribute to ensuring that the number of organisms escaping and their potential for influencing local populations will be reduced.

The ballast water released at a wide variety of locations when cargoes are being loaded or fresh ballast is taken on board may contain a wide variety of exotic species. The Marine Environment Protection Committee (MEPC) of the International Maritime Organisation (IMO) adopted in 1991 Guidelines for Preventing the Introduction of Unwanted Aquatic Organisms and Pathogens from Ships' Ballast Water and Sediment Discharge. The implementation of these guidelines, however, varies greatly between countries. Additionally, nearly all countries have issued regulations on the use or deliberate release of genetically modified aquatic organisms as well as on the introduction of non-native species.

7.5 User Conflicts

The North Sea area provides a rich diversity of habitats for biota which may be the subject of conflicting user interests. Such conflicts could be related to a number of different activities such as coastal protection measures and harbour installations, land reclamation, coastal and offshore industrial installations, extraction of sand and gravel, disposal of waste and dredged material, mariculture and recreation. Military activities resulting in weapon and munition dumps may have a negative effect on the marine environment and seafood quality, and pose a health and safety risk to those who work at sea. Disturbances and effects of such human activities may be permanent or temporary and can be categorized as resulting in changes in habitat size or changes in habitat conditions, or combinations thereof. Most of the above-mentioned activities will, however, only have local and limited influence on fisheries. Therefore, only those activities which are believed to be of significant importance for fisheries will be touched upon.

The North Sea is an important source of mineral aggregates. The amount of sand and gravel taken from the marine areas has been about 34 million tonnes annually in recent years. Aggregates of marine sediments are required principally for construction purposes, land reclamation and beach replenishment schemes. As acceptable landbased sources are being diminished, pressure is increasing to meet the demand using marine deposits. In turn this leads to greater potential for conflicts between the marine aggregate extraction industry and other users of the ocean, in particular the fisheries.

Extraction of marine aggregates has both physical and chemical impacts as well as biological impacts on the environment. Studies have shown that the benthic biomass can be drastically reduced following extraction activities and that the recovery of the benthos may take ten years or more.

Direct physical destruction of the coastal spawning and nursery areas is caused by various filling, dredging and sand aggregate activities in the coastal zone.

These activities have the potential to ruin shores and seabeds and damage biotopes, animal and plant life. Shallow banks and soft bottom areas, which constitute important spawning and nursery areas for many commercial fish species, are of particular importance for the present condition of the marine ecosystem.

However, estimates of the scale of the effect of aggregate extraction on marine life and fisheries suggest that, unless spawning grounds are disturbed, the overall effects on fish stocks are likely to be negligible although there may be areas of local significance.

The offshore oil and gas industry has become a major economic activity in the North Sea since the late 1960s. About 300 platforms are producing the oil and gas which are transported by about 10 000 km of pipeline across most areas of the North Sea. It is quite clear that this offshore activity has reduced the area available for fisheries.

Seismic surveys are used to prospect for oil-bearing strata under the North Sea. Survey vessels follow planned tracks over zones of interest, emitting acoustic pulses from air guns, and detecting the echoes on a long towed array of hydrophones. Fishermen have expressed concern for some time about the effects of these surveys. Seismic investigation may have impacts on single fish or fisheries activities through direct physiological effects or through influence on behaviour. The possible physiological effects occur only within a few meters from airguns, and are more pronounced during the early life stages of the fish as eggs, larvae and fry. Behaviour impacts are seen on fish in later stages and on adult fish.

Recent studies have shown that seismic surveys with airgun shooting scare the adult fish and may result in temporary catch reduction in the surrounding area. Fish on spawning migration or at the spawning grounds may avoid seismic sounds in similar ways as other adult fish. Even though seismic shooting may kill or damage fish eggs and larvae at a distance of a few meters from the air guns, this additional mortality has been found to be insignificant at stock level.

8

Towards a New Management

Fisheries management policies must be supported by the political will to make them sufficiently strict, to implement them fully and to enforce them comprehensively. If not, it cannot be expected that fish stocks will be maintained within biologically safe limits or that associated negative effects on other biota will be minimized. Ministers agree that it is necessary to redouble effort to develop sustainable management policies, to implement them fully and enforce them comprehensively, and to seek to deepen and broaden support for sustainable and effectively applied fisheries policies from the public and the fishing industry.

(The Esbjerg Declaration, Article 15.)

8.1 Summary

Ecosystem considerations in the management of North Sea fisheries have until recently played a minor role and have in general been restricted to multispecies interaction between fish stocks. Assessment of multispecies interaction has major implications for the long-term management of the North Sea ecosystems, but is of less importance in the year by year management of single fish stocks. Due to the present state of scientific knowledge and the complexity of the North Sea ecosystems, biological interactions between species are usually not incorporated into annual scientific recommendations on catch levels. There is scope for a broadening of the ecosystem considerations in fisheries management in the future.

The fisheries management measures that have been adopted have only partially succeeded in obtaining an appropriate balance between fishing effort and the available fish resources. As a result many stocks are subject to overfishing and could be in danger of being depleted. In order to meet such problems, pre-agreed management measures could be applied when the state of a stock is approaching biological limit reference points. In the context of the bilateral Norway-EU fisheries agreement, mid-term management objectives have been set for mackerel, herring and plaice. However, these are the few exceptions to the general pattern that there exist no concrete long-term management objectives for fisheries management in the North Sea. EU and Norway have agreed that there is a case for broadening the scope of the system of exchange of information on catches and landings in order to reduce the risk of overshooting quotas and improve the basis for future scientific advice. The adoption of selective techniques by the fishing industry should be encouraged in order to reduce the risk of unwanted by-catch such as by-catch of juvenile target species and other organisms.

With regard to the environmental management, ecosystem considerations have played an increasing role in objectives and decision-making over the last 20 years as the general understanding of ecosystem components and effects of pollution upon them has improved.

An integrated ecosystem approach in North Sea management could be defined as seeking to consider all significant factors that affect species and populations within the ecosystems, including the effect of fishing activities. This would mean that both scientists in their advice, and fisheries managers when making decisions concerning commercially important species, have to take other groups of organisms into account. It also means that environmental managers should take account of the problems in fisheries resulting from pollution and the introduction of non-indigenous organisms. An important part of the ecosystem approach is that management should be based upon the best available scientific knowledge of the functioning of the ecosystem.

Area protection is one way of protecting the diversity of ecosystems in the North Sea and of the associated species and their habitats. Two types of area protection are presently in use in the North Sea:

i) areas assigned to protect certain species or habitats such as nature reserves and
ii) areas closed permanently, or seasonally to certain activities including fisheries (e.g. the «plaice box»).

The application of such protected and closed areas could be an important part of the future management of the North Sea, as it has been for a number of years.

Socio-economic factors have often been given as a reason for not effecting necessary management measures in fisheries. Effort is now being geared towards increased cooperation between the fishing industry and local communities along the North Sea coasts. More knowledge with regard to the socio-economic context of fisheries management would help the understanding of the consequences of different fisheries management measures.

Support from the fisheries sector is essential for integrated fisheries management to be succesful. Co-management could be used as an instrument to achieve this support. This implies in the first place involvement of the interested parties (including environmental organizations) in the decision-making process. The application of the instrument of co-management could be further elaborated, taking into account the differences between the several North Sea states.

Future management of the North Sea ecosystems could be based on the following elements:

- **Elaboration and implemention of an ecosystem approach;**
- **Implementation of the precautionary approach;**
- **Establishment of medium and long-term objectives including target and limit reference points;**
- **Preparation of recovery plans for depleted stocks, threatened species or habitats;**
- **Development of stock management strategies including pre-agreed measures; and**
- **Encouragement of greater responsibility and commitment by the fisheries sector and other interested parties.**

8.2 Introduction

In order to meet the challenges described in the previous chapters there is a need to look for new management tools and methods.

Apart from the impact of fishing activities, the marine environment and the living resources are under pressure from many other human activities. Pollution from the catchment area transported via rivers as well as pollution and litter from ships can severely effect the North Sea. Sand and gravel extraction, aquaculture, coastal construction work and offshore oil and gas installations also represent a strain on the marine environment and its resources. The total effects of all these activities make the ecosystems vulnerable and thus make it important to take precautions when management decisions are taken.

This chapter highlights some of the challenges and possible management tools in relation to the future North Sea management such as: an integrated fisheries and environmental management of the North Sea, establishment of long-term management objectives, establishment of recovery plans for depleted stocks or threatened species or habitats and possible pre-agreed actions in order to avoid crisis situations in the fisheries. Future regimes will also need to further develop management objectives, including setting target and limit reference points for the different fish stocks.

8.3 Towards Integration of Fisheries and Environmental Objectives

The primary aim of the North Sea management is to ensure sustainable, sound and healthy ecosystems, maintain biodiversity and ensure sustainable exploitation of the living resources in order to achieve economically viable fisheries.

An important part of integrated fisheries and environmental management for the North Sea should be the development of long-term management objectives in order to conserve the biological diversity and the fish resources for the future generations, thereby ensuring inter-generational equity. In setting management objectives, these should also cover species other than fish species. The setting of management objectives is the responsibility of managers, but scientific and industrial advisory bodies should play an important role in this process by identifying and analysing the most reasonable types of objectives and targets available to managers, particularly those which would accelerate rebuilding and enhance sustainability. In such a process, precaution should be reflected in any targets and objectives set and these objectives should be both quantifiable and quantified.

The involvement of interested parties like fishermen, scientists, managers and industry should lead to better understanding on all levels and may help to solve environmental and socio-economic problems.

The basis for development of integrated management objectives is the concept of biological diversity (mentioned in Chapter 5.7), the precautionary approach and the ecosystem approach.

8.3.1 The Precautionary Approach

The Esbjerg Declaration states that the precautionary principle is the guiding principle to achieve the objective of a sustainable, sound and healthy North Sea ecosystem. The scope of application of the precautionay principle has been successively broadened from toxic substances to natural substances released in large quantities such as nutrients, to all emissions responsible for global warming. Since the early 1990s, the precautionary principle has been progressively accepted and widened to encompass the management of fisheries.

Sometimes it seems difficult to distinguish between the precautionary principle and the precautionary approach. The latter term will be used in the following.

The need for a precautionary approach to ocean management was stressed in the Rio Declaration and in Agenda 21. The principle 15 of the Declaration states that «in order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.»

The agreement from the UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks gives the general provisions relating to the precautionary approach (Article 6). FAO started the preparations of a Code of Conduct for Responsible Fisheries in 1992 and finalized it in 1995. The code includes a section on the precautionary approach which is being progressively reflected in fisheries management.

The Government of Sweden, in close co-operation with FAO, held a Technical Consultation on the Precautionary Approach to Capture Fisheries and Species Introduction in Lysekil, Sweden, 6-13 June 1995. It highlighted that the requirement to deal explicitly with uncertainty, in order to reduce risks to the resources and their environment (and indeed to the fishing communities), necessitates significant changes in the field of science, technology and fisheries management, and a set of possible applications of the precautionary approach in the fisheries management was suggested.

The precautionary approach concept is still under development, one of the issues being how to implement the precautionary approach in the North Sea fisheries management. As a part of the preparations for the Intermediate Ministerial Meeting, Norway hosted a seminar on the Precautionary Approach to North Sea Fisheries Management in Oslo 9-10 September 1996.

The main conclusions from the seminar can be summarized as follows:

- Most of the important commercial fish stocks in the North Sea are fully exploited or overexploited and cannot be regarded as being managed in accordance with the precautionary approach;
- Increased dialogue between all those with a legitimate interest in a fishery is an important ingredient of a precautionary approach;

- Target and limit reference points should be agreed and mechanisms established for applying pre-agreed measures when stock levels approach these reference points;
- It is essential to prepare and implement restoration plans as soon as possible for a number of fish stocks; and
- The poor reliability of reported catch and effort data has been recognized as a major problem in providing scientific advice on fisheries in recent years.

There is a need to implement the precautionary approach in future fisheries and environmental management of the North Sea.

8.3.2 Ecosystem Approach

An ecosystem approach involves considering all the physical, chemical and biological variables within an ecosystem. In the management of living resources this means that the decisions are based upon the best available scientific knowledge of the functions of the ecosystem, including the interdependence of species and the interaction between species (food chains) and the abiotic environment, as well as knowledge of the temporal development of the ecosystem. It could therefore imply a widening of the multispecies approach, currently used in fisheries, to encompass not only fish but also other organisms which directly or indirectly depend on fish or on which fish depend, as well as other significant biotic and abiotic environmental factors.

The need for an ecosystem approach to resource management has been recognized both by scientists and managers. This would mean that both scientists in their advice, and fisheries managers when making decisions concerning commercially important species, have to take other groups of organisms into account. It also means that environmental managers should take account of the problems in fisheries resulting from pollution and the introduction of non-indigenous organisms, and the protection of other biota. Effective management from an ecosystem perspective requires knowledge about the main driving forces for *inter alia* changes in the biomass production. Improved knowledge of the underlying biological interactions such as food chains will provide a basis for better management practices in response to fluctuating but interlinked stocks.

There is a need to further elaborate and implement the concept of an ecosystem approach in future fisheries and environmental management of the North Sea.

8.4 Towards Integrated Management

The North Sea should be seen as a whole and managed as one ecosystem. Any future ecosystem approach to the North Sea management would imply that management decisions are based on the precautionary approach, taking into account all ecosystem effects of human activities as well as the impact of the environment on its resources. What might be the steps for the further development of an ecosystem approach in the North Sea management? Future management could be based on interdisciplinary advice taking into account e.g. the biological, oceanographical and socio-economic aspects. This would include the application of multispecies models where environmental factors as well as non-commercially exploited organisms are included in the scientific advice. Spawning and nursery areas could be given higher priority when establishing protected areas both on a national and international scale.

One of the most urgent issues in the process towards a sustainable use of the marine resources is the further integration of environmental objectives and fisheries policy. Physical planning, coastal zone management and fisheries are relevant policy areas where the need for integration is obvious. The integration should take place not only on the local level, but also in national legislation, as well as in international agreements and decisions. Such an integration is, however, often difficult to achieve. Sectorized decision-making and lack of knowledge about effects on the marine ecosystem of different activities in the relevant fora are important obstacles in this context.

Conflicting interests often result in demands for scientific justification for measures, often with reference to lack of data, lack of reliable data, and lack of ability to give a scientifically reliable and representative account of the actual situation or a prediction of the future situation. However, the understanding of the ecosystem components and the effects of pollution on the ecosystems have improved, and ecosystem considerations have therefore played an increasing role in the management objectives and decisions of the environmental management bodies over the last 20 years. Ecosystem considerations will play an increasingly important role in the future management of the North Sea.

While legislation in the North Sea states only in part reflects an «ecosystem approach» to the protection of the marine environment, there has been a clear development since the first environmental measures were introduced in the 1970s in the wake of the 1972 UN Conference on Environmental Protection.

The approach has gradually changed from addressing primarily the question of discharges of pollutants, to one which takes into account the impact of all human activity on the ecosystem and natural resources. Account is also taken of the complex way in which effects are transmitted, (*inter alia* through transportation and transformation of pollutants), focusing on ecosystem effects and resource conservation rather than on singular effects only. Both the European Community legislation and the Norwegian legislation reflect this approach.

The European Commission has in 1996 issued a draft proposal for a Council Directive establishing a Framework Directive for European Community Water Policy, proposing further reform of Community water legislation by integrating the management of surface and groundwater. The Directives' environmental objectives for surface water status, comprise both the ecological status and the chemical status. The ecological status is an expression of the quality of the structure and function of aquatic ecosystems. It takes into account the physical and chemical nature of water and the physical structure of the water body, but it concentrates on the condition of the biological elements of the ecosystem. When the Directive is implemented there will be a coherent and consistent framework to address the protection of the aquatic environment, integrating the requirements which have to be made in order to conserve resources and species and their habitats in rivers and coastal waters.

The new 1992 OSPAR Convention which is expected to enter into force in 1997 has been considered as an integrated tool for the protection of the environment of the northeast Atlantic. In this spirit, a new Annex to the Convention relating to the protection of species and habitats is being developed.

8.5 Socio-economic Aspects

As explained in Chapter 4, the adaptation of fleet capacity and effort to available resources has not been universally successful. There is overfishing of a number of important stocks and vessel efficiency continues to increase («technical creep»). There is also a development towards a slimmed down fleet of large super-vessels (highly centralized, low employing). All these factors have major socio-economic implications for coastal communities, employment and fisheries management.

The North Sea fisheries sectors and coastal communities will face difficult times ahead with the effort reductions implicit in restoring stocks in relation to Safe Biological Limits and in keeping them there. Management strategies for the reduction of negative impacts on fishery dependent communities should be part of the future management of the North Sea. Such strategies could include the provision of alternative employment outside the fisheries sector, re-education or financial compensations. In order to evaluate the socio-economic consequences of future effort reduction measures in the fisheries, the amount of information on socio-economic issues available for the North Sea area should be increased.

8.6 Strategies and Actions

In order to ensure a sustainable development of the North Sea ecosystems with their living resources, the precautionary approach and an ecosystem approach should also be reflected in the development of plans for future strategies and actions.

For managers to be able to evaluate the development of the North Sea ecosystems in the future, time-series based on regular scientific surveys could be elaborated.

The need for developing new integrated management objectives was discussed in Chapter 8.3. An important follow-up of such objectives is the elaboration of associated management strategies for all commercial stocks in the North Sea. Elements in such future management strategies are reflected below.

8.6.1 Adaptation of Fleet Capacity and Effort

One of the fundamental challenges for all fishery management is to obtain an appropriate balance between the available fish resources and the deployed fishing effort. The main problem is the general overcapacity in the fleets, and this is probably the main reason why fisheries management of the North Sea has not been successful. Although schemes to reduce capacity have been applied, the reduction has been compensated by an increase in efficiency, with the result that no reduction in fishing pressure has been achieved. Fishing effort by the existing fleets is partly regulated under present systems, but outputs are the basis for control. Output control does not, however, in itself control fishing effort. The development of strategies and actions for adaption of fleet capacity and effort to available fisheries resources has started and is described in Chapter 4.4.

8.6.2 Establishment and Application of Reference Points

It is recognized that the sustainable utilization of living resources should be based on scientific advice. An important aspect of advice is the provision of target and limit reference points which may apply both to the size of the stocks and to the level of exploitation of them. There is a growing recognition of the need to set limits reference points that specify biomass levels greater than MBAL. Reference points can be used, for example, in determining an upper limit to the fishing pressure on a stock or in setting TACs, as described in Chapter 4.5.2. For many stocks reference points have not yet been established and it is important that the concept of reference points should be implemented for more North Sea stocks in future in the context of the precautionary approach. This would facilitate the adoption of pre-agreed measures described further in Chapter 8.6.7.

8.6.3 Improved Fisheries Technology

Although the need to protect young fish has been recognized in many management measures implemented in the last few decades (e.g. mesh size limits, minimum landing sizes and by-catch regulations), most emphasis has been placed by gear technologists on improving catching efficiency. However, over the past decade the emphasis has shifted to improving the selectivity of fishing gear. It is important that this is continued. Norway has for several years put a lot of effort into developing sorting grid systems for different types of fisheries.

In June 1996 the European Commission presented its new proposal on technical conservation measures to the Council of Ministers. The new regulation includes a combination of minimum mesh sizes and associated percentages of target species, and it also contains a number of new provisions aimed at increasing the conservation effect, e.g. the mandatory use of square-meshed panels and the mandatory use of sorting grids or separator trawls in shrimp fisheries. The aspect of long-term profit resulting from a sustainable utilization of living resources, could motivate the fishing industry to apply better gear and fishing practices on a voluntary basis in the future.

In the future, more emphasis should be put on developing gear types and fishing techniques which reduce negative impacts on non-commercial species and their habitats. In line with the precautionary approach, novel gear types should be thoroughly tested before being applied in the North Sea fisheries. Further details on gear selectivity and their impacts on species and habitats can be found in Chapter 4.5.5 and Chapter 6.

8.6.4 Improved Control and Enforcement

The existing control and enforcement system and the problems related to enforcement are described in Chapter 4.5.4. All relevant authorities agree that there is considerable potential to improve the control and enforcement, and this should receive further consideration. To strengthen the co-operation on control and enforcement, the EU and Norway have agreed that there is a case to broaden the scope of exchange of information on catches and landings, including third country landings, in their respective ports. This co-operation will be accompanied by improved contact between relevant authorities and exchange of observers.

8.6.5 Co-management and Transparency

Co-management has been explained in a OECD study: «Central to the idea of cogovernance is that the meso and micro level of society should participate significantly more in governing. Citizens and «stakeholders» should more actively be involved in the formulation and implementation of public policies. Co-management implies a less legalistic approach of governing at the micro level, leaving more discretion to individuals and firms to adapt their conduct to «the spirit of some public policy».»

A more holistic approach to the management of the North Sea could open up for the involvement of interested parties in different sectors and on different levels. This will secure a better foundation for management decisions and may also help to solve or at least enlighten socio-economic problems and relationships.

Participation from all with a legitimate interest in the conservation and management of fish stocks should be an important ingredient of the fisheries management. To ensure a better understanding of – and compliance with – management measures, a well-functioning system for co-operation and communication between managers, scientists and interested parties is essential. This could *inter alia* involve consultation with fishermen at different levels and with the representatives of the industry and other interested parties in national and international fora.

In fisheries management, enforcement is an essential part. A particular problem for fisheries is that an individual willing to restrict his fishing activities often is exposed to the risk that his colleagues will continue as before. One way to resolve this problem, at least partially, is to apply co-management as a management tool.

In 1993 the Dutch government introduced a co-management scheme in the fishery sector and this has worked out very well. It was generally felt that co-management can be successful in managing fisheries at a local and national level but is yet to be tested internationally. The Netherlands held a workshop on co-management in Groningen 9-10 January 1997. The conclusions from this seminar were:

- Co-management involves two main ingredients, i) consultation between central administration and user/interest groups over the content of the management strategy, ii) delegation of specific management functions to these groups on the appropriate levels;
- Co-management requires an integrated relationship between administration, fishing industry and environmental interests at all levels of decision-taking;
- Co-management cannot be brought into being through legislation but rather through consultation and agreement; and
- Co-management is expected to help to achieve greater integration of fisheries and environmental policy, and to encourage greater responsibility and commitment by the fisheries sector to policy and management decisions.

8.6.6 Area Protection

Management measures such as area closures for fisheries management and area protection are already in use as described in Chapter 4 and 5. The need for real-time management i.e. short-term closure in response to particular problems such as excessive by-catches of young fish, could be explored and utilized. The full effects of completely closed areas for wider environmental purposes are difficult to assess. Attempts to evaluate this have been made in recent years. However, it is not always possible to develop models for different relevant theoretical problems, particularly in relation to the migration of fish between areas. Further research is required.

The European Commission's new proposal on technical measures contains amendments to existing conditions for closed areas as well as new closed areas.

There are plans to establish coastal marine areas in Norwegian territorial waters in the North Sea. Representativity and rareness have been the main criteria when selecting suitable localities for protection purposes. It will, however, take about 3-5 years to work out a formal proposal for protection.

As mentioned in Chapter 5 there are no protected offshore areas in the North Sea. The protection of marine habitats and species beyond territorial waters should therefore be considered further.

8.6.7 Pre-agreed Measures

In applying the precautionary approach in the management of fisheries, the setting of pre-agreed measures are essential and this applies whether stocks are above or below agreed limit reference points. Such pre-agreed measures prescribe the actions to be taken when particular reference points are reached or approached, when these actions are to be taken and by whom.

In defining pre-agreed measures a number of early warning signs of impending problems can be identified. In addition to reference points such as the Minimum Biologically Acceptable Level, potential problems may be indicated by:

- Changes in environmental factors known to affect the living conditions of fish and particularly their survival in the early part of their life history;
- Changes in the spatial distribution of a stock and in the extent of the spawning areas which may be related to the abundance of the stock;
- Changes in catch-per-unit-effort in the fisheries which are also related to abundance; and
- Changes in the abundance of other species which indicate the general conditions in the sea.

Examples of the type of pre-agreed measures that might be considered are temporary closure to enable the stock situation to be monitored and reductions in catch levels.

8.6.8 Recovery Plans

In the present situation several commercially important fish stocks are at very low levels and the need for recovery plans for depleted stocks is apparent. If a stock is outside Safe Biological Limits, management measures should be applied in order to rebuild the stock, and must include measures to reduce the fishing mortality. The specific measures and duration of any recovery plan depend *inter alia* on the biological characteristics of the stock, such as recruitment, individual growth and natural mortality. Recovery plans may also include species of no commercial importance and habitats.

8.6.9 Improved Reporting

Scientific advisory bodies like ICES have expressed grave concern over poor reporting as an increasing problem for reliable stock assessment. As most fisheries assessments depend on reliable fisheries statistics, the assessments and corresponding management advice may be severely hampered by misreporting. Improved and accurate reporting from fisheries is therefore a pre-requisite in responsible fisheries management, and systems to safeguard proper reporting schemes should therefore be implemented in all fisheries. The poor reliability of reported catch data will require continued attention by the authorities involved.

There is also limited knowledge on the effect of fishing on non-target species and other components of the ecosystem. This could *inter alia* be improved by including more detailed information on by-catch in the catch reports.

At present, limited data are available on socio-economic factors. A number of economic studies have been carried out but there is a need for further work in this area. It is important that such data and analysis are incorporated in the advisory process, and that estimates of the reliability of the outputs are provided.

9

Need for Enhanced Knowledge

This part is intended to address and summarize the need for research and improvement of knowledge identified in the previous chapters.

9.1 Basic Ecological Knowledge

- Enhance the knowledge on non-commercially exploited species.
- Study the long-term effects of the change in the community structure with a shift from long-lived species to short-lived species, and in certain areas, the decrease in species diversity, in particular the decrease in large species of fish and some species of benthos (e.g. *Arctica islandica*).
- Study the interactions (predation, production and competition) between fish, mammals, seabirds and other types of organisms.
- Enhance the knowledge of interspecies relations between the main commercially exploited species (who eats who?) and the possible interactions with other organisms.
- Study the ecological effects of elevated population levels of scavenging seabird species.
- Study the stock size, population structure and distribution of sandeel and the importance of sandeel in the North Sea ecosystems.

9.2 Ecological Effects of Fisheries

- Study the impact of fisheries on the whole ecosystem. Undisturbed areas established for scientific purposes could be an important step to enhance such knowledge.
- Study the recolonization of the seabed and the recovery of damaged habitats.
- Enhance the knowledge on the effect of damage to habitats and communities caused by some demersal gear (notably beam trawl in flatfish fisheries).
- Further research on selective gear both with regard to size and to species.
- Study the effects of the high by-catches of many non-commercially exploited species of fish, shellfish and some benthic species.
- Study the effects of the return to the sea of large quantities of dead organic material (discards and offal).
- Study the effects of fisheries on seabirds and other organisms as a result of reduction in food supplies (competition for resources).
- Study the amounts and effects of unaccounted fish mortality such as that caused by non-recorded catch and discards, lost gear and fish escaping through the gear.
- Study the extent and effect of accidental by-catch of sea birds and marine mammals.

9.3 Other Human Effects on Fisheries and its Resources

- Investigate the needs, effects and consequences for fisheries of establishing offshore protected areas as a means of protecting species and habitats.
- Enhance the knowledge on the biological effects of contaminants, such as persistent organics, hormone-like substances, trace metals and petroleum hydrocarbons on the ecosystem, both on North Sea scale and on a more local scale.

9.4 Socio-economic Aspects

- Enhance the knowledge on all socio-economic aspects related to fisheries.
- Research the possibilities to enhance support from interested parties for integrated fisheries management.
- Research the possibilities of the application of co-management systems.

ANNEX I

Terminology

Alien species: Non-indigenous species or non-native species.

Advisory Committee on Fishery Management (ACFM): See ICES

Beam trawl: A tapering bag of netting which can be towed over the seabed. The mouth of the bag is held open by a long beam, the ends of which are supported above the seabed by a pair of strong metal runners. The underpart of the bag, which drags over the bottom, is attached to a groundrope. Sometimes beam trawls are fitted with tickler chains which plough up the bottom in front of the groundrope, so that fish in the sediment cannot escape by letting the net ride over them.

Benthos / Benthic species: Species (plants and animals) that live near, on or in the seabed. Macrobenthos: the fraction larger than 1 mm. Epibenthos: animals sessile or moving about on the seabed.

Biological reference points: A biological reference point is a value of fishing mortality (F) or stock size estimated through agreed scientific procedures. The values correspond to states of the fishery or the stock and are increasingly being used in fishery management advice. An example of a biological reference point used to indicate the state of a stock is MBAL (Minimum Biologically Acceptable Level), representing a level of spawning stock size used by the International Council for the Exploration of the Sea (ICES) to identify those stocks that may be in danger of severe depletion if they are not allowed to rebuild as quickly as possible.

It is usual to distinguish between two types of biological reference points: limit reference points and target reference points. Limit reference points set boundaries which should not be crossed and which are designed to keep the stock within Safe Biological Limits. Target reference points refer to harvesting strategies which may optimize the fishery within Safe Biological Limits, e.g. by giving the maximum sustainable yield. However, a clear distinction is not always made between limit and target reference points in management.

Examples of limit reference points are MBAL (Minimum Biologically Acceptable Level) representing a level of spawning stock size below which it is unwise to go, and F_{med} representing a maximum level of sustainable fishing mortality. Target reference points are F_{MSY}, F_{max} and $F_{0.1}$, which are designed to maximize or optimize the yield (see explanation below).

The most widely used reference points are derived from analysis of yield per recruit, spawning stock biomass per recruit, production models or stock and recruitment relationships.

The most common reference points are the following:

F_{max}: the fishing mortality rate which correspond to the maximum yield per recruit as a function of fishing mortality. This value is often difficult to estimate because of the flat-topped shape of the Y/R-curve, therefore $F_{0.1}$ is often preferred.

$F_{0.1}$: the fishing mortality rate at which the slope of the yield per recruit curve as a function of fishing mortality is 10% of its value near the origin. $F_{0.1}$ is always lower than F_{max}.

B_{msy}: the biomass corresponding to a maximum sustainable yield as estimated from a production model.

F_{msy}: the fishing mortality rate which corresponds to the maximum sustainable yield as estimated by a production model. MSY is the yield that should result if that exploitation level were maintained until equilibrium is reached.

F_{low} represents a level of F at which recruitment has been sufficient to balance the mortality in about 9 out of 10 years. The likelihood of a decline in the stock at this level of exploitation is therefore low.

F_{med} corresponds to the level of F where recruitment in half of the years has been sufficient to balance the mortality. There should therefore be a good chance of sustainability at the F_{med} fishing level. Long-term considerations have shown that little is gained by increasing F above F_{med}.

F_{high} represents a level of F where recruitment has not been sufficient to balance the mortality in about 9 years of 10. Exploitation at this level is therefore likely to result in a decrease in the stock.

All the above reference points are concerned with the level of fishing mortality. The stock size reference point presently most referred to is the Minimum Biologically Acceptable Level (MBAL).

The Minimum Biologically Acceptable Level of spawning stock size is a reference point used by ICES to identify those stocks that may be in danger of severe depletion if they are not allowed to rebuild as quickly as possible. In the absence of any defined management objectives for fish stocks, ICES chose MBAL as a yardstick to distinguish between those stocks that were considered to be within or outside Safe Biological Limits. This enabled ICES to maintain consistency in its advice on different stocks and from year to year.

MBAL may be defined as that level of spawning stock below which the probability of poor recruitment increases as spawning stock size decreases. The implications of a stock going below MBAL are potentially serious because any sustained decrease in recruitment can lead to a progressive decrease in the stock, with the possibility of eventual collapse (roughly defined as a decrease to 5% of the unexploited stock size).

The definition of MBAL has proved problematic in many stocks, either because the data are insufficient or because the stock has shown no sign of a decrease in recruitment at any level of stock so far recorded. In the latter case the level of MBAL must be assumed to lie at any level of spawning stock below the lowest level so far recorded. In such cases the lowest recorded level is used by default as an estimate of MBAL.

Biota: All living organisms.

By-catch: Discarded catch plus incidental catch. (Definition proposed by a by-catch workshop in Newport, Oregon, USA in February 1992 (McCaughran 1992).) The by-catch consists mainly of non-target species, but may also include species of commercial interest.

Capacity of the fleet: Catching ability of the fleet.

Closed areas: Areas closed permanently, seasonally or temporarily to certain activities. In fisheries management, flexible closed areas are used to protect juvenile fish and in some cases spawning fish.

Demersal species: Species that live close to the seabed, see benthic species.

Discards: The portion of the catch returned to the sea as a result of economic, legal or personal considerations. (Definition proposed by a by-catch workshop in Newport, Oregon, USA in February 1992 (McCaughran 1992).)

Eutrophic: Enhanced level of nutrients (nitrogen, phosphorus).

Fish: In this report fish may include all fish species and shellfish including crustaceans and molluscs. However, fish may also refer to fish species (*inter alia* cod, herring).

Fishing activity: All commercial activity inside and outside territorial waters in the North Sea in order to exploit fish resources. (Defined after consultations with ICES.)

Fishing mortality rate: The proportion of the stock in the sea that is taken by fishing. Fishing mortality can be expressed as a percentage or as a «fishing mortality rate», an expression of the likelihood that a fish will die at any instance of time. See biological reference points.

Flatfish: Species with a flattened body shape like plaice and sole.

Furunculosis: A bacteria-induced lethal disease mainly affecting salmon. The bacteria causing this is called *Aeromonas salmonicida ss. salmonicida*.

Habitat: For the time being there is no commonly approved definition of habitats. A tentative explanation of the word could be: «Natural environment of an animal or plant.»

The International Council for the Exploration of the Sea (ICES): ICES is the oldest intergovernmental organization in the world concerned with marine and fisheries science (established in 1902) and has eighteen member states on both sides of the Atlantic including all North Sea states except Switzerland. Work organized by ICES is carried out under the Advisory Committee on the Marine Environment (ACME) and ICES Advisory Committee on Fishery Management (ACFM). The latter provides scientific advice on fish stocks.

Incidental catch: Retained catch of non-target species. (Definition proposed by a bycatch workshop in Newport, Oregon, USA in February 1992 (McCaughran 1992).) Nontarget species may in this context also be commercial fish species.

Industrial fisheries: Fisheries for reduction purposes e.g. fish meal and oil. The main fish species caught in this fishery are sandeel, Norway pout and sprat.

Infauna: Animals living in the sediment.

North Sea Task Force (NSTF): The Second International Conference on the protection of the North Sea requested the International Council for the Exploration of the Sea (ICES) and the Oslo and Paris Commissions (OSPARCOM) to establish a task force which would have the following objective: «To carry out work leading, in a reasonable timescale, to dependable and comprehensive statement of circulation patterns, inputs and dispersion of contaminants, ecological conditions and effects of human activities in the North Sea.» A central task was the preparation of a North Sea Quality Status Report (1993 QSR).

The Minimum Biologically Acceptable Level (MBAL): See biological reference points.

Offal: Offal arising from onboard cleaning and gutting of fish and dumped into the sea.

Otter trawl: The otter trawl has a bag of netting resembling that of the beam trawl in general shape, but considerably larger. The sides of the bag are extended outwards by the addition of wings of netting attached to large, rectangular «otterboards». The pressure of water causes the otterboards to diverge as they move, pulling the mouth of the net wide open horizontally. The groundrope is a heavy, steel-wire rope, carrying on its central part a number of large steel bobbins, about 60 cm in diameter, and on its lateral parts several large rubber discs. These help the trawl to ride over obstructions on the seabed.

Precautionary principle / Precautionary approach: See Chapter 8.3.1.

Protected areas: Areas assigned to protect certain species or habitats such as nature reserves.

Pelagic species: Species that typically live well above the seabed.

Polychlorinated biphenyls (PCBs): A group of chlorinated organic compounds which have sub-lethal effects, are slowly degradable, bioaccumulate in organisms and are biomagnified in the food chain. Used in condensers, hydraulics, transformers, paints, concrete etc.

Polycyclic aromatic hydrocarbons (PAH): From emissions and discharges of oil, incomplete combustion processes and industrial effluents.

Plaice box: See Chapter 3.4.1 under «plaice» and «closed areas» above.

Plankton / Planktonic organisms: Small organisms with low ability of moving, *inter alia* drifting with the watercurrents.

Roundfish: Species with a rounded body shape like cod, haddock, whiting and saithe.

Safe Biological Limits (SBL): When spawning stock size is below the Minimum Biologically Acceptable Level (MBAL) or expected to fall below MBAL in the near future, the stock is considered to be outside Safe Biological Limits.

Spawning stock biomass (SSB): The biomass of the adult population.

Target species: Species at which a fishery is specifically aimed.

Tributyl tin (TBT): Used as an antifouling agent.

Undisturbed areas: Areas established, on an experimental basis, in order to assess the recovery and redevelopment of the marine ecosystem.

ANNEX II

List of Species

ENGLISH	LATIN	FRENCH	GERMAN
Birds:			
Arctic tern	*Sterna paradisaea*	Sterne arctique	Küstenseeschwalbe
Black guillemot	*Cepphus grylle*	Guillemot à miroir	Gryllteiste
Common gull	*Larus canus*	Goéland cendré	Sturmmöwe
Common scoter	*Melanitta nigra*	Macreuse noire	Trauerente
Eider	*Somateria mollissima*	Eider à duvet	Eiderente
Fulmar	*Fulmarus glacialis*	Fulmar	Eissturmfogel
Gannet	*Morus bassanus*	Fou de Bassan	Basstölpel
Great black-backed gull	*Larus marinus*	Goéland marin	Mantelmöwe
Great skua	*Stercorarius skua*	Grand labbe	Skua
Guillemot	*Uria aalge*	Guillemot de Troil	Trottellumme
Herring gull	*Larus argentatus*	Goéland argenté	Silbermöwe
Kittiwake	*Rissa tridactyla*	Mouette tridactyle	Dreizenmöwe
Lesser black-backed gull	*Larus fuscus*	Goéland brun	Heringmöwe
Oystercatcher	*Haematopus ostralegus*	Huîtrier pie	Austernfischer
Puffin	*Fratercula arctica*	Macareux moine	Papageitaucher
Razorbill	*Alca torda*	Pinguine torda	Tordalk

ENGLISH	LATIN	FRENCH	GERMAN
Marine mammals:			
Bearded seal	*Erignathus barbatus*	Phoque à barbe	Bartrobbe
Bottlenose dolphin	*Tursiops truncatus*	Hyperoodon	Nördlicher Entenwal
Common dolphin	*Delphinus delphis*	Dauphin des anciens	Gemeiner Delphin
Common seal (Harbour seal)	*Phoca vitulina*	Phoque commun	Seehund
Fin whale	*Balaenoptera physalus*	Rorqual commun	Finwal
Grey seal	*Halichoerus grypus*	Phoque gris	Kegelrobbe
Harbour porpoise	*Phocoena phocoena*	Marsouin	Schweinswal
Harp seal	*Phoca groenlandica*	Phoque de Groënland	Grönländische Robbe
Hooded seal	*Cystophora cristata*	Phoque à capuchon	Klappmütze
Humpback whales	*Megaptera novaeangliae*	Mégaptrère	Buckelwal
Minke whale	*Balaenoptera acutorostrata*	Petit rorqual	Zwergwal
Pilot whale	*Globicephala melaena*	Globicéphale noir	Grindwal
Ringed seal	*Phoca hispida*	Phoque marbré	Ringelrobbe
Risso's dolphin	*Grampus griseus*	Dauphin gris	Rissos Delphin
Sperm whale	*Physeter macrocephalus*	Cachalot	Pottwal
White-beaked dolphin	*Lagenorhynchus albirostris*	Dauphin à bec blanc	Langfinnendelphin
White-sided dolphin	*Lagenorhynchus acutus*	Dauphin à flancs blancs	Weisseiten-Delphin
Fish:			
Anglerfish (Monkfish)	*Lophius piscatorius*	Braudroie commune	Seeteufel
Bib	*Trisopterus luscus*	Tacaud commun	Franzosendorch
Blue-fin tuna	*Thunnus thynnus*	Thon rouge	Roter Thun
Blue-mouth	*Helicolenus dactylopterus*	Sébaste chèvre	Blaumaul
Blue whiting	*Micromesistius poutassou*	Merlan bleu	Blauer Wittling
Boarfish	*Capros aper*	Sanglier	Eberfisch
Brill	*Scophthalamus rhombus*	Barbue	Brill
Catfish	*Anarihichas lupus*	Loup	Katfisch
Cod	*Gadus morhua*	Morue commune	Dorsch
Common dab	*Limanda limanda*	Limanade commune	Scharbe
Common skate	*Raja batis*	Raie grise	Glattroche
Common sole	*Solea solea*	Sole	Seezunge
Cuckoo ray	*Raja naevus*	Raie fleurie	Kuckucks-rochen
Dogfish	*Scyliorhinus canicula*	Aiguillat	Katzenhai
Dragonet	*Callionymus lyra*	Dragonet	Gemeiner leierfisch
European flounder	*Platichtys flesus*	Flet	Flunder
Four-bearded rockling	*Rhinonemus cimbrius*	Motelle à quatre barbillions	Vierbärtelige See quappe
Greater weever	*Trachinus draco*	Grande vive	Petermann
Greenland halibut	*Reinhardtius hippoglossoides*	Halibut noir	Schwarzer heilbutt
Grey gurnard	*Eutrigla gurnardus*	Grondin gris	Grauer Knurrhahn
Haddock	*Melanogrammus aeglefinus*	Eglefin	Schellfisch
Hake	*Merluccius merluccius*	Merlu	Seehecht
Halibut	*Hippoglossus hippoglossus*	Flétan de l'Atlantique	Heilbutt
Herring	*Clupea harengus*	Hareng commun	Hering
Horse mackerel	*Trachurus trachurus*	Chinchard commun	Stöcker

ENGLISH	LATIN	FRENCH	GERMAN
John Dory	*Zeus faber*	Saint-Pierre	Herings-König
Lemon sole	*Microstomus kitt*	Limanade-sole commune	Echte Rotzunge
Lesser weever	*Trachinus vipera*	Peterman	Vive
Ling	*Molva molva*	Grande lingue	Leng
Long rough dab	*Hippoglossoides platessoides*	Balai de l'Atlantique	Rauhe Scharbe
Mackerel	*Scomber scombrus*	Maquereau commun	Makrele
Megrims	*Lepidorhombus* spp	Cardines	Butte
Mullet	*Mullus surmuletus*	Mulet	Meeräsche
Norway pout	*Trisopterus esmarkii*	Tacaud norvégien	Stintdorsch
Plaice	*Pleuronectes platessa*	Plie commune	Scholle
Pollack	*Pollachius pollachius*	Lieu jaune	Pollack
Poor cod	*Trisopterus minutus*	Petit tacaud	Zwergdorch
Rainbow trout	*Oncorhynchus mykiss*	Truite arc-en-ciel	Regenbogenforelle
Red gurnard	*Aspitrigla cuculus*	Grondin rouge	Kuckucksknurrhahn
Roundnous grenardier	*Coryphaenoides rupestris*	Grenardier de roche	Grenaridierfisch
Saithe	*Pollachius virens*	Lieu noir	Köhler
Salmon	*Salmo salar*	Saumon	Lachs
Sandeel	*Ammodytes* spp.	Lançon	Sandaal
Sardine	*Sardina pilchardus*	Sardine	Sardine
Seabass	*Dicentrarehus labrax*	Bar commun	Meerbarsch, Seebarsch
Sea trout	*Salmo trutta*	Truite	Forelle
Silver smelts	*Osmeridae* spp.	Ésperlans	Stinte
Solenette	*Buglossidium luteum*	Petite sole jaune	Zwergzunge
Sprat	*Sprattus sprattus*	Sprat	Sprotte
Spurdog	*Squalus acanthias*	Aiguillat commun	Dornhai
Starry ray	*Raya radiata*	Raie radièe	Atlantischer stechrochen
Thornback ray	*Raja clavata*	Raie bouclèe	Nagelroche
Turbot	*Psetta maxima*	Turbot	Steinbutt
Tusk	*Brosme brosme*	Brosme	Lumb
Whiting	*Merlangius merlangus*	Merlan	Wittling
Witch flounder	*Glyptocephalus cynoglossus*	Plie grise	Rotzunge
Molluscs			
Common cockle	*Cerastoderma edulis*	Coque commune	Essbar Herzmuschel
Cuttlefish	*Sepia officinalis*	Sèche	Sepia
Dogwhelk	*Nucella lapillus*	Bigorneau	Strandschnecke
Horse mussel	*Modiolus modiolus*	Moule appât	Grosse Miesmuschel
Mussel	*Mytilus edulis*	Moule commune	Miesmuschel
Oyster	*Ostrea edulis*	Huître	Europäische Auster
Rayed trough shell	*Mactra corallina*		
Pacific oyster	*Crassostrea gigas*	Huître creuse japonaise	Passificshe Felsenauster
Quahog	*Arctica islandica*	Cyprine	Islandsmuschel
Queen scallop	*Chlamys opercularis*	Vanneau	Gedeckelte KammMuschel
Razor clam	*Ensis* spp.	Couteau courbe	Schwertförmige

ENGLISH	LATIN	FRENCH	GERMAN
Scallop	*Pecten maximus*	Coquille Saint-Jacques	Pilgermuschel
Slipper limpet	*Crepidula fornicata*		
Spisula(Trough shell)	*Spisula solida* / *Spisula subtruncata*		
Squid	*Loligo* sp.	Calmar	Kalmar
Striped venus	*Chamelea gallina*	Petite praire	Gestreifte Venusmuschel
Tower shell	*Turritella communis*		
Whelk	*Buccinum undatum*	Buccin	Wellhornschnecke
Crustaceans			
Brown shrimp	*Crangon crangon*	Crevette grise	Garnele
Deep sea shrimp (Northern prawn)	*Pandalus borealis*	Crevette nordique	Tiefseegarnele
Edible crab	*Cancer pagurus*	Tourteau	Taschenkrebs
Helmet crab	*Corystes cassivelaunus*		
Hermit crab	*Paguridae*	Pagures	Einsiedlerkrebse
Lobster	*Homarus gammarus*	Homard	Hummer
Norway lobster	*Nephrops norvegicus*	Langoustine	Kaisergranat
Spider crab	*Maja squinado*	Arignèe de mer	Seespinne
Other species			
Dead man's fingers	*Alcyonium digitatum*		
Dinophysis	*Dinophysis* spp.		
Gyrodactylus	*Gyrodactylus salaris*		
Sabellaria	*Sabellaria* sp.		
Sea-mouse	*Aphrodite aculeata*		
Zostera	*Zostera* sp.		

ANNEX III

List of Fish and Shellfish Stocks

currently included in the Report of the ICES Advisory Committee on Fishery Management or managed by TACs and Quotas

The North Sea as defined in this Report (excluding Vb and VIa east of 5°W). A map of ICES areas is included at the end of this Annex. Stocks for which no assessments and/or forecasts are provided are stippled. Stocks considered to be outside Safe Biological Limits are shown by light stippling and bold type.

Fish stock or stock component	ICES Fishing Areas in which the stock is distributed	Type of assessment carried out	Catch forecast provided	State of stock (with reference to Safe Biological Limits SBL)	Corresponding TAC areas (different TACs separated by ;)
North Sea					
Cod	IV, VIId, IIIa (Skagerrak)	Analytical	Yes	**Outside SBL**	IV, EU zone of IIa
Haddock	IV, IIIa	Analytical	Yes	Within SBL	IV, EU zone of IIa
Whiting	IV, VIId	Analytical	Yes	Probably within SBL	IV, EU zone of IIa
Saithe	IV, IIIa	Analytical	Yes	Close to SBL	IV, IIIa, EU zone of IIa & Baltic
Plaice	IV	Analytical	Yes	**Outside SBL**	IV, EU zone of IIa
Sole	IV	Analytical	Yes	Within SBL	IV, II
Herring (autumn-spawners)	IV, VIId, IIIa	Analytical	Yes	**Outside SBL**	IVa,b, EU zone of IIa, IVc,VIId
Downs herring	IVc, VIId	Included in total North Sea	Included in total North Sea	**Outside SBL**	IVc,VIId
Sprat	IV	No assessment	No	Not known	EU zone of IIa & IV
Mackerel (North Sea component)	IV	Analytical assessment for combined stock components	Included in forecast for all northern stock components	**Collapsed**	IV, IIIa, EU zone of IIa & Baltic

Horse mackerel (North Sea stock)	IIIa (eastern part), IVb,c, VIId	No assessment	No	Not known	EU zone of IIa & IV
Norway pout	IV, IIIa	Analytical	No	Within SBL	IIIa, EU zone of IIa & IV
Sandeel	IV	Analytical	No	Within SBL	-
Sandeel	IVa (Shetland)	No assessment	No	Probably within SBL	UK waters at Shetland
Northern prawn (*Pandalus borealis*)	IVa (Fladen Ground)	No assessment	No	Not known	-
Northern prawn (*Pandalus borealis*)	IVb (Farn Deeps)	No assessment	No	Not known	-
Norway lobster (*Nephrops norvegicus*)	IVa (Moray Firth, Noup)	No analytical assessment	No	Fully exploited	EU zone of IIa & IV
Norway lobster (*Nephrops norvegicus*)	IVa (Fladen Ground)	No analytical assessment	No	Not fully exploited	EU zone of IIa & IV
Norway lobster (*Nephrops norvegicus*)	IVb,c (Botney Gut, Silver Pit)	No analytical assessment	No	Fully exploited	EU zone of IIa & IV
Norway lobster (*Nephrops norvegicus*)	IVb,c (Farn Deeps, Firth of Forth)	No analytical assessment	No	Not defined	EU zone of IIa & IV
English Channel					
Cod	VIId	Included in IV	Yes	See North Sea	VIIb-k,VIII, IX, X, CECAF area
Whiting	VIId	Included in IV	Yes	See North Sea	VIIb-k
Sole	VIId	Analytical	Yes	Within SBL	VIId
Plaice	VIId	Analytical	Yes	Within SBL	VIId,e
Norway lobster (*Nephrops norvegicus*)	VIId,e	No reported landings	-	-	VII
Cod (Celtic Sea & Western Channel)	VIIe,f,g,h	Analytical	For total stock area	Close to SBL	VIIb-k,VIII
Whiting (Celtic Sea & Western Channel)	VIIe,f,g,h	Analytical	For total stock area	Within SBL	VIIb-k
Plaice	VIIe	Analytical	Yes	**Outside SBL**	VIId,e
Sole	VIIe	Analytical	Yes	Close to SBL	VIIe
Herring	VIIe,f	-	-	-	VIIe,f
Sprat	VIId,e	No assessment	No	Not known	VIId,e
Skagerrak					
Cod	IIIa (Skagerrak)	Included in IV	Yes	See North Sea	IIIa (Skagerrak)

Haddock	IIIa	Included in IV	Yes	See North Sea	IIIa, EU zone of Baltic
Whiting	IIIa	No assessment	No	Not known	IIIa
Plaice	IIIa	Analytical	Yes	Within SBL	IIIa (Skagerrak)
Sole	IIIa	No analytical assessment	No	Within SBL	IIIa, EU zone of Baltic
Northern prawn (*Pandalus borealis*)	IIIa, IVa East (Skagerrak & Norwegian Deep)	Analytical	Yes	Within SBL	IIIa
Herring (springs-pawners)	Baltic 22-24, IIIa	No analytical assessment	No	Uncertain	IIIa (including North Sea autumn-spawners)
Sprat	IIIa	No assessment	No	Not known	IIIa (Mixed clupeoid TAC)
Norway pout	IIIa	Included in IV	No	See North Sea	-
Sandeel	IIIa	No assessment	No	Uncertain	-
Norway lobster (*Nephrops norvegicus*)	IIIa	No analytical assessment	No	Indications of overexploitation	EU zone of IIIa & Baltic
Widely distributed and migratory stocks occurring in area					
Hake (Northern stock)	IIIa, IV, VI, VII, VIIIa,b	Analytical	For total stock area	Close to SBL	IIIa, EU zone of Baltic; IV, EU zone of IIa;
Mackerel (Western component)	IIa, IIIa, IVa, Vb, VI, VII, VIIIa,b	Analytical assessment for combined stock components	For all northern areas	Not defined	VI,VII,VIIIa,b,d,e, XII, XIV, EU zone of IIa & Vb,
Horse mackerel (Western stock)	IIa, IVa, Vb, VIa, VIIa-c, ek, VIIIa,b,d,e	Analytical	Yes	Not precisely defined	VI,VII,VIIIa,b,d,e, XII, XIV, EU zone of Vb; North Sea catches included in North Sea TAC
Blue whiting	I-IX, XII, XIV	Analytical	Yes	Not precisely known	TAC recommended for NEAFC regions 1 & 2 (TAC set for EU zone of IIa & IV)
Deep-water resources	Deeper parts of IIIa & IV	No assessments	No	Not known	-
Blue ling	Widely distributed	No assessment	No	Not known	-
Ling	Widely distributed	No analytical assessment	No	Uncertain	-
Tusk	Widely distributed	No analytical assessment	No	Uncertain	-

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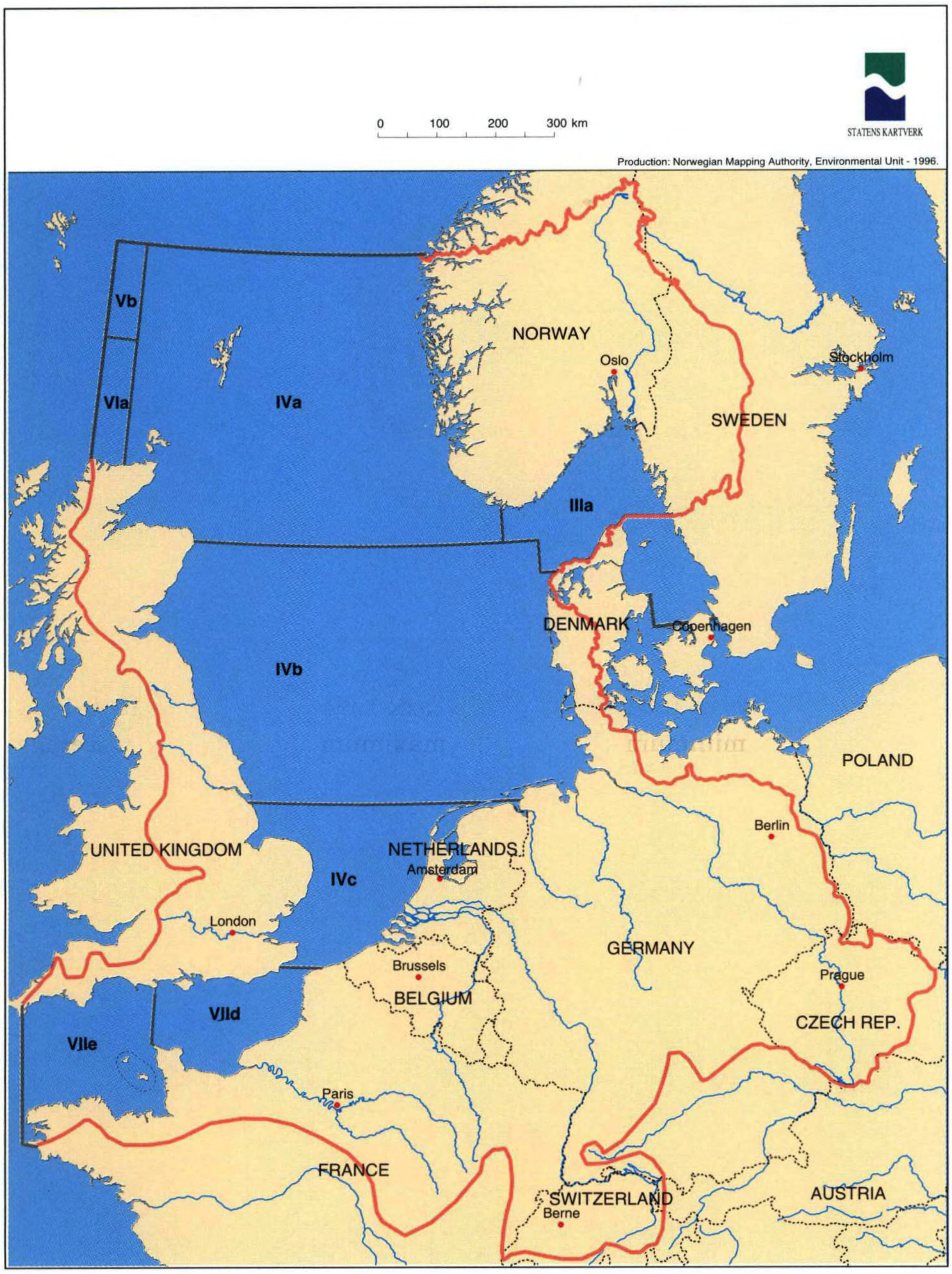
Other species with reported landings in IIIa, IV and VIId,e of more than 1 000 tonnes in either 1994 or 1995 for which there are no international stock assessment

European eel
Argentines (silver smelts)
Megrim
Turbot
Brill
Greenland halibut
Witch flounder
Common dab
Lemon sole
European flounder
Pollack
Roundnose grenadier
Catfish
Gurnards
Anglerfish
Sardine
Spurdog (Spiny dogfish)
Skates
Edible crab
Spinous spider crab
European lobster
Common shrimp
Whelk
Blue mussel
Common scallop
Queen scallop
Common cockle
Common squid
Cuttlefish
Striped venus

North Sea and ICES areas



ANNEX IV

Landings

Fishing Mortality Rates, Spawning Stock Biomass (in 1000 tonnes) and Recruitment (in millions) of Commercial Species.

HC=human consumption

Cod in IV	1963-1994 minimum	1963-1994 maximum	1990-1994 average
HC landings	88	341	97
HC fishing mortality (ages 2-8)	0.47	0.99	0.85
Spawning stock biomass	57	284	60
Recruitment at age 1	108	903	222

Cod in Skagerrak	1978-1994 minimum	1978-1994 maximum	1990-1994 average
HC landings	9	30	15
HC fishing mortality (ages 3-6)	0.47	1.53	1.02
Spawning stock biomass	7	17	8
Recruitment at age 1	9	34	14

Cod in Kattegat	19xx-1994 minimum	19xx-1994 maximum	1990-1994 average
HC landings	? ?	?	

Cod in VIId	1976-1994 minimum	1976-1994 maximum	1990-1994 average
HC landings	2	14	2.6
HC fishing mortality (ages 2-4)	0.61	1.99	1.38
Spawning stock biomass	0.4	3.4	0.7
Recruitment at age 1	1	48	3

Cod in VIIe	1987-1994 minimum	1987-1994 maximum	1990-1994 average
HC landings	0.5	2.7	0.7

Haddock in IV	1963-1994 minimum	1963-1994 maximum	1990-1994 average
HC landings	45	525	65
By-catch in industrial fisheries	2	338	7
Discards	27	260	53
HC fishing mortality (ages 2-6)	0.48	0.94	0.72
Spawning stock biomass	62	825	105
Recruitment at age 0	2 087	357 997	37 572

Haddock in IIIa	1983-1994 minimum	1983-1994 maximum	1990-1994 average
HC landings	1.8	8.0	3.3
By-catch in industrial fisheries	0.4	7.2	2.7

Whiting in IV	1960-1994 minimum	1960-1994 maximum	1990-1994 average
HC landings	41	105	45
By-catch in industrial fisheries	8	152	29
Discards	27	241	39
HC fishing mortality (ages 2-6)	0.35	1.05	0.49
Spawning stock biomass	231	606	265
Recruitment at age 0	13 743	114 247	27 677

Whiting in IIIa	1975-1994 minimum	1975-1994 maximum	1990-1994 average
Total landings	5	49	11

Whiting in VIId	1976-1994 minimum	1976-1994 maximum	1990-1994 average
HC landings	3.5	9.2	5.4
HC fishing mortality (ages 2-4)	0.07	0.79	0.56
Spawning stock biomass	9	62	10
Recruitment at age 1	30	491	91

Whiting in VIIe	1987-1994 minimum	1987-1994 maximum	1990-1994 average
Total landings	1.5	2.7	1.8

Saithe in IV and IIIa	1970-1994 minimum	1970-1994 maximum	1990-1994 average
HC landings	86	253	95
HC fishing mortality (ages 3-6)	0.31	0.93	0.57
Spawning stock biomass	78	485	87
Recruitment at age 1	91	542	182

Sole in IV	1957-1994 minimum	1957-1994 maximum	1990-1994 average
HC landings	11	35	32
HC fishing mortality (ages 2-8)	0.13	0.55	0.47
Spawning stock biomass	25	149	79
Recruitment at age 1	12	559	166

Sole in VIId	1982-1994 minimum	1982-1994 maximum	1990-1994 average
HC landings	3.2	5	4.3
HC fishing mortality (ages 3-8)	0.33	0.61	0.41
Spawning stock biomass	7.1	11.5	9.6
Recruitment at age 1	8.5	46.4	27

Sole in VIIe	1969-1994 minimum	1969-1994 maximum	1990-1994 average
HC landings	0.4	1.5	0.8
HC fishing mortality (ages 3-7)	0.16	0.44	0.29
Spawning stock biomass	2.4	5.9	2.9
Recruitment at age 1	1.2	8.6	3.8

Plaice in IV	1957-1994 minimum	1957-1994 maximum	1990-1994 average
HC landings	71	169	131
HC fishing mortality (ages 2-10)	0.20	0.45	0.42
Spawning stock biomass	252	493	320
Recruitment at age 1	235	1276	400

Plaice in IIIa	1972-1994 minimum	1972-1994 maximum	1990-1994 average
HC landings	8	27	11

Plaice in VIId	1980-1994 minimum	1980-1994 maximum	1990-1994 average
HC landings	2.7	10.4	6.8
HC fishing mortality (ages 2-6)	0.35	0.65	0.51
Spawning stock biomass	5.8	15.2	10.9
Recruitment at age 1	14	64.7	23.9

Plaice in VIIe	1976-1994 minimum	1976-1994 maximum	1990-1994 average
HC landings	0.6	2.6	1.7
HC fishing mortality (ages 3-7)	0.40	0.83	0.72
Spawning stock biomass	1.3	4.1	2.7
Recruitment at age 1	2	13	4

Norway pout in IV	1974-1994 minimum	1974-1994 maximum	1990-1994 average
Industrial landings	101	736	179
Fishing mortality (ages 1-2)	0.52	1.23	0.58
Spawning stock biomass	95	376	199
Recruitment at age 0	57 202	306 115	107 886

Norway pout in IIIa	1976-1994 minimum	1976-1994 maximum	1990-1994 average
Industrial landings	17	86	47

Sandeel in IV	1976-1994 minimum	1976-1994 maximum	1990-1994 average
Industrial landings	488	1039	727
Fishing mortality (ages 1-2)	0.31	0.95	0.51
Spawning stock biomass	427	1703	859
Recruitment at age 0	200 596	1 288 619	701 214

Sandeel in IIIa	1989-1994 minimum	1989-1994 maximum	1990-1994 average
Industrial landings	16	85	46

Sandeel in Shetland	19xx-1994 minimum	19xx-1994 maximum	1990-1994 average
Industrial landings	?	?	?

Mackerel caught in IV	1982-1994 minimum	1982-1994 maximum	1990-1994 average
Total catch	35	476	381

Mackerel (total stock)	1984-1994 minimum	1984-1994 maximum	1990-1994 average
Landings	602	825	740
Fishing mortality (ages 4-8)	0.15	0.29	0.22
Spawning stock biomass	2 357	3 324	2 937
Recruitment at age 0	2 699	7 977	3 373

North Sea horse mackerel	1982-1994 minimum	1982-1994 maximum	1990-1994 average
Total catch	4 33	13	

Western horse mackerel	1982-1994 minimum	1982-1994 maximum	1990-1994 average
Total catch	41	433	380

Herring in IV, VIId & IIIa	1983-1994 minimum	1983-1994 maximum	1990-1994 average
Total landings	387	876	627
Fishing mortality (ages 2-6)	0.33	0.65	0.53
Spawning stock biomass	438	1 302	837
Recruitment at age 0	37 031	97 353	45 571

ANNEX V

Joint Action by EU and Norway under the Fisheries Agreement

Preliminary agreed actions (The European Commission and Norway):

i Convene joint scientific working groups to develop common views in respect of management on shared stocks.

See response to questions iii, vi and viii in the Basis Report on Fisheries and Fisheries related Species and Habitats Issues.

ii Work jointly towards a responsible and sustainable utilisation of North Sea fish stocks;

This is always the intention of any cooperation between Norway and EU. The main operative fora are the technical working meetings and the annual bilateral consultations.

In the context of the quota agreement for 1996, Norway and the EU decided to implement a multi-annual management strategy for i.a. herring, mackerel and plaice. In the consultation for fisheries for 1997 it was agreed to intensify the work on new management systems for herring and mackerel. The purpose of such a strategy is to take management decisions that will apply over more than one year in light of the current scientific knowledge of the stocks. This in turn should provide for greater stability of exploitation, and for the setting of limit and target reference points in accordance with a precautionary approach. The strategy incorporates the objective of successively rebuilding stocks to higher levels, thus increasing current yields.

iii Continue work on evaluating the effectiveness of management measures presently in use for demersal stocks in the Community and Norwegian parts of the North Sea.

A working group was convened in the autumn of 1995. The report, SEC(95) 2159/6 December 1995, contains useful and updated information on the state of affairs relating to demersal fisheries in the North Sea.

A main conclusion of the report is that the manner in which current fisheries are conducted causes removal of a very high proportion of the stocks annually, resulting in a high dependency on fishing for the younger age-groups, and hence a high dependency on recruitment. In this context it is recognized that quantitative management decisions in the form of TACs (Total Allowable Catches) must be accompanied by appropriate technical measures that will ensure better selectivity in catches to ensure a more rational exploitation pattern.

In light of the above, the EU and Norway have decided to follow up work relating to i.a. discards, selectivity of fishing gear and management relating to closed seasons/areas and other technical measures.

iv Assess the probable effectiveness of any new measures that may contribute to the recovery of fish stocks.

See response to questions iii, vi and viii in the Basis Report.

v Continue jointly to develop catch reporting and catch statistics with the aim ofreducing discrepancies between reported catches and ICES catch statistics, by assessing misreporting, inadequate accounting of discards, by-catches and other factors contributing to the total out-take of the stocks.

vi Jointly evaluate the management regimes for North Sea herring in order to improve the management regimes of the direct herring fisheries as well as fisheries in which herring constitutes a significant by-catch.

Both the EU and Norway are concerned about the quantities of herring taken as by-catch in fisheries directed at other species than herring. These catches are taken in addition to existing agreements on TACs for herring and work against the intention of the TACs to ensure acceptable levels of spawning stock biomass and fishing mortality rate.

The report of a joint working group on North Sea Herring, (SEC(95) 1600/ 27 September 1995), reviews current problems relating to the management of this stock. A main conclusion of the review conducted is the assumption that the most effective way to improve the exploitation pattern and improve the overall management of herring catches, particularly by-catches of predominantly juvenile herring, will be achieved by enlarging the scope and application of quantitative measures by the use of monitoring and sampling schemes.

Further discussions carried out during the last bilateral consultations have led to the intention to institute a new management regime for North Sea herring by the start of 1998.

vii Consult on fishery regulations in the North Sea, with a view to achieving, as far as possible, the harmonisation of regulatory measures in the fishery zones of the two parties.

See response to questions vi and viii in the Basis Report.

viii Promote the development and introduction of fishing gear and fishing practices which will improve selectivity and reduce unwanted and/or harmful by-catches of fish, marine mammals as well as birds.

Norway and EU have agreed to meet early in 1997 to discuss possible means to reduce discards, to improve the exploitation pattern of various fisheries and to improve selectivity of fishing gear.

ix Increase exchange of catch statistics which may contribute to promotion of effective control of relevant fisheries.

To strengthen the co-operation on control and enforcement, the EU and Norway have agreed to broaden the scope of the system of exchange of information on catches/ landings, including 3. country landings, in the respective ports of the parties. Such co-operation will be accompanied by increased contact between control and enforcement experts and exchange of observers.